ON MATHEMATICS AND SCIENCE EDUCATION IN THE US AND EUROPE

Chiara R. Nappi

In the last few years the deficiencies of US education in mathematics and science have come into clearer focus. In high school, US students lag behind students in most European (as well as some Asian) countries in terms of math and science performance. In college, six out of ten students who enroll with the intent of pursuing a scientific career end up switching to a non-science major. At the PhD level, half of the graduate students in math and science are foreigners.

This situation has raised much concern. It is felt by many national leaders that unless things change, the US's economic standards will follow those of the test scores. A shortage of scientists and engineers in the coming decade is already predicted, and it is argued by many that one way the US can meet these future demands is to get more women and minorities into science.

The problems experienced by women and minorities in math and science are also well known. Girls consistently score between 40 and 50 points lower than boys on the math section of the SAT test. Blacks account for 2% of all employed scientists and engineers, while they represent 10% of the US work force. Women account for 15% of scientists and engineers (up from 9% in 1976, mostly due to the influx of foreign female PhDs), but they are 44% of all employees.

There is, however, a point that has not been made: The participation of women in math and science seems to be worse in the United States than it is in Europe. There, the difference between boys' and girls' performances in math and science in high school final exams is less dramatic.[1] In European colleges, enrollment of men and women in math and science courses is more balanced. And, although most women science majors opt to become math or science teachers in middle or high school, the percentage of women in research and academia—about 20%—is higher than it is in the United States.[2]

The reasons behind these phenomena are many and complex. It is, however, enlightening to point out some of the differences between the educational systems in the US and Europe that may explain these differences. Indeed, comparing methods can be more informative than just comparing test scores.

First of all, up to middle school, the study of math and science (especially math) proceeds at a much slower pace in the US than in Europe. For instance, the first two years of math—usually called "algebra 1" and "geometry"—taken by the average American high school student mostly cover topics that European children learn in middle school. Because a majority of American high schools only require one or two years of math to graduate, many students never take a math course beyond algebra 1 or geometry. In other words, a student can graduate from an American high school knowing only as much math as a middle school student in Europe.

A consequence of this approach is that the amount of mathematics that foreign high school students learn over four or five years is concentrated in the last two years of high school in the US. These math courses are therefore necessarily very fast-paced and intensive. Moreover, they are usually elective, or optional, courses. It is not surprising that a good 50% of American students give up and content themselves with only fulfilling the minimal requirements. By doing so, however, these students, typically aged only 15, have virtually precluded themselves from pursuing math or science in college. Indeed, to be a science or math major in college, one must at least study trigonometry (and maybe precalculus), usually a fourth-year math course in high school. It is this lack of a good high school background that is responsible for the 60% of US college science students who switch to non-science majors.

There is no doubt that such a system places American students at a disadvantage with respect to students abroad. The approach in Europe is more systematic and steady in math and science, as in all other subjects: Students start studying math and science at an earlier age and proceed through high school at a more relaxed pace. In the lower grades, while basic math and problem-solving skills are mastered, concepts of higher-order mathematics are also introduced. In high school, there are no crash courses. For example, most American high school students study algebra intensively for a whole year, with daily classes on the subject, only to drop it the following year to concentrate on another subject, such as geometry, for another intense full year. But in Europe these subjects are studied in parallel over several years. Likewise, the physics that American students are supposed to learn in a year is spread over three or four years in Europe. Concepts in math and science need to be assimilated, and that takes time. European high school students study physics, chemistry, biology and mathematics every year. The amount that they study varies from one type of high school to another, but they all must take these subjects every year.

The point I want to make is the following: *If courses are unnecessarily tough, and morever optional, students do tend to opt out.* The teenage years are particularly critical. Boys and girls undergo so many physical and emotional changes that it is unwise to place too much pressure on them just then. It is the time when gender roles and stereotypes really sink in. Especially in the United States, there is a great deal of pressure on girls to concentrate on being socially successful. Morever, stereotypes can have an

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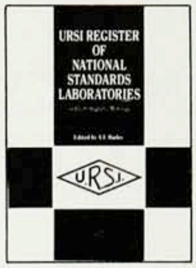

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unhealthy influence in an educational system like the American one. For example, the preconceived notion that girls and blacks are less capable in math and science than their white male peers may explain why girls and blacks are less likely to enroll in optional high school math and science courses; this in turn contributes to the disparate SAT results mentioned above. It is well known that these problems start in high school and that there is no significant difference between boys' and girls' performances in math and science up to eighth grade.[3] Further, as observed previously, girls in European high schools do seem to perform better than their American counterparts. It is not that stereotypes or gender roles do not exist in Europe. They do. However, in more structured educational systems like those in Europe, there is much less room for stereotypes to have an effect. No matter how you envision your role in life, you still need to know a required amount of math and science before you get out of high school. And because courses are not made unnecessarily intense and demanding in European schools, all students can handle them better, in spite of some inevitable teenage crises.

The American educational system, which is generally perceived as a more liberal system and therefore a more desirable one, is actually very selective. It selects the very talented and self-motivated students, those who would do well in any system. But it does not give a fair chance to the others; it simply neglects them. Many students, if properly and systematically educated, can blossom into the technicians and the competent teachers that the society needs. A social consideration is important here: An educational approach based on difficult and elective courses tends to discriminate against lower-class children, who often do not have the supportive home environment that would channel them toward math and science and help them through these subjects.

Another difference that might be relevant is that the educational system is highly centralized in the US, while it is state-regulated in Europe. In Italy, for instance, the same curriculum is used all over the country. Children of the same age study the same topics in all subjects at about the same time. The Italian system has proved to be a powerful social equalizer: During the course of one generation, it has leveled enormous cultural differences between north and south, men and women. A national curriculum has the advantage that results do not depend too heavily on the particular geographical area, school district or even the teachers' level of competence. It is also much easier to restructure or change the curriculum in a more centralized system. Part of the problem that the US faces in math and science education is to reconcile local authority with national needs.

In Europe, teaching is perceived as a desirable job for which one must be highly qualified. Teachers are government employees, with decent state-regulated salaries (the same for men and women), benefits, pensions and maternity or family leave. A teacher needs a university degree in the appropriate field—math, physics, chemistry or biology—to teach the subject in middle or high school. Because most European students choose their field of specialization before they enroll in college, prospective teachers take only courses in their subject or in closely related ones. By the time they graduate from college, they are highly qualified to pursue their teaching careers. This contrasts with the situation in US high schools, where apparently one in three physics teachers and one in five chemistry teachers are not trained in those disciplines.[4]

In conclusion, US students' performance in math and science could be highly improved by a more systematic approach to math and science teaching. One of the main problems at the moment is that US schools tend to start teaching math and science too late, and therefore much too fast, with the result that teenagers are driven away from the *optional* math and science courses. This approach hurts everyone, but its most serious impact is on women and minorities. A change would represent an important step toward equality in education and society.

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