1987

NSF SEMINAR

It is a pleasure to participate today in a discussion of issues related to science education in the United States.

I think it might be useful if I directed my remarks to those issues which are now receiving widespread public attention as a result of the literally dozens of research reports that have been published in the past two years about the state of our education system -- particularly math and science education. As you know, the conclusions of many of these reports are quite grim. (At least the large print. Bad news makes better press than good news.)

One report concludes:

> "Our nation is at risk. Our once unchallenged preeminence in commerce, industry, science and technological innovation is being overtaken by competitors throughout the world."

Not all observers, however, have been quite so pessimistic. A. Bartlett Giamatti, President of Yale and a member of one of the most publicized recent education commissions, wrote that he considered making the following remarks to Yale's entering freshman class:

> "Ladies and gentleman of the class of 1987: I am delighted to see you all here. After all the critiques and debate about the American high school this summer, I did not know if anyone could or would show up this fall. You are a very strong group, as strong a freshman class as we have ever had. Your presence here argues for the health of American secondary education...you have come here not despite but because of school systems and teachers who have taken a battering recently, a battering all out of proportion to their responsibility... ."

Today I will discuss several conclusions from recent reports in the area of math and science education and assess the extent to which they are supported by

research findings. I will then consider some tradeoffs in curriculum, school finance, and social opportunity that should be conisdered before implementing solutions to these perceived problems.

Research Findings

The most common conclusions are:

1. The U.S. system of education is not producing trained scientists, mathematicians, engineers and computer scientists in numbers sufficient to meet demands;

2. The problems will become even more severe in the next decade, when technological advances will increase the need for highly trained personnel in these fields;

3. U.S. students are less well trained, as measured by their test scores, than are their peers in other industrialized countries; and

4. U.S. students are less well trained than were their predecessors.

First, reports contend that the American system of education is not producing enough scientists, mathematicians, engineers, or computer specialists to meet demands.

The facts are quite different:

- Not only are there enough scientists and mathematicians, but by 1990, the number of science and math graduates is expected to exceed the number of jobs in these fields.

- Projections also show an overall balance between supply and demand for engineers for the rest of the decade.

- While the current demand for computer scientists exceeds the supply, the number of students receiving computer science degrees is rapidly

increasing. By the end of the 1980s, even these shortages may be largely corrected.

- The Bureau of Labor Statistics suggests that some of the exaggerated predictions of shortages may stem from the methodology used in surveying projected business and military demand.

Second, the reports contend that technological advances will increase future demand for highly trained and computer literate personnel.

- It is true that computer and engineering fields will have a high growth rate, but they will not create the greatest number of new jobs. The fact is that not one of the 19 occupations expected to produce the largest numbers of new jobs between 1982 and 1995 will be in high technology. Some comparisons are helpful.

- The Bureau of Labor Statistics projects 779,000 new jobs for building custodians, 217,000 new openings for computer systems analysts, and 205,000 new openings for computer programmers.

- The number of new kindergarten and elementary teaching positions--511,000--is expected to be greater than the number of positions for computer systems analysts and computer programmers combined (422,000).

- The number of new openings for engineers--584,000-- will not be substantially greater than the 511,000 new openings projected for kindergarten and elementary teachers.

- It is interesting to compare these figures with the occupational choices of the 1984 freshman class. 16.5% these students said they planned to be engineers or computer specialists compared to only 3.4% who planned to become elementary school teachers. Interest in computer fields among college-bound seniors taking the SAT increased almost tenfold between 1973 and 1983.

Third, American students are considered less well trained, as measured by test

scores, than students in other industrialized countries.

Yes and no.

- It is true that the average high school student in the United States scores lower in international comparisons than the average high school student in other industrialized countries.

- But these results do not compare equal proportions of high school age groups. Only about 20% of the age group in Europe attended upper-secondary school when these data were collected--the highest achieving 20%--compared to 80% of the age group in the United States.

- When the top students are compared, American students score at about the same level as their counterparts in many industrialized countries--not a bad result considering American high schools include virtually the entire age group, typically working together in the same classroom.

- It also might be reassuring for critics of American education to know that the Japanese -- despite their extremely high scores on math tests -- are reexamining their own education system.

Fourth, it has been widely reported that American students today are less well trained in math and science than were students in previous years.

- In fact, high school students took more mathematics in 1980 than they did in 1972 and about the same amount of science.

- And achievement scores of students likely to major in science and math are as high or higher than they were in previous years. (These findings are based on college board and graduate record achievement tests and on advanced placement tests.)

- Declines that do occur (and results are mixed) are on tests assessing

the basic scientific and mathematical knowledge of the general population--primarily the National Assessment of Educational Progress (NAEP) and the SAT. The widely reported decline in the SAT math score, for example, occurred from the late 1960's to the mid-1970's, when it began to level off. The SAT math score has remained essentially the same for the past 10 years. (The average score was 472 in 1975 and 471 in 1984.) The reported decline in the proportion of high SAT math scores also has been exaggerated. In 1972, 17.8% of college-bound seniors scored at 600 and above, compared to 16.6% in 1984. The percentages for 700 and above were 3.5% and 3.3% respectively and for 750 and above, 0.9% and 0.7%.

- But even these declines are partially explained by increases in the numbers, and changes in the socioeoconomic characteristics, of students taking the test--certainly not a reflection of the quality of education. (One observer attributed the test score decline to increased strontium-90 in the atmosphere.)

Implications

Why does all this matter? Does it make a difference if we overstate or inadequately define the problems in math and science education? I have several concerns, though clearly there may be some benefits -- for example, more training opportunities for teachers and greater public acceptance of increasing educational expenditures when these increases are linked to reform. For the most part, however, I do not believe that these reforms (though intentions may be good) will produce fundamental improvements in the quality of education students receive.

First, the emphasis of the reforms on increasing requirements for traditional science and math courses (and on mandated test programs which encourage coursework that can be measured by objective test items) does little to improve the education of the large majority of students who might benefit more from courses that are not designed along narrow disciplinary lines.

- As all of you know well, most students learn these traditional math and

science courses by rote. It is unlikely that requiring more of these courses will increase students' interest in science, their knowledge about scientific method, their awareness of scientific issues in the context of public policy, or their ability to apply mathematics -- but this is where the emphasis is needed.

- Unfortunately, the trend to simply require more courses seems inconsistent with current thinking about the most useful science curricula. These curricula attempt to give students a chance to understand the development of a limited number of major scientific concepts -- but to understand these concepts in depth -- rather than attempting to teach a lot of superficial facts in survey courses which are quickly forgotten. (Like Defense budgets, it is easier to add to science textbooks that to make policy decisions about what to cut.)

- The college and university faculty who work with entering freshmen do not necessarily support the emphasis of recent reports. For example, some of the MIT engineering faculty are skeptical about the usefulness of requiring high school physics. They also do not report significant problems in high school science and math instruction, at least for their students, although they do feel there are problems for the general student body. A good foundation in math (with greater emphasis on probability and statistics) is considered more important than science for entrance to MIT. The most significant problems are in writing, English literature, foreign languages and work ethic. One faculty member felt that the math and science emphasis after Sputnick may in fact have been counterproductive to learning other subject matters which are particularly appropriate for pre-college students.

- Similarly, a group of representatives from colleges and universities who testified before the National Science Board Commission said they wanted students well grounded in math (up to, but not including calculus). The students did not need to know science, although an interest in it was particularly helpful.

Second, increasing course and graduation requirements is likely to increase

problems in another widely publicized area -- shortages of math and science teachers. In fact, the whole isssue of teacher shortages needs clarification. These are certain considerations that the public debate rarely mentions.

- o There are shortages in a number of other fields--vocational/technical education, special education and, more recently, shortages of elementary and even high school teachers in some school districts.

- o Reported teacher shortages result from budget constraints and from surpluses of teachers in other fields, as well as from the simple unavailability of "qualified" math and science teachers. Shortages of math and science teachers do not necessarily mean these teachers can readily find jobs.

- o In addition, increased requirements may actually lower the quality of science annd math instruction if -- for whatever reason -- qualified teachers cannot be hired to teach these courses.

Third, in addition to problems of teacher shortages, the enormous increases in bureaucratic requirements accompanying recent reforms also are likely to affect the quality of education students receive.

- o Increases in State requirements make Federal regulations (about which there has been so much concern in recent years) seem mild. There literally are thousands of new laws and policies. (It is estimated that Colorado alone has 114 news laws affecting public schools.)

- o All of this means that schools are likely to become even more boring places, less intellectually stimulating for students -- and for teachers as well -- than they are now, certainly not a trend that will make it easier to attract outstanding teachers and principals -- without whom, of course, the education reforms can accomplish little.

- o Clearly, these trends run counter to the school effectiveness and management literature which emphasizes the importance of employees having at least the perception of some control over their own working

environments.

Fourth, the emphasis on math and science may reduce resources for other parts of the curriculum which are in need of improvement as least as much as math and science (a point which I fear may be of less concern to this particular audience than to some others).

- For example, SAT scores have shown greater declines in verbal than in math scores. The quality of students' writing leaves much to be desired. Students don't know a lot about history or government -- a point that is well illustrated by some quotations by Benjamin Stein based on his recent conversations with high school and college students in the Los Angeles area. I think these quotations might put the "problem" we face in some perspective:

  I quote: Recently a 19-year-old junior at the University of Southern California sat with me while I watched "Guadalcanal Diary" on TV. It goes without saying that the child had never heard of Guadalcanal. More surprisingly, she did not know who the United States was fighting against in the Pacific. ("The Germans?") She was genuinely shocked to learn that...the United States had fought a war against the Japanese. ("Who won?")

  Stein goes on to describe another student at USC sho did not have any clear idea when World War II was fought. She believed it was some time this century. (She is a journalism major.) She also had no clear notion of what had begun the war for the United States. ("Pearl Harbor? Was that when the United States dropped the atom bomb on Hiroshima?) Even more astounding, she was not sure which side Russia was on and whether Germany was on our side or against us.

  A few students have known how many U.S. senators California has, but none has known how many Nevada or Oregon has. ("Really? Even though they're so small?")

Of the teenagers with whom Stein worked, none had ever hear of Lenin. Only one could identify Joseph Stalin. (Stein's favorite was the student who responded that Stalin was the president just before Roosevelt.)

None (of the students) could name even one of the first 10 Amendments to the Constitution or connect them with the Bill of Rights.

Only a few could articulate in any way at all why life in a free country is different from life in an un-free country.

Fifth, I am also concerned that inaccurate assumptions about the state of math and science education in the United States may lead to unrealistic expectations about the job market. Clearly, our society will need significant numbers of highly trained scientists, mathematicians, engineers, computer scientists. But the proportion of total employment in these fields has been greatly exaggerated and may already have lead to unnrealistic expectations on the part of some students, who are choosing these fields in large numbers.

- The computer field provides a useful illustration. It is a field where the job market is still very good -- in fact where there still are problems on the supply side -- and where applicants with the proper training and experience can write their own ticket. But even in the computer field, jobs for some applicants are not so easy to obtain as they were only a few years ago.

- In part, this change has occurred because enrollments in computer education programs of all types -- programs in high schools, training institutes, colleges, and graduate schools -- have risen sharply in the past few years. For example, graduate school enrollment in computer science increased 20 percent between 1982 and 1983.

- Employers also are becoming more selective. The education requirements are increasing as are the requirements for training and experience in the field to which the computer is being applied.

- All this is a relatively complex picture. I am concerned that it is not reaching students who hope that one or two programming courses will give them access to jobs in computer science. The field continues to have increasing opportunities, but these opportunities may not exist for students who do not carefully match their training and experience with the jobs they wish to obtain. This probably was not the case even a few years ago.

Finally, I am concerned that little attention has been paid to the financial and social costs of the recommendations.

- It has been estimated that the total cost of all of the recommendations in recent education reports would be $20B to $30B om new funds each year--more than the total Federal expenditure ($15.4B) in FY 1983 for elementary, secondary and higher education programs, including student aid at the college level.

- There also is little consideration given to the social costs of such recommendations as stricter course and graduation requirements. How does increased prescriptiveness of State requirements affect the ability of teachers to meet the inndividual needs of students in their classrooms, not a hypothetical student discussed by recent reports?

- How would requiring algebra II and physics affect dropout rates, tracking, or the future employment prospects of students who fail? Bill Aldridge, executive director of the National Science Teachers Association, put it this way:

> "High school science and math courses present content that largely duplicates content offered in college courses. These high school courses offer little more than preparation for that next course which the vast majority of students will never take. Present proposals to increase graduation requirements in science and math will force all students either to take these courses or drop out of school."

Unfortunately, the conclusions of recent education reports have not encouraged a careful consideration of the effects of suggested "reforms." I am concerned that in the rush to offer solutions for ill-defined problems, we may neglect students and issues most in need of attention.

Thank you.