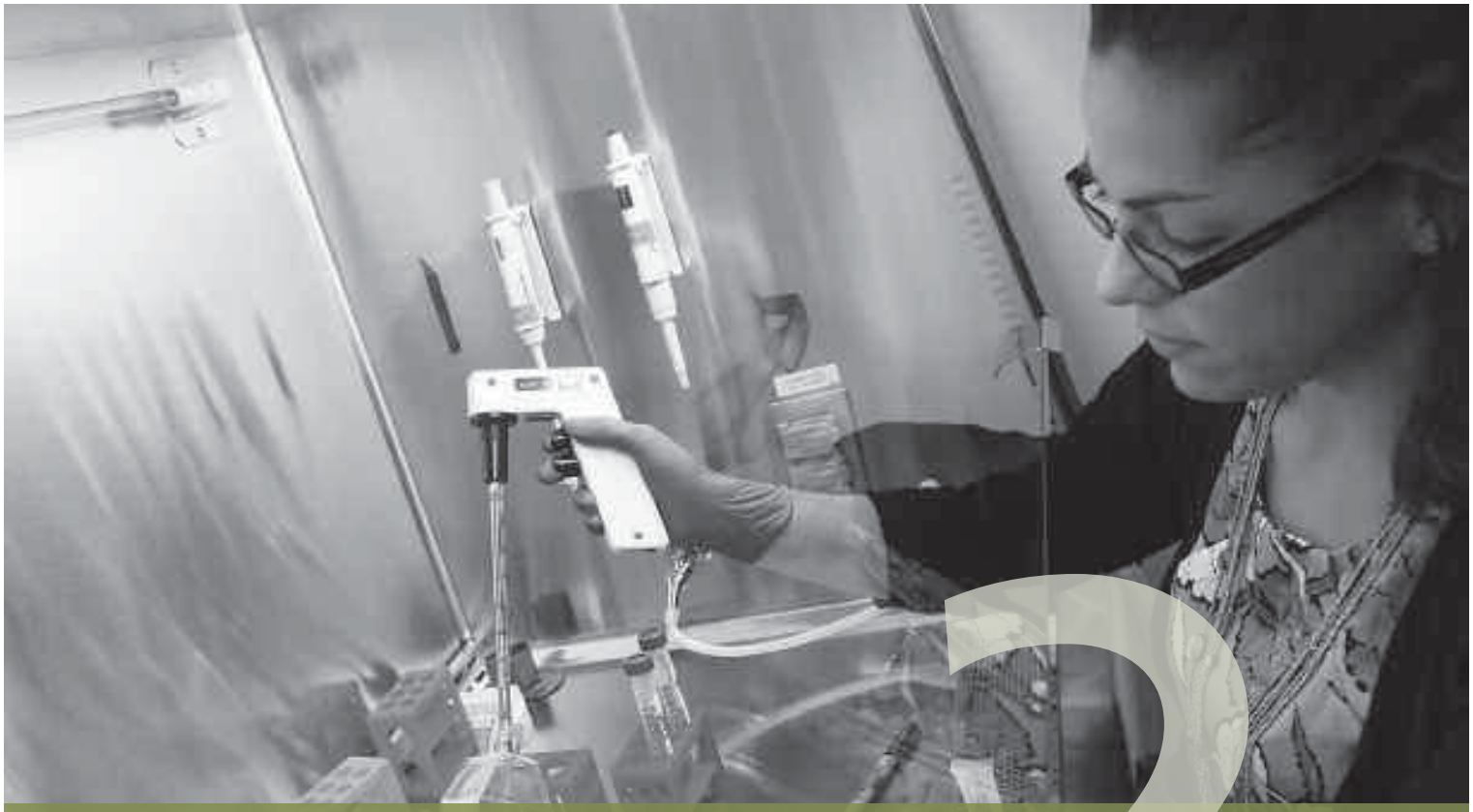


what gender is science?

by maria charles

Photo by Spencer Platt, Getty News Images

Gender equality crops up in surprising places. This is nowhere more evident than in science, technology, engineering, and mathematics (STEM) fields. The United States should be a world leader in the integration of prestigious male-dominated occupations and fields of study. After all, laws prohibiting discrimination on the basis of sex have been in place for more than half a century, and the idea that men and women should have equal rights and opportunities is practically uncontested (at least in public) in the U.S. today.

This egalitarian legal and cultural context has coincided with a longstanding shortage of STEM workers that has spurred countless initiatives by government agencies, activists, and industry to attract women into these fields. But far from leading the world, American universities and firms lag considerably behind those in many other countries with respect to women among STEM students and workers. Moreover, the countries where women are best represented in these fields aren't those typically viewed as modern or "gender-progressive." Far from it.

Sex segregation describes the uneven distributions of women and men across occupations, industries, or fields of study. While other types of gender inequality have declined dramatically since the 1960s (for example, in legal rights, labor force participation rates, and educational attainment), some forms of sex segregation are remarkably resilient in the industrial world.

In labor markets, one well-known cause of sex segregation is discrimination, which can occur openly and directly or through more subtle, systemic processes. Not so long ago, American employers' job advertisements and recruitment efforts were targeted explicitly toward either men or women depending on the job. Although these gender-specific ads were prohibited under Title VII of the 1964 Civil Rights Act, less blatant forms of discrimination persist. Even if employers base hiring and promotion solely on performance-based criteria, their taken-for-granted beliefs about average gender differences may bias their judgments of qualification and performance. Sociologists and economists have documented this cognitive bias and "statistical discrimination" through diverse experiments. It turns out that people's beliefs about men's and women's different natures lead them to assess task performance accordingly, even in the absence of any actual performance differences. Such biased assessments reinforce existing patterns of sex segregation because many occupational tasks are regarded as quintessentially "masculine" or "feminine." For example, beliefs about women's capacity for nurturing and men's technical and mechanical skills might lead an employer to perceive gender-conforming applicants (say, male pilots and female nannies) to be better qualified.

But discrimination isn't the whole story. It's well-established that girls and young women often avoid mathematically-intensive fields in favor of pursuits regarded as more human-centered. Analyses of gender-differentiated choices are controversial among scholars because this line of inquiry seems to divert attention away from structural and cultural causes of inequalities in pay and status. Acknowledging gender-differentiated educational and career preferences, though, doesn't "blame the victim" unless preferences and choices are considered in isolation from the social contexts in which they emerge. A sociological analysis of sex segregation considers how the economic, social, and cultural environments influence preferences, choices, and outcomes. Among other things, we may ask what types of social context are associated with larger or smaller gender differences in aspirations. Viewed through this lens, preferences become much more than just individuals' intrinsic qualities.

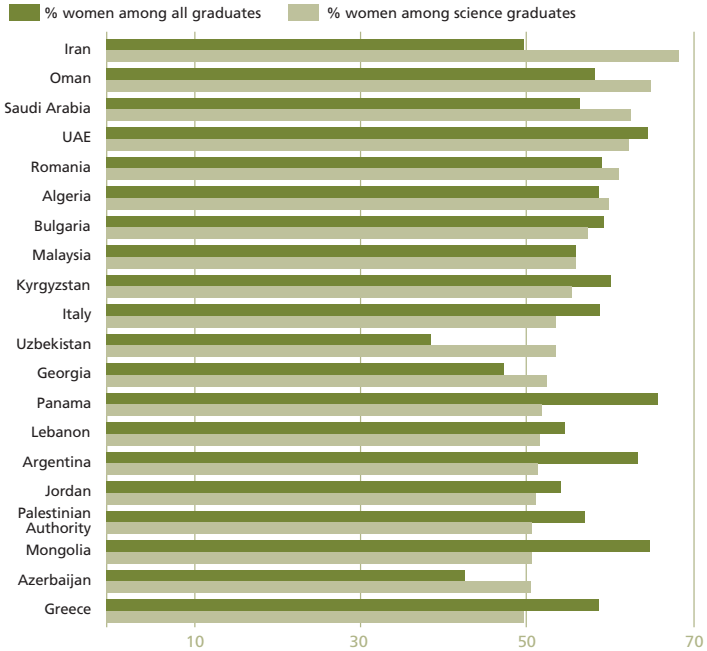
An excellent way to assess contextual effects is by investigating how career aspirations and patterns of sex segregation vary across countries. Recent studies show international differences in the gender composition of STEM fields, in beliefs about the masculinity of STEM, and in girls' and women's reported affinity for STEM-related activities. These differences follow unexpected patterns.

STEM around the world

Many might assume women in more economically and culturally modern societies enjoy greater equality on all measures, since countries generally "evolve" in an egalitarian direction as they modernize. This isn't the case for scientific and technical fields, though.

Statistics on male and female college graduates and their fields of study are available from the United Nations Educational, Scientific, and Cultural Organization (UNESCO) for 84 countries covering the period between 2005 and 2008. Sixty-five of those countries have educational systems large enough to offer a full range of majors and programs

Where women earn the majority of science degrees



Source: UNESCO Data Center, 2010

These are the countries in which women earn 50 percent or more of the science degrees awarded.

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(at least 10,000 graduates per year).

One way of ranking countries on the sex segregation of science education is to compare the (female-to-male) gender ratio among science graduates to the gender ratio among graduates in all other fields. By this measure, the rich and highly industrialized U.S. falls in about the middle of the distribution (in close proximity to Ecuador, Mongolia, Germany, and Ireland—a heterogeneous group on most conventional measures of "women's status"). Female representation in science programs is weakest in the Netherlands and strongest in Iran, Uzbekistan, Azerbaijan, Saudi Arabia, and Oman, where science is disproportionately female. Although the Netherlands has long been considered a gender-traditional society in the European context, most people would still be intrigued to learn that women's representation among science graduates is nearly 50 percentage points lower there than in many Muslim countries. As seen in the table on page 23, the most gender-integrated science programs are found in Malaysia, where women's 57-percent share of science degree recipients precisely matches their share of all college and university graduates.

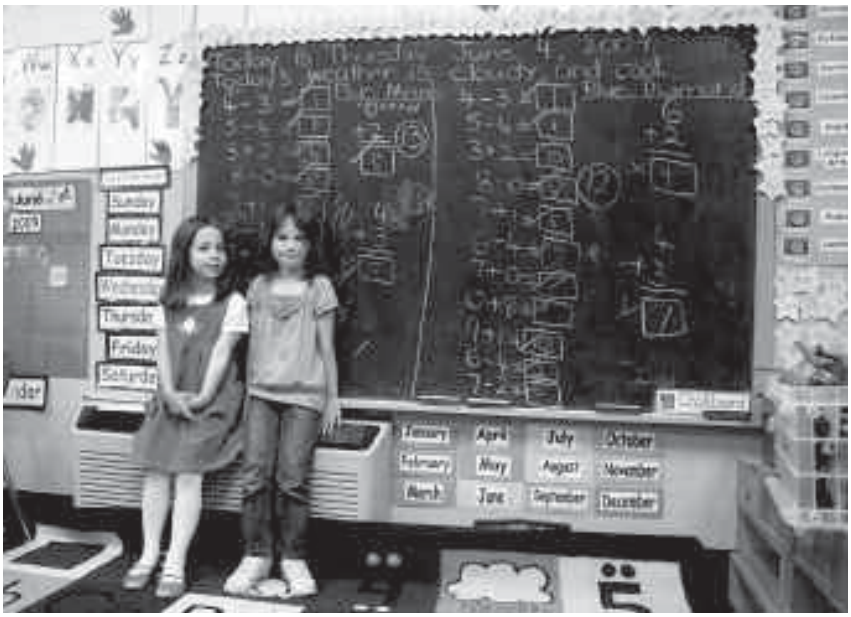


Photo by Woodley Wonder Works

"Science" is a big, heterogeneous category, and life science, physical science, mathematics, and computing are fields with very different gender compositions. For example, women made up 60 percent of American biology graduates , but only about 19 percent of computing graduates, in 2008, according to the National Center for Educational Statistics.

But even when fields are defined more precisely, countries differ in some unexpected ways. A case in point is computer science in Malaysia and the U.S. While American computer scientists are depicted as male hackers and geeks, computer science in Malaysia is deemed well-suited for women because it's seen as theoretical (not physical) and it takes place almost exclusively in offices (thought to be woman-friendly spaces). In interviews with sociologist Vivian Lagesen, female computer science students in Malaysia reported taking up computing because they like computers and because they and their parents think the field has good job prospects. The students also referenced government efforts to promote economic development by training workers, both male and female, for the expanding information technology field. About half of Malaysian computer science degrees go to women.

Engineering is the most strongly and consistently male-typed field of study worldwide, but its gender composition still varies widely across countries. Female representation is generally weaker in advanced industrial societies than in developing ones. In our 2009 article in the *American Journal of Sociology,* Karen Bradley and I found this pattern using international data from the mid-1990s; it was confirmed by more recent statistics assembled by UNESCO. Between 2005 and 2008, countries with the most male-dominated engineering programs include the world's leading industrial democracies (Japan, Switzerland, Germany, and the U.S.) along with some of the same oil-rich Middle Eastern countries in which women are so well-represented among science graduates (Saudi Arabia, Jordan, and the United Arab Emirates). Although women do not reach the fifty-percent mark in any country, they come very close in Indonesia, where 48 percent of engineering graduates are female (compared to a 49 percent share of all Indonesian college and university graduates). Women comprise about a third of recent engineering graduates in a diverse group of countries including Mongolia, Greece, Serbia, Panama, Denmark, Bulgaria, and Malaysia.

While engineering is uniformly male-typed in the West, Lagesen's interviews suggest Malaysians draw gender distinctions among engineering *subfields*. One female student reported, "…In chemical engineering, most of the time you work in labs... So I think it's quite suitable for females also. But for civil engineering… we have to go to the site and check out the constructions."

girl geeks in america

Women's relatively weak presence in STEM fields in the U.S. is partly attributable to some economic, institutional, and cultural features that are common to affluent Western democracies. One such feature is a great diversity of educational and occupational pathways. As school systems grew and democratized in

the industrial West, educators, policymakers, and nongovernmental activists sought to accommodate women's purportedly "human-centered" nature by developing educational programs that were seen to align functionally and culturally with female domestic and social roles. Among other things, this involved expansion of liberal arts programs and development of vocationally-oriented programs in home economics, nursing, and early-childhood education. Subsequent efforts to incorporate women, *as women,* into higher education have contributed to expansion in humanities programs, and, more recently, the creation of new fields like women's studies and human development. These initiatives have been supported by a rapid expansion of service-sector jobs in these societies.

In countries with developing and transitional economies, though, policies have been driven more by concerns about advancing economic development than by interests in accommodating women's presumed affinities. Acute shortages of educated workers prompted early efforts by governments and development agencies to increase the supply of STEM workers. These efforts often commenced during these fields' initial growth periods—arguably before they had acquired strong masculine images in the local context.

Another reason for stronger sex segregation of STEM in affluent countries may be that more people (girls and women in particular) can afford to indulge tastes for less lucrative care and social service work in these contexts. Because personal economic security and national development are such central concerns to young people and their parents in developing societies, there is less latitude and support for the realization of gender-specific preferences.

Again, the argument that women's preferences and choices are partly responsible for sex segregation doesn't require that preferences are innate. Career aspirations are influenced by beliefs about ourselves (What am I good at and what will I enjoy doing?), beliefs about others (What will they think of me and how will they respond to my choices?), and beliefs about the purpose of educational and occupational activities (How do I decide what field to pursue?). And these beliefs are part of our cultural heritage. Sex segregation is an especially resilient form of inequality because people so ardently believe in, enact, and celebrate cultural stereotypes about gender difference.

believing stereotypes. Relationship counselor John Gray has produced a wildly successful series of self-help products in which he depicts men and women as so fundamentally different that they might as well come from different planets. While the vast majority of Americans today believe women should have equal social and legal rights, they also believe men and women are very different, and they believe innate differences cause them to *freely choose* distinctly masculine or feminine life paths. For instance, women and men are expected to choose careers that allow them to utilize their hard-wired interests in working with people and things, respectively.

Believing in difference can actually produce difference. Recent sociological research provides strong evidence that cultural stereotypes about gender difference shape individuals' beliefs about their own competencies ("self-assessments") and influence behavior in stereotype-consistent directions. Ubiquitous cultural depictions of STEM as intrinsically male reduce girls' interest in technical fields by defining related tasks as beyond most women's competency and as generally unenjoyable for them. STEM avoidance is a likely outcome.

Shelley Correll's social psychological experiment demonstrates the self-fulfilling effects of gender beliefs on self-assessments and career preferences. Correll administered questions purported to test "contrast sensitivity" to undergraduates. Although the test had no objectively right or wrong answers, all participants were given identical personal "scores" of approximately 60 percent correct. Before the test, subjects were exposed to one of two beliefs: that men on average do better, or that men and women perform equally well. In the first group, male students rated their performance more highly than did female students, and male students were more likely to report aspiring to work in a job that requires contrast sensitivity. No gender differences were observed among subjects in the second group. Correll's findings suggest that *beliefs about difference* can produce gender gaps in mathematical self-confidence even in the absence of actual differences in ability or performance. If these beliefs lead girls to avoid math courses, a stereotype-confirming performance deficit may emerge.

Sex segregation is especially resilient because people so ardently believe in, enact, and celebrate gender stereotypes.

Concern about such self-fulfilling prophesies was one reason for the public furor that erupted when Lawrence Summers, then president of Harvard, opined in 2005 that innate biological differences might help explain women's underrepresentation in high-level math and science. Summers's critics, who included many members of the Harvard faculty, reacted angrily, suggesting that such speculation by a prominent educational leader can itself reduce girls' confidence and interest in STEM careers by reinforcing cultural stereotypes.

enacting stereotypes. Whatever one believes about innate gender difference, it's difficult to deny that men and women often behave differently and make different choices. Partly, this reflects inculcation of gender-typed preferences and abilities during early childhood. This "gender socialization" occurs

through direct observation of same-sex role models, through repeated positive or negative sanctioning of gender-conforming or nonconforming behavior, and through assimilation of diffuse cultural messages about what males and females like and are good at. During much of the 20th century, math was one thing that girls have purportedly not liked or been good at. Even Barbie said so. Feminists and educators have long voiced concerns about the potentially damaging effects of such messages on the minds of impressionable young girls.

Ironically, freedom of choice seems to help construct and give agency to stereotypically gendered "selves."

But even girls who don't believe STEM activities are inherently masculine realize others do. It's likely to influence their everyday interactions and may affect their life choices. For example, some may seek to affirm their femininity by avoiding math and science classes or by avowing a dislike for related activities. Sociologists who study the operation of gender in social interactions have argued that people expect to be judged according to prevailing standards of masculinity or femininity. This expectation often leads them to engage in behavior that reproduces the gender order. This "doing gender" framework goes beyond socialization because it doesn't require that gender-conforming dispositions are internalized at an early age, just that people know others will likely hold them accountable to conventional beliefs about hard-wired gender differences.

The male-labeling of math and science in the industrial West means that girls and women may expect to incur social sanctions for pursuing these fields. Effects can be cumulative: taking fewer math classes will negatively affect achievement in math and attitudes toward math, creating a powerful positive feedback system.

celebrating stereotypes. Aspirations are also influenced by general societal beliefs about the nature and purpose of educational and occupational pursuits. Modern education does more than bestow knowledge; it's seen as a vehicle for individual self-expression and self-realization. Parents and educators exhort young people, perhaps girls in particular, to "follow their passions" and realize their "true selves." Because gender is such a central axis of individual identity, American girls who aim to "study what they love" are unlikely to consider male-labeled science, engineering, or technical fields, despite the material security provided by such degrees.

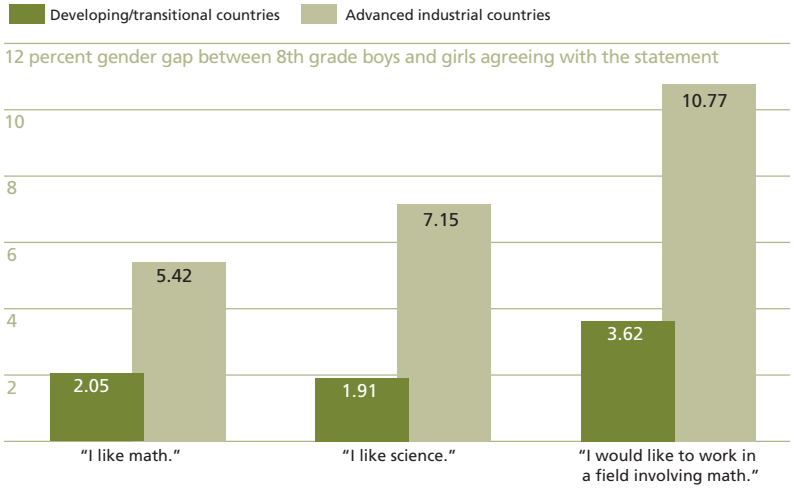
Although the so-called "postmaterialist" values of individualism and self-expression are spreading globally, they are most prominent in affluent late-modern societies. Curricular and career choices become more than practical economic decisions in these contexts; they also represent acts of identity construction and self-affirmation. Modern systems of higher education make the incursion of gender stereotypes even easier, by allowing wide latitude in course choices.

The ideological discordance between female gender identities and STEM pursuits may even generate attitudinal aversion among girls. Preferences can evolve to align with the gender composition of fields, rather than vice versa. Consistent with these arguments is new evidence showing that career-related aspirations are more gender-differentiated in advanced industrial than in developing and transitional societies. As can be seen below, the gender gap in eighth-graders' affinity for math, confidence in math abilities, and interest in a math-related career is significantly smaller in less affluent countries than in rich ("postmaterialist") ones. Clearly, there is more going on than intrinsic male and female preferences.

questioning STEM's masculinity

Playing on stereotypes of science as the domain of socially awkward male geniuses, CBS's hit comedy "The Big Bang Theory" stars four nerdy male physicists and one sexy but academically challenged waitress. (Female physicists, when they do show up, are mostly caricatured as gender deviants: sexually unattractive and lacking basic competence in human interaction.) This depiction resonates with popular Western understandings of sci-

Who likes math and science?



Values give male to female difference in percentage points, averaged across countries. Calculations of data from the Trends in International Math and Science Survey by Maria Charles and Karen Bradley, "Indulging our Gendered Selves? Sex Segregation by Field of Study in 44 Countries," *American Journal of Sociology* (2009), 114(4):924.

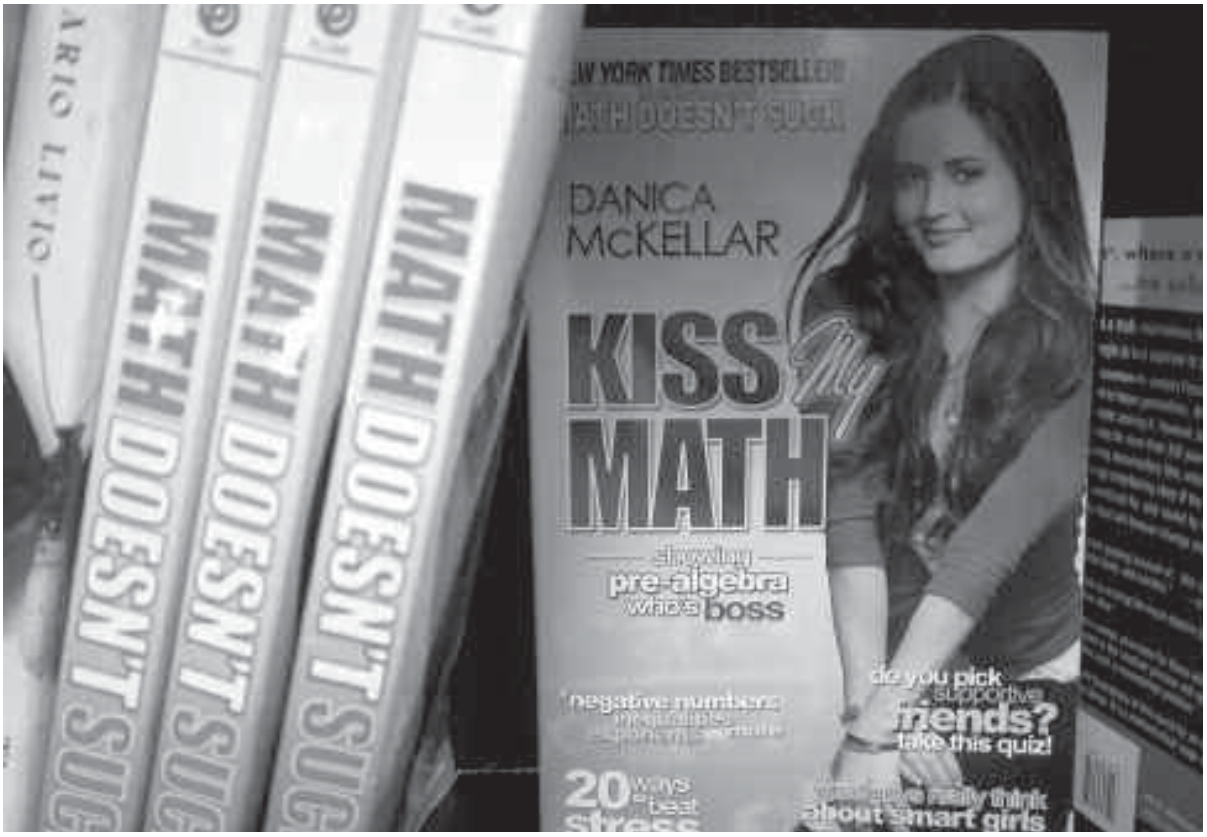


Photo by Justin Morgan

Television star and self-proclaimed "math geek" Danica McKellar's books specifically aim to engage adolescent American girls in math and science.

entific and technical pursuits as intrinsically masculine.

But representations of scientific and technical fields as *by nature* masculine aren't well-supported by international data. They're also difficult to reconcile with historical evidence pointing to long-term historical shifts in the gender-labeling of some STEM fields. In *The Science Education of American Girls,* Kim Tolley reports that it was *girls* who were overrepresented among students of physics, astronomy, chemistry, and natural science in 19th century American schools. Middle-class boys dominated the higher-status classical humanities programs thought to require top rational powers and required for university admission. Science education was regarded as excellent preparation for motherhood, social work, and teaching. Sociologist Katharine Donato tells a similar story about the dawn of American computer programming. Considered functionally analogous to clerical work, it was performed mostly by college-educated women with science or math backgrounds. This changed starting in the 1950s, when the occupation became attractive to men as a growing, intellectually demanding, and potentially lucrative field. The sex segregation of American STEM fields—especially engineering, computer science, and the physical sciences—has shown remarkable stability since about 1980.

The gender (and racial) composition of fields is strongly influenced by the economic and social circumstances that prevail at the time of their initial emergence or expansion. But subsequent transformative events, such as acute labor shortages, changing work conditions, and educational restructuring can effect significant shifts in fields' demographic profiles. Tolley, for example, links men's growing dominance of science education in the late 19th and early 20th century to changing university admissions requirements, the rapid growth and professionalization of science and technology occupations, and recurrent ideological backlashes against female employment.

A field's designation as either "male" or "female" is often naturalized through cultural accounts that reference selected gender-conforming aspects of the work. Just as sex segregation across engineering subfields is attributed to physical location in Malaysia (inside work for women, outside work for men), American women's overrepresentation among typists and sewers has been attributed to these occupations' "feminine" task profiles, specifically their requirements for manual dexterity and attention to detail. While the same skills might be construed as essential to the work of surgeons and electricians, explanations for men's dominance of these fields are easily generated with reference to other job requirements that are culturally masculine (technical and spatial skills, for example). Difference-based explanations for sex segregation are readily available because most jobs require diverse skills and aptitudes, some equated with mas-

culinity, some with femininity.

looking forward

Should we be concerned about women's underrepresentation in STEM if this result follows from choices made in the absence of coercion or discrimination? I believe sex segregation should be of more than academic interest for at least three reasons. First, "separate but equal" principles often translate into "separate but unequal" outcomes, as is evident in the lower pay in female- than in male-dominated work. Second, sex segregation has feedback effects, reinforcing gender stereotypes and limiting perceived educational, family, and career options for subsequent generations. And third, women may represent an untapped labor pool in STEM fields where global shortages threaten to undermine national competiveness and economic development.

What then might be done to increase women's presence in STEM fields? One plausible strategy involves changes to the structure of secondary education. Some evidence suggests more girls and women complete degrees in math and science in educational systems where curricular choice is restricted or delayed; *all* students might take mathematics and science throughout their high-school years or the school might use performance-based tracking and course placement. Although such policies are at odds with Western ideals of individual choice and self-expression, they may weaken penetration of gender stereotypes during the impressionable adolescent years.

Of course, the most obvious means of achieving greater integration of STEM is to avoid reinforcing stereotypes about what girls and boys like and what they are good at. Cultural shifts of this sort occur only gradually, but some change can be seen on the horizon. The rise of "geek chic" may be one sign. Aiming to liberate teen-aged girls from the girls-can't-do-math and male-math-nerd stereotypes, television star and self-proclaimed math geek Danica McKellar has written three how-to math books, most recently *Hot X: Algebra Exposed,* presenting math as both feminine and fun. Even Barbie has been updated. In contrast to her math-fearing Teen Talk sister of the early 1990s, the new Computer Engineer Barbie, released in December 2010, comes decked out in a tight t-shirt printed in binary code and equipped with a smart phone and a pink laptop. Of course, one potential pitfall of this math-is-feminine strategy is that it risks swapping one set of stereotypes for another.

So, what gender is science? In short, it depends. When occupations or fields are segregated by sex, most people suspect it reflects fields' inherently masculine or feminine task content. But this presumption is belied by substantial cross-national variability in the gender composition of fields, STEM in particular. Moreover, this variability follows surprising patterns. Whereas most people would expect to find many more female engineers in the U.S. and Sweden than in Columbia and Bulgaria, new data suggest that precisely the opposite is true.

Ironically, the freedom of choice that's so celebrated in affluent Western democracies seems to help construct and give agency to stereotypically gendered "selves." Self-segregation of careers may occur because some believe they're naturally good at gender-conforming activities (attempting to build on their strengths), because they believe that certain fields will be seen as appropriate for people like them ("doing" gender), or because they believe they'll enjoy gender-conforming fields more than gender-nonconforming ones (realizing their "true selves"). It's just that, by encouraging individual self-expression in postmaterialist societies, we may also effectively promote the development and expression of culturally gendered selves.

recommended resources

Shelly J. Correll, "Constraints into Preferences: Gender, Status, and Emerging Career Aspirations." *American Sociological Review* (2004), 69:93-113. Presents evidence from experiments on how beliefs about gender influence beliefs about our own competence and constrain career aspirations.

Paula England, "The Gender Revolution: Uneven and Stalled." *Gender & Society* (2010), 24:149-166. Offers reasons for the persistence of some forms of gender inequality in the United States.

Wendy Faulkner, "Dualisms, Hierarchies and Gender in Engineering." *Social Studies of Science* (2000), 30:759-92. Explores the cultural linkage of masculinity and technology within the engineering profession.

Sarah Fenstermaker and Candace West (eds.), *Doing Gender, Doing Difference: Inequality, Power, and Institutional Change* (Routledge, 2002). Explores how and why people reproduce gender (and race and class) stereotypes in everyday interactions.

Cecilia L. Ridgeway, *Framed by Gender: How Gender Inequality Persists in the Modern World* (Oxford University Press, 2011). Describes how cultural gender beliefs bias behavior and congnition in gendered directions and how this influence may vary by context.

Yu Xie and Kimberlee A. Shauman, *Women in Science: Career Processes and Outcomes* (Harvard University Press, 2003). Uses data from middle school to mid-career to study the forces that lead fewer American women than men into science and engineering fields.

Maria Charles is in the sociology department at the University of California, Santa Barbara. She is the co-author (with David Grusky) of *Occupational Ghettos: The Worldwide Segregation of Women and Men.*