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Statement of

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Chairman

Board of Governors of the Federal Reserve System

before the

Committee on Education and the Workforce

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I am pleased to be here this morning to discuss improving mathematics and science education in our elementary and secondary schools. In this regard, I am conveying my own views, not necessarily those of the Federal Reserve.

We are in a period--especially in this country--of rapid innovation that is yielding dramatic changes in the way goods and services are produced and in the ways that they are delivered to final users. These innovations are markedly elevating the skill levels that will be needed if our increasingly sophisticated capital stock is to function effectively in the years ahead. Such considerations are an important element in the ongoing dialogue that our nation's leaders in business, labor, education, and public policy must have if we, together, are to be successful in meeting the rising demand for skilled workers. Success in this area will, in turn, allow us to realize the potential that advances in science and technology have to enhance living standards for a large majority of Americans.

The pressures we face today are not unlike those of a century ago, when our education system successfully responded to the multiplying needs brought about by a marked acceleration in technological innovation. As those advances put new demands on workers interacting with an increasingly more complex stock of productive capital, high-school education proliferated--enabling students to read manuals, manipulate numbers, and understand formulae. Students were thus accorded the skills necessary to staff the newly developing assembly lines in factories and the rapidly expanding transportation systems whose mechanical and automotive jobs required a widening array of cognitive skills. For those who sought education beyond high school, land grant colleges sprang up, as states reacted to the increased skills required by industry and especially agriculture, the dominant occupation a century ago.

By today's standard, the required share of "intellectual workers" in our labor force was then still small. But the technological innovations of the latter part of the nineteenth century began to bring an increasing conceptualization of our gross domestic product--that is, a greater emphasis on value added stemming from new ideas and concepts as distinct from material inputs and demanding physical labor. The proportion of our workforce that created value through intellectual endeavors, rather than predominantly through manual labor, began a century-long climb. In 1900, only one out of every ten workers was in a professional, technical, or managerial occupation. By 1970, that proportion had doubled, and today those types of jobs account for nearly one-third of our workforce.

Moreover, this simple statistic undoubtedly understates the ongoing increase in the analytic content of work, because there also seems to have been a marked increase in the need for conceptual skills in jobs that a decade or so ago would have been easily characterized as fully manual labor. Indeed, the proliferation of information technologies throughout the economy in recent years has likely accelerated this shift in the skill requirements of many occupations away from routine work and toward non-routine interactive and analytical tasks.

Another signal of the ongoing rise in demand for conceptual skills in recent years has been the increase in relative wages for college-educated workers. During the 1980s and much of the 1990s, as demand for skilled workers outpaced the supply, the gap between the wages of the college educated and those with a high-school diploma or less widened considerably. More recently, as labor markets tightened, that gap has leveled off. Real wage gains have picked up for workers with less than a college education. But evidence of a high skills premium for workers with college degrees remains--not just for high-tech workers but across a broad range of occupations.

Innovation boosts output per hour and the freed pool of workers seek to exploit other opportunities. Their success is evidenced by the dramatic decline in the unemployment rate since 1992. The capital invested in any endeavor needs human interaction in order to function. But the new jobs that have been created by the surge in innovation require that the workers who fill them use more of their intellectual potential. This process of stretching toward our human intellectual capacity is not likely to end any time soon. Indeed, the dramatic increase in the demand for on-the-job technical training and the major expansion of the role of our community colleges in teaching the skills required to address our newer technologies are persuasive evidence that the pressures for increased learning are ongoing.

At the same time that we have been witnessing these substantial increases in the demand for human input, we see little evidence that the general level of human intelligence has changed much--indeed, has changed at all--over the centuries. Fortunately, human beings exhibit a pronounced ability to stretch their intellectual capabilities when called upon. Hence, while the intellectual output of humans may appear to have an upper limit, that limit seems to be sufficiently flexible to assuage most concerns. Nonetheless, in today's economy, it is becoming evident that a significant upgrading or activation of underutilized intellectual skills will be necessary to effectively engage the newer technologies.

Expanding the number of individuals prepared to use a greater proportion of their intellectual capacity means, among other things, that our elementary and secondary students must broaden their skills in mathematics and related sciences. In my experience, competency in mathematics--both in numerical manipulation and in understanding its conceptual foundations--enhances a person's ability to handle the more ambiguous and qualitative relationships that dominate our day-to-day decisionmaking. The study of science, of course, also advances problem-solving skills.

Early success in problem solving clearly enhances the self-esteem of young people and encourages them to engage in ever more complex reasoning. We all tend to gravitate toward those activities that we do best. This is a self-reinforcing process in which early success promotes further effort in a self-perpetuating direction. This is true of playing Little League baseball or the piano, as well as doing math.

If we are to improve the scientific reasoning skills of our young people, we need to encourage a deeper interaction with numbers and their manipulation to a point at which students are confident and proud of their level of skills--in many instances an outcome they may not have anticipated. One is led to wonder whether the early sharpening of intellectual rigor that occurs when young students struggle to negotiate the complexities of doing multiplication and division the old-fashioned way is not without enduring value. A superficial understanding that does not stretch a child's intellectual capacity, in my experience, cannot galvanize an enhanced reality-based sense of self-esteem.

In this regard, it is discouraging that so many students who clearly demonstrate impressive verbal or other conceptual skills find mathematical procedures intimidating. According to a recent survey of student attitudes toward math conducted by the Department of Education, fewer than half of the high-school seniors surveyed said that they like mathematics, a proportion similar to the proportion who felt that they were good at it. Even more disturbing, these proportions were lower than those in the surveys conducted in 1990. Some research indicates that such “math anxiety” has a negative effect on mathematics performance and that strategies for increasing students' confidence in their mathematical abilities are likely to have additional benefits in terms of achievement.[1] If we can enhance their self-esteem and provide them with a strong curriculum and effective teaching, students may well find themselves rising to a level of analytic capability beyond their previous vision.

There is clearly work to be done, for, as you know, the international comparisons of student achievement in mathematics and science that were conducted in 1995 suggested that our fourth graders were among the highest rated around the world but that our eighth and twelfth graders fell short of their peers in other countries. These comparisons heightened the debate about the quality of education that students are exposed to between the fourth and twelfth grades and raised concerns about prospects for a continuing shortfall of American-educated skilled technicians.

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[1]Hsui-Zu Ho and others, “The Affective and Cognitive Dimensions of Math Anxiety: A Cross-National Study,” *Journal for Research in Mathematics Education* (May 2000). This article cites a long literature on “math anxiety” among U.S. students and reports that it also has an adverse effect on students in China and Taiwan.

To be sure, substantial reforms in math and science education had been under way for some time prior to the 1995 study and have continued since. It is encouraging that the latest results on trends in academic progress from the National Assessment of Educational Progress show some improvement in both subjects. Perhaps that improvement will show up in a narrowing of the gap between our students and those abroad when the results of a follow-up survey of international comparisons are released later this year. Nonetheless, with the conceptual demands on our workers continuing to rise, substantial further progress needs to be made in raising the analytic competency of our graduating high-school seniors.

Addressing this issue is crucial for the future of our nation. It is obviously just a matter of time before the bulk of our workforce will require a much higher level of problem-solving skills than is currently evident. And while we have been fortunate to attract so many skilled young people to our shores, we must nonetheless strive to increase math and science achievement so that our students can take advantage of the considerable opportunities that will exist in tomorrow's labor market. In that way, we can realize the potential of technological change for bringing substantial and lasting benefits to our economy.

As a final point, I would stress that, even with the increasing intellectual specialization so necessary if we are to move to an ever higher degree of specialization in our overall economy, we also need to ensure that all students have a broad knowledge of the world at large. Major technological advances are becoming increasingly interdisciplinary. Many academics argue, I believe rightly, that significant exposure to a liberal education--music, literature, and the arts--broadens intellectual awareness, enhancing the ability to reach across disciplines to forge new ideas. Thus, while we must strengthen math and science education to address the requirements of the newer technologies we see on the horizon, we should not lose sight of the advantages of a liberal education.

I do not doubt that many of our most innovative and successful dot-com entrepreneurs are exceptionally, but narrowly, technically focused and educated. But if technology is to fit into a broader society of complex democratic institutions such as ours, it is important that all participants have an adequate awareness of its structure and values. For it is the latter that we as a people endeavor to achieve. Our technologies are only a means to that end.