letters

Women in physics: Why and why not?

I read Evalyn Gates's Opinion piece "A Scientific Point of View" (PHYSICS TODAY, April 2006, page 64) with great interest. I have read several articles that offered a similar presentation and reached a similar conclusion. However, no one, in my opinion, has ever truly explained one point: Why is it important to increase the number of women in physics? Why does that matter? Will it improve the quality of physics?

I am not suggesting that physics needs more men than women—or more women than men. In the research center where I work, about 25% of the postgraduate researchers are women, and I believe my colleagues care about the quality of the science produced, not about the gender of the person producing it.

I do not understand why it is important to have more women as physicists—or as firefighters, bullfighters, divers, or any other profession. I believe that regardless of gender, individuals should be able to do what best suits their abilities.

I realize that my point of view may seem naive, but I would appreciate a clear and logical argument.

Vicente Aboites
(aboites@cio.mx)
Center for Research in Optics
Leon, Mexico

"A Scientific Point of View" by Evalyn Gates appears to be more about the physics community being a politically correct cross section of society than about the quality of its science or its usefulness to society. Gates's comments raise two questions for us.

Our first question is a basic one: Are there gender inequalities in physics? Gates implies that the answer is yes.

According to data from the American Institute of Physics, Gates says, the number of female full professorships nearly doubled from 3% to 5% in only four years, while the female new-faculty hiring rate remained "commensurate with the available candidate pool." Furthermore, the number of women in full professorships nearly doubled in the time it takes to earn a BS in physics. Gates did not laud that achievement but described it as "embarrassingly low." Indirectly, she is proposing an affirmative action program for female physicists when she says we should "achieve parity at the faculty level." However, she later contradicts herself by stating that "women as a group do not need special treatment, [only] equal treatment."

Gates also notes that 46% of high-school physics students are female but only 23% of the physics undergraduate degree recipients are female. She points out, as do Rachel Ivie and Kim N. Ray,[1] that cultural influences "may" play a role in the decision of women not to pursue a physics degree, but Gates neglects to account for a significant skewing aspect: Many high schools require that college-bound students take additional science credits—physics, for example. So the data regarding numbers of female physics students at the high-school level may reflect only a preference for attending college, not a preference for physics.

The second question we have is this: Must technical communities be cross-sectional representations of their greater societies? Gates suggests that they should be. Unfortunately, the question immediately leaves the realm of facts and statistics and lands squarely in a domain where physicists have little experience or qualification—the emotional and political arena of social engineering. Will the social engineering of physics stop once that "parity" is achieved? Probably not. Will the next step be to lower physics graduation requirements simply to attract students from other career fields in the hope of meeting some artificial parity requirement? That outcome is not as far-fetched as some may think.

How are women faring in other career fields? It is well observed that female engineering students tend to favor such specialties as biomedical or materials engineering over the traditional mechanical, civil, and electrical domains. This phenomenon is dominated by sociological and psychological factors. The nerdy reputation that attaches to traditional engineering does not help cultivate the social connections and relationships that our society stresses for young women. Alternatively, the newer engineering fields, particularly biomedical, can be viewed as exciting, and as more people-oriented and compassionate—qualities that our society emphasizes in young women.

Is the lack of male nurses viewed as a crisis in medicine? Considering that females currently dominate the nursing and medical aid communities, and the doctor community approaches parity, is society concerned at the prospect of a female-dominated medical community? Of course not. So why should we be concerned that males may be more socially inclined to physics?

To achieve social similitude, the physics community must either change society or abandon the meritocracy that yielded the great founders of our field. Let's allow students to choose their own careers in line with their interests and dreams. We risk losing professional integrity if we cast aside the meritocracy of physics for cross-sectional similitude with society merely for the sake of political correctness. And rather than acting as sociologists, we should remain focused on our expertise and true to our goal: good physics that is good for society. Once society has fixed its problems, the optimal solution will percolate throughout the physics community so long as we maintain our unbiased meritocracy.

Reference

1. R. Ivie, K. N. Ray, *Women in Physics and Astronomy 2005*, American Institute of Physics, College Park, MD (2005).

Jerry Smith
(jr_smith@vt.ed)
Wei Smith
(wehuang5@vt.edu)
Arlington, Virginia

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Evalyn Gates notes that a student's career decisions may be influenced by cultural attitudes. From my years of teaching and advising, I have seen that the influence of parents on the choice of a career is also a major factor.

In many instances, I saw students pushed by parents to become engineers or doctors, careers that did not fit their interests or abilities. Some I managed to persuade to change; a few changed majors only after failing a physics course.

Unfortunately science professors have little chance to influence students who have been pushed out of science into arts or social studies. I did encourage a few women to defy their parents and major in a science.

Another possible motivator away from physics could be that in many colleges and universities, students must choose the subject of their major upon entrance. Admittedly the sequential structure of courses starting late in the second year can cause scheduling difficulties if a major is not yet chosen. One woman, for example, came into my office in the second semester of her sophomore year and said, "I have a problem. I like physics." We worked out a program for a major, and she eventually completed her bachelor's and PhD degrees in physics.

Too many people today are looking only at the financial gains of a career. After four to six years in graduate school plus at least a year as a poorly paid postdoc, a PhD holder in science can expect an entry-level position to pay about half what a lawyer will make after three years of postgraduate work, and less than half what an MBA will make with two postgraduate years. Furthermore, when a woman is married, a physics degree does not offer much flexibility in finding suitable career positions for both her and her husband in the same vicinity. Fortunately for us some men and women still have become, as I. I. Rabi said, "the Peter Pans of the World. They kept their curiosity."

E. O. LaCasce
Bowdoin College
Brunswick, Maine

In her essay Evalyn Gates argues that women are underrepresented in physics because of gender biases and that our physics community has an obligation to rectify this perceived inequity. She says, "Institutions that award fewer than about 40% of bachelor's degrees to women should be actively investigating to find out why."

A much wider male-to-female discrepancy was reported in the *New York Times* recently. It seems that women commit only 7% of the murders in New York City. There is one bright spot, however: In the spouse-offing category, women lead men two to one.

Certainly men and women are different. Our forebears who dealt with cows and bulls, roosters and hens, and rams and ewes never questioned such differences. Although gender differences in the intrinsic intellectual abilities important in physics are surely small, if not nonexistent, men and women differ in certain personality traits such as aggression (murderous or otherwise), which unfortunately has some effect on status, even in physics. More important is that in judging their best roles in society, women tend to make different choices from men. The influx of women into medicine and biology rather than physics and engineering likely follows from such differences in interests rather than gender biases.

It is important to reduce illegitimate gender biases in all elements of society. I suggest, though, that the most important bias is found in the structures of the paths to leadership roles. These paths mesh poorly with women's biological rhythms. When I review the wedding announcements in the *New York Times*, I find that attractive and accomplished brides are marrying at an average age of about 30—halfway between menarche and menopause. Thus, among advanced societies, women are properly playing a larger role in leadership, but the birth rate lags behind replacement levels. We are becoming extinct.

I have long been interested in the status of women in science. When I was young, Maria Skłodowska Curie was my hero. At the time of my retirement, I could claim that more women received their PhD working with me than with anyone in the history of Yale physics. And my wife, Eleanor Adair, is a significant figure in her area of environmental physiology. Ellie's career path was significantly modified—mainly delayed—by her raising of our three children.

Rather than work toward quotas that incorrectly assume men and women are equivalent, we had better work toward a more radical end, a reconstruction of our corner of a society currently fitted to male biology so that it better fits that of females.

Robert K. Adair
(adair@hepmail.physics.yale.edu)
Yale University
New Haven, Connecticut

Evalyn Gates advocates a "scientific point of view" for what she calls the problem of too few women in physics.

Yet the data she cites suggest gains that appear to exemplify vigorous affirmative action. Disparities in the number of women in the physical sciences, engineering, and mathematics are easily explained by objective data. Due to biological differences, significantly more men than women are at the extremes of mental ability. Charles Darwin pointed out the greater variability of males in his *The Descent of Man* (1871). For example, the ratio of male to female math geniuses is 13 to 1.

Studies of mathematically gifted young women in special programs such as the Johns Hopkins Study of Mathematically Precocious Youth reveal striking sex differences in values and interests. Most of the women preferred careers in law, medicine, and biology where they could work with people and living things rather than with inanimate objects. Even though mathematically capable young women are aware of their abilities and opportunities, they choose these fields far less frequently than do young men. Less than 1% of females in the top 1% of mathematical ability are pursuing doctorates in math, engineering, or physical sciences. Eight times as many similarly gifted males are doing so. The mathematically gifted woman's first career choice is medicine, followed by law, humanities, and biology.

The relative lack of women in mathematics and certain science fields, then, is due to two factors: the far greater number of gifted males, and the propensity of gifted females to choose other fields.

Ideologies that portray gender differences as tantamount to gender discrimination are troubling because they ignore the facts and threaten freedom of choice. Radical proposals to solve the perceived discrimination would result in hiring and promoting less-qualified women over more-qualified men in mathematics, chemistry, engineering, physics, and computer science.

Joseph Spicatum
Missoula, Montana

With regard to the equal treatment of male and female physicists, I think the playing field has been level for a while. Female physicists have the same level of recognition and approval as males, at least at the University of Toronto.

We can continue to have a level playing field for men and women in physics. Instead of trying to change women's preference for future careers, we should change ourselves. We should think of new ways to make physics more appealing to female students. This has been the key to the success of other professions such as law and medicine in attracting larger numbers of women.

Kamyar Hazaveh
(kamyar_hazaveh@yahoo.com)
University of Toronto
Toronto, Ontario

Gates replies: Vicente Aboites poses an important question: Why should the physics community care about the number of women in its ranks? Or the number of minorities for that matter? The most compelling reason is because we want to create and work within a system that is fair and unbiased, a system that identifies, encourages, and supports the brightest and most motivated scientists and science students.

The difficulty is convincing some members of our community that we are not yet a pure meritocracy. Many male and female physicists believe that, as Kamyar Hazaveh states, "the playing field has been level for a while"—that they themselves, and their colleagues, are completely gender neutral in all of their scientific interactions with colleagues and students. Unfortunately, this is not true for any of us. Physicists are human and we are subject to the cultural and social influences that pervade society.

The evidence that gender inequalities in science continue is presented in the references of my original piece, and in the more recent report, *Beyond Bias and Barriers: Fulfilling the Potential of Women in Academic Science and Engineering* (National Academies Press, 2006). I strongly recommend this report to all the letter writers and anyone else interested in this issue. The report's authors do an excellent job of presenting and summarizing, in far more detail than is possible here, statistics on women in science and engineering, current data on gender biases in academia, and institutions' structural obstacles that impede the progress of women and minorities. The authors also offer specific recommendations for addressing the inequities.

Jerry and Wei Smith would like to believe that these gender biases do not exist—an attitude that is not supported by the data.

The data also do not support Joseph Spicatum's hypothesis that the low percentage of women in physics can be explained by a combination of gender differences in ability and interest. His first point, that the gender imbalance is due to a difference in mathematical ability at the very high end, has two problems. The ratio of 13:1 he quotes arises from studies done in the early 1980s.[1] If that ratio reflects an innate difference between males and females at the highest end of the mathematical-ability spectrum, it should remain constant over time. It has not. This same study has been repeated by researchers at the Johns Hopkins University several times since 1983. The ratio decreased to 5.7:1 in 1994 and to 4:1 in 1997; and the most recent data from the Johns Hopkins group show a 3:1 ratio.[2] Obviously, one should be careful in interpreting these results. Perhaps we should wait until the data have stopped moving before drawing strong conclusions from them. Second, mathematical genius as defined by high math scores is not a prerequisite for success in science and engineering. Fewer than one-third of college-educated professional men employed in science and engineering have SAT math scores above 650.[3]

Spicatum's second argument is that women, even those with high math ability, are less interested in physics. If this is true, we need to ask why. Physics is a broad and fascinating field, from cosmology to nanotechnology to medical physics. The low number of women in undergraduate physics programs (23%) cannot be explained by some purported innate lack of interest in the physical sciences and math; chemistry undergraduates are nearly 50% female, and chemistry is inherently no more "feminine" in its subject matter or work environment than physics. Women also earn close to 50% of undergraduate degrees in mathematics, so interest in math seems to be independent of gender. (Data from the American Institute of Physics Statistical Research Center are available at http://www.aip.org/statistics.)

The field of computer science may hold some interesting lessons that we can apply to our own field. For example, an article in the 18 December 2005 issue of the *Boston Globe* explored the dramatic drop in the number of young women studying computer science and questioned why women were "shunning a field once seen as welcoming." The percentage of bachelor's degrees in computer science awarded to women rose to a high of 37% in the mid-1980s before declining to about 27%—and lower at research institutions—by 1998. Innate differences in interest do not change over such short time periods; however, the culture within computer science experienced dramatic changes during that period as huge numbers of students flocking into the rapidly growing field strained departmental resources.

We need to identify the reasons why young women view physics as a less appealing, less welcoming, or less viable option for them, as opposed to math or chemistry, for example. We can then act on Hazaveh's suggestion to make a career in physics more attractive to incoming students. This is not, of course, a recommendation that we change the subject matter or lower standards of success in physics courses. But if we find, for example, that a major factor in choosing a career path is the belief that physics is an essentially masculine avocation, it is our responsibility to counteract that view. We need to make it clear that physics is an exciting and rewarding field that will offer equal support, encouragement, and opportunities to students of any race or gender. And then we need to work to make sure that statement is true. At the same time, we also must determine if a failure to retain already interested and talented female students is a factor.

Such attitudes as those expressed by Smith and Smith and by Spicatum are not just unsupported, they are damaging. Work by Claude Steele and others on stereotype threat,[4] for example, demonstrates the negative impact that expectations based on stereotypes of race and gender have on performance. A belief that women are less able or less interested in physics will be transmitted to students and potential students and will affect their performance and their decisions. Physics is a challenging subject, and even subtle discouragement—or lack of encouragement—will help to perpetuate the problem.

The National Academies report concludes that "it is not lack of talent, but unintentional biases and outmoded institutional structures that are hindering the access and advancement of women." E. O. LaCasce and Robert Adair identify some of the structural impediments. (Although I have to admit that Adair's focus on reproductive biology was somewhat disconcerting.) They note that traditional physics tracks may pose problems for married physicists and those with children. That issue affects young physicists of both genders, as child-rearing responsibilities become more equally shared and dual-career couples become more common. Creative solutions—in the form of flexible tenure clocks, reasonable maternity/paternity leave policies, active mentoring programs, and dual-career-partner hiring initiatives—are already being implemented at some institutions. Such programs can improve the academic climate for all scientists.

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4. See, for example, S. J. Spencer, C. M. Steele, D. M. Quinn, *J. Exp. Soc. Psychol.* **35**, 4 (1999).

Evalyn Gates
(gates@oddjob.uchicago.edu)
University of Chicago
Chicago, Illinois

Building better schools to harvest better minds

The average public school education is far too slow, easy, and boring for young