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U. S. SCIENCE EDUCATION - AN OVERVIEW

Bassam Shakhashiri

I am delighted to be here even though it might be a much shorter period of time than I anticipated because of the National Science Board meeting. They are about to consider a very important initiative that the Foundation is about to launch in science, mathematics and engineering education - the so-called state-wide systemic initiative. If time allows, I will say a few things about it.

The issues that are before us have been discussed and debated previously, and continue to be documented, although some people say not well-enough documented. There are some of us who require more documentation for a more careful assessment in order to try to figure out which ways are effective. For those who care about refinement in terms of measurement and identification of problems, please move on and do what you need to do. Meanwhile, the rest of us are going to work on the problem anyway because if we don't pay attention to it right now, bluntly speaking, the country will continue to go "right down the tubes." We continue to debate whether or not there are problems; whether or not these problems should be solved at the federal level, at the state level or at the local level. What is the nature of the problems?

I will now "flash" before you some data, much of which you already know about. Let me state very clearly that in my opinion, the situation we are facing now is by far more critical and more consequential than any we have faced in the post-Sputnik area. We will use that as a reference point, although historians of science and technology have something to say about Sputnik and whether or not it really was the trigger that caused the country to act. But, what we face now is even more critical and more consequential than it was back then for a lot of reasons. Those reasons are:

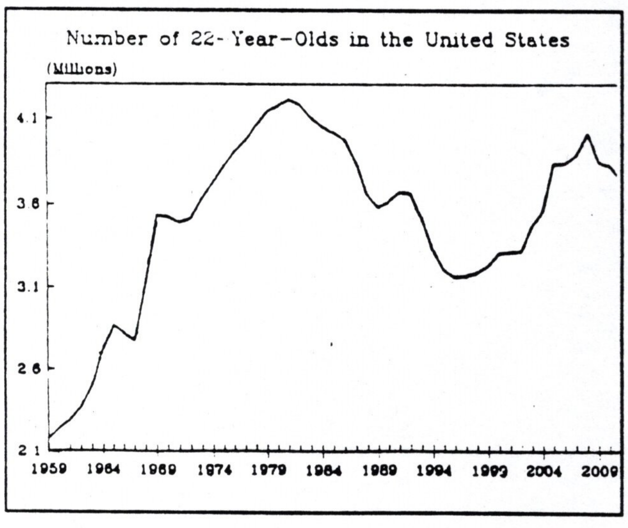
- The population of the United States in the past 30 years or so has increased by about 50 million people. That is the approximate population of all of Great Britain and twice the population of Canada. The significance of this fact is that we have more students to teach and need many more qualified teachers at all educational levels to teach them. There has been a tremendous change in scale in the population; and societal institutions, especially educational institutions, are very sluggish in terms of responding to changes in scale of that sort, not just in education, but also in society as a whole. So, this is a serious problem that we need to address.

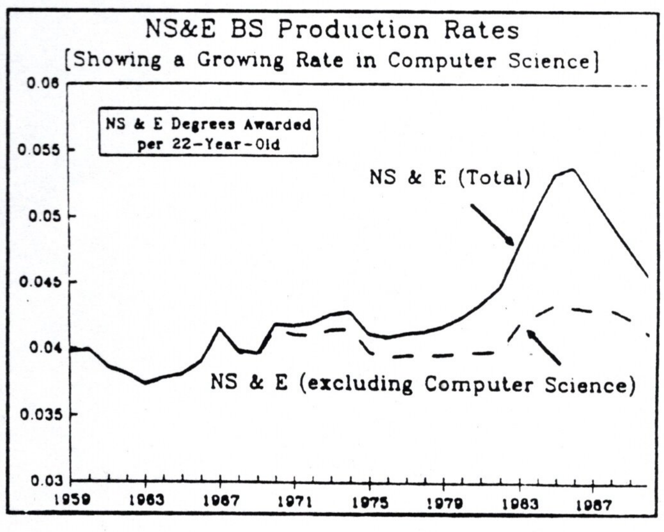
- For the country to maintain its international pre-eminence in science and technology in the global economy, in the arts and humanities and in all walks of life, we must have a good supply of scientists and engineers coming through the educational system. As you all know, that is what NSF set out to do in the immediate post-Sputnik era - all the teacher institutes, all the curriculum development projects, all the fellowships - were aimed at increasing the flow of talent into careers in science, mathematics and engineering. To a very large extent, NSF and the country succeeded.

The demographic picture causes us to be alarmed about our ability to do more of the same, which I will get back to shortly.

■ The third reason that the situation is more critical and more consequential now than 30 years ago or so (and the most important of all three reasons) is that we now live in a very advanced scientific and technological society. We must pay attention to the education in science and technology of the non-specialists. We need an educated citizenry that can distinguish between astronomy and astrology. We need a public at-large that can deal successfully with the complex issues related to animal rights. We need our fellow citizens to be able to deal successfully with pollution and pollution control problems. We need the public at-large to benefit from the tremendous advances that we have made in the nutritional sciences. We need our fellow citizens to understand and be able to act on why the cutting of the rain forests in South America is bad for the global environment. As you know, it is good for the economy of Brazil. It creates jobs; it helps solve part of Brazil's problem; yet there are some global considerations that have to be recognized and dealt with.

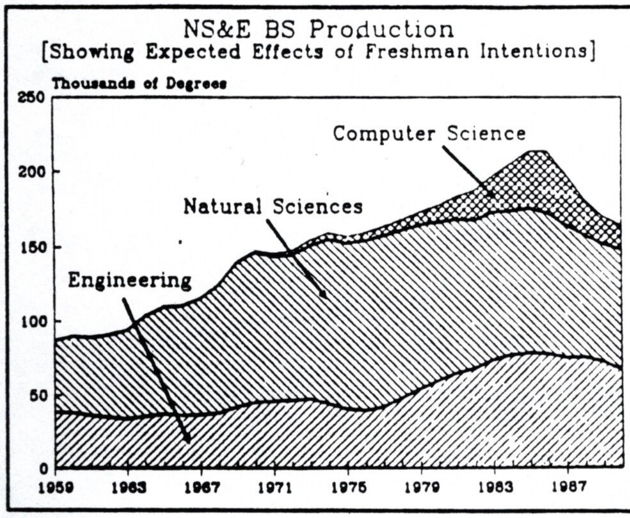
So, the point is that we have twin missions - first to increase the flow of talent into careers in science, mathematics and engineering; and second to see to it that the public at-large is literate in science, mathematics and technology. It is the second part of this twin mission that is new, and thus, I will dwell more of this part than on the need for an adequate number of professionals in science and technology.





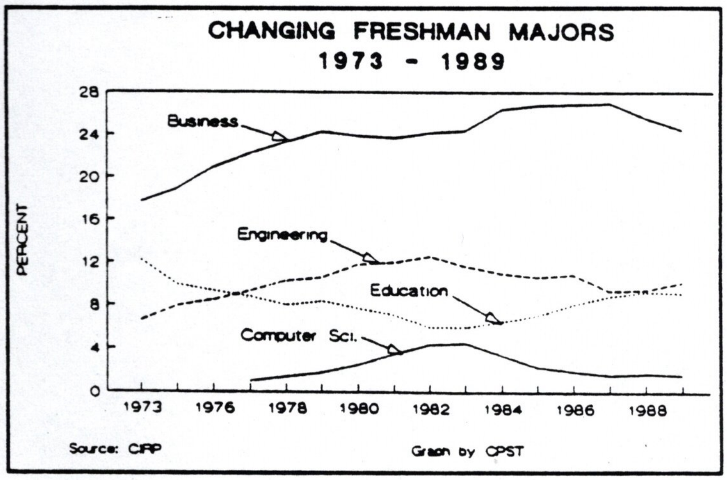
So, let us now look at some data. We see here the number of 22-year-olds in the U.S., and as shown, the number will continue to go down through the year 1997. We choose 22-year-olds because that is the age at which a person gets a bachelor's degree.

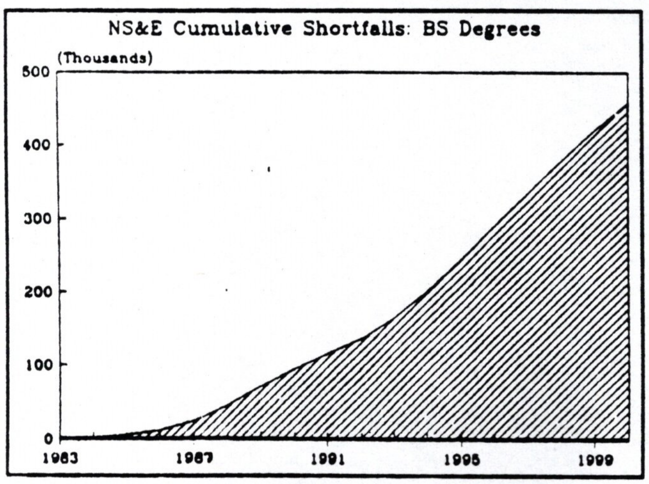
Of that population of 22-year-olds, about 4% end up getting a BS degree in the natural sciences and engineering. There are fluctuations as you see near the tail end of this display, but the number to remember is that about 4% of all 22-year-olds receive a BS degree in the natural sciences and engineering, including mathematics.



The important thing that we want to look at, however, is the trend, showing that near the end of the 1980s, the interest in science, math and engineering careers by freshmen is going down. This interest is a concern to us especially as we want to nurture the talent in America that might consider going into science, mathematics and engineering careers. You might ask where are these people going if they are not going into science, engineering or mathematics.

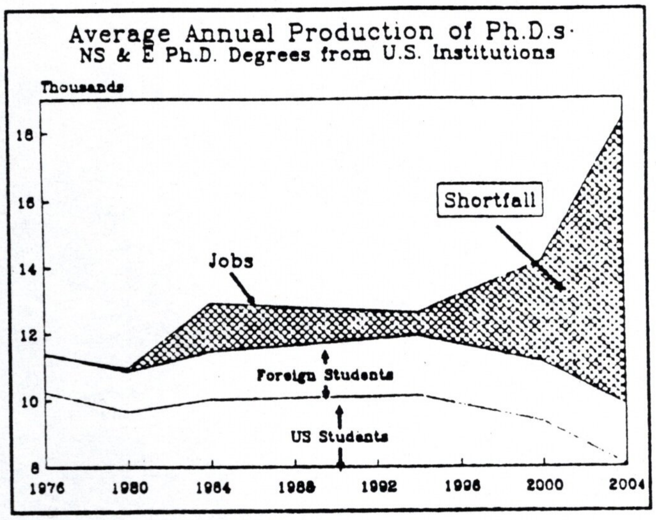
As shown here from data from the UCLA Freshman Survey Program, these people are going into business. Now, there is nothing wrong with going into careers in business, in law, etc., provided that those of us who are in the sciences, mathematics and engineering see to it that those people are literate in science, mathematics and engineering. We cannot afford to have the gap expand between the scientific community and the rest of the population. Thus, we have a major responsibility in that regard.



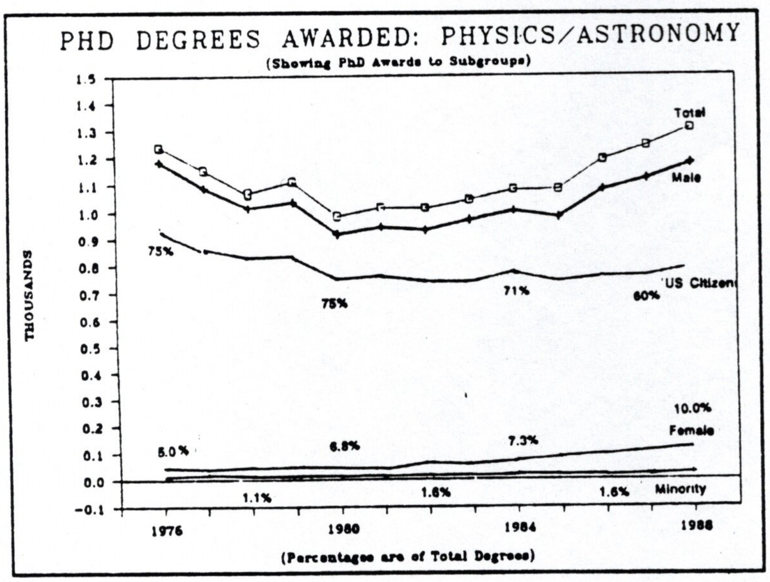


As you know, there have been various estimates on the cumulative shortfalls of BS degree holders in the natural sciences and engineering and one estimate puts it at about 430,000 holders of the BS degree in the natural sciences and in engineering, but it has been estimated to be as high as 750,000 and as low as 350,000. The point is it is a large number, regardless of its value.

The same kind of projection is made at the PhD level, where the shortfall by the year 2000 is estimated to be about 8000 holders of the PhD degree in math, science and engineering.

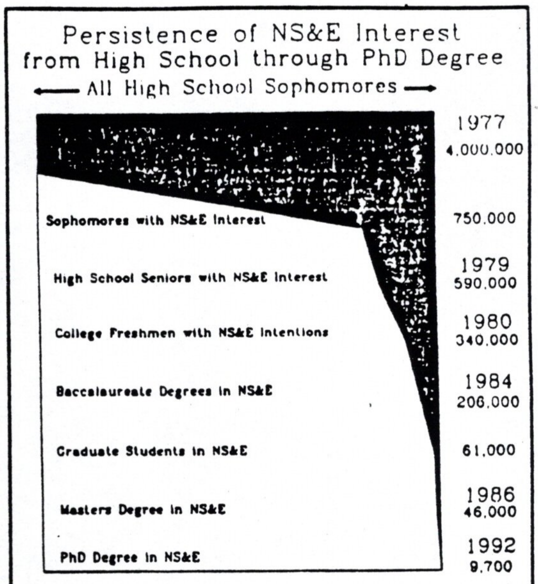


This comes at a time when the country is undertaking a number of big projects including the superconducting super collider, the space station, the mapping of the human genome, AIDS, SDI - just to mention five - and there are many others. All of these are going to require highly skilled people at the BS degree level and at the PhD level in science, math and engineering. The fact that foreign students continue to come to America for higher education is significant, but what is more significant is that many of them are going back to their native countries. This is unlike what I have done. I came here in 1957 from my native Lebanon and have stayed, having enjoyed the wonderful hospitality and the tremendous opportunities that are available in this country. Foreign students flock to our shores from around the globe. This is the greatest tribute to our institutions of higher education. The challenge that we have in this country is to see if we can get our native born students to partake in paying that tribute.



Looking at the PhD degrees awarded in physics and astronomy, you see that the trend is upward, which is encouraging, but it is upward because it includes foreign students. At the bottom of the display, you see the participation of women and minorities - they are almost indistinguishable from the axis of the graph. Looking at U.S. citizens, (the middle) you see little change over time. There is nothing wrong in attracting students from around the globe to come to America. Science has no international boundaries. Human pursuits have no international boundaries. Yet, we must find ways to get our native-born students to partake in those activities, consider careers in these fields, and successfully go on to graduate school.

Another familiar display is the so-called science personnel pipeline showing the persistence of interest in natural science or engineering from the sophomore year through a PhD. I want this picture to be imprinted in your memory banks because it tells us a great deal about what we are trying to do and how we might want to deal with it. Of a population of 4,000,000 high school sophomores, 750,000 expressed an interest in the natural sciences and engineering. When they got to be seniors, the number dropped down to 590,000. When those who went on to college a year later entered college, the number dropped down to 340,000, and by 1984 only 206,000 received a BS degree in the natural sciences and engineering. Of those, 61,000 entered graduate school, of whom 46,000 received master's degrees and in a few years from now - in 1992 - fewer than 10,000 will get the PhD degree in the natural sciences and engineering. As you can see in this pipeline, there is tremendous leakage. In fact, it is not a leakage, it is a hemorrhage in terms of the loss of talent not only to the country, but to mankind and to humanity because a lot of people are not going onto careers in science, math and engineering. Yet, we find ourselves living in a very advanced scientific and technological society that requires highly skilled people in this area.

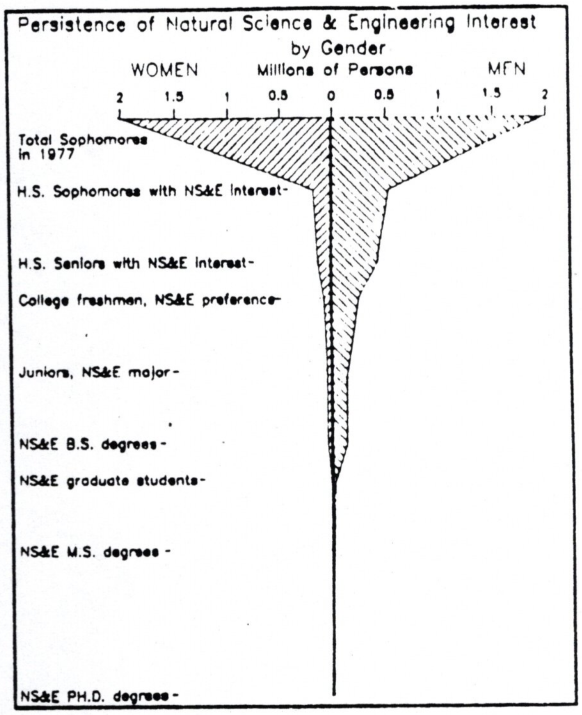


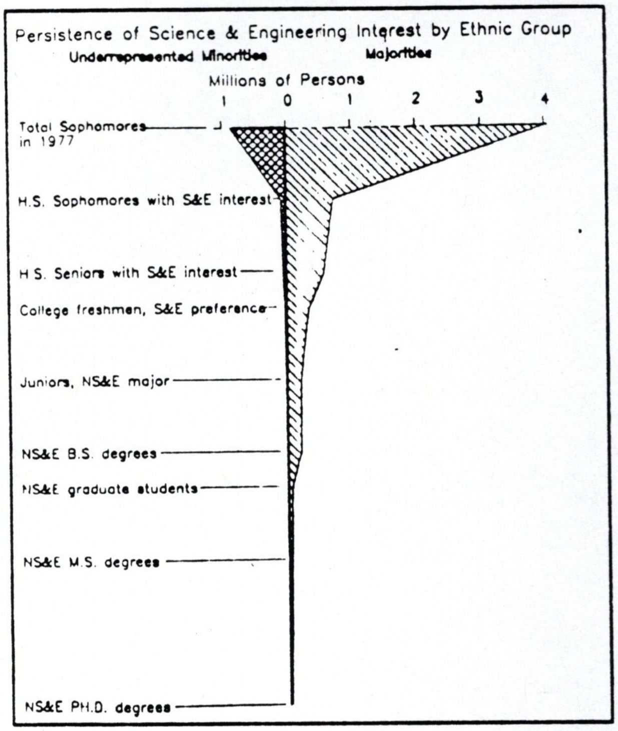
(The Pipeline)

It is so easy to look at a display like this, focusing attention on the dark part of the display. What we must do, what we are trying to do, is also to have attention be focused on the white area of this display. Remember the twin mission that we embarked on - to increase the flow of talent into this area, but also to make the general population literate in science. It is the responsibility of the scientific community to see to it that the public at-large is literate, is appreciative of what science is and what scientists do. In fact, I would settle for having the public at-large be tolerant of what scientists want to do.

It really does not take a mathematically literate person to figure out that a small change in the slope at the top will have a tremendous effect at the bottom of this display. Nowadays, the level of mathematical literacy is so low that it **does** take a mathematically literate person to figure that one out. We must be concerned about mathematical literacy, science literacy, technological literacy for everyone. This chart displays the times when students expressed their opinions about science. It is fairly well understood and even agreed that the battle is lost, not at the sophomore year of high school, but before that. That is why the NSF is focusing heavily on the pre-high school years - the middle school years and the elementary school years. What we need is to see where this leakage of talent occurs, and make sure that those who opt to go on to other careers are literate in science, appreciate what science can do, and helpfully support it.

The display of the same population by gender looks like an asymmetrical champagne glass. What the NSF, all the federal agencies and all the research universities focus on is the area at the bottom, which is indistinguishable from the stem of the champagne glass. There is tremendous loss of talent in this area. And again, don't forget about the white area in these displays - not just the people inside the asymmetrical champagne glass. Of course, in science, we love symmetry. It is aesthetically pleasing. What we would like to see is a symmetrical champagne glass. There are two ways in which this can be done. One is unacceptable.



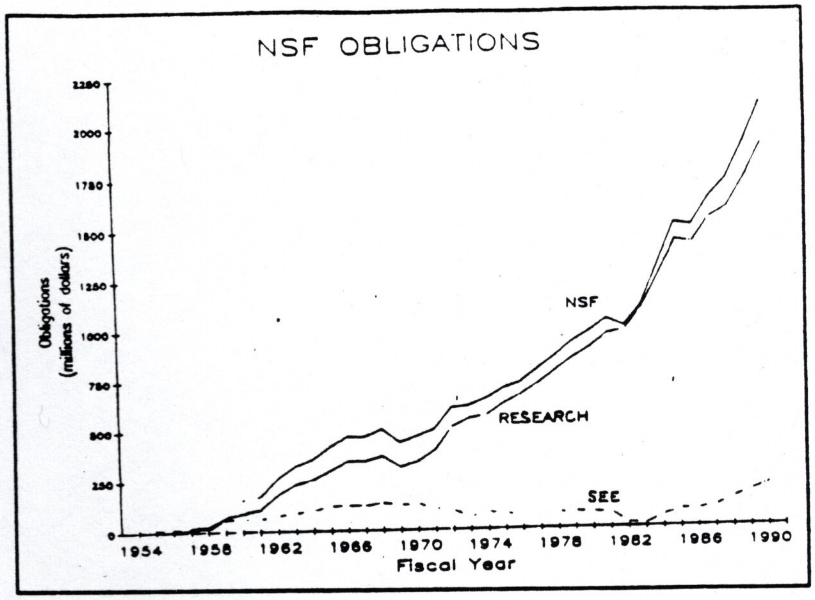


The next display presents the persistence of interest in science by underrepresented minorities. Again, it shows a tremendous loss of talent. On international comparison tests, the U.S. students rank very low - near the bottom. Now, I don't believe for one second that the talent in this country is any different than the talent anywhere else in the world. Yet, these kinds of studies tell us that there is something in our society, something in our educational system that we have got to be paying attention to. I know that for the most part what we ought to be paying attention to is not science *per se,* it is the societal dimension.

This comes at a time when the population profile is about 16 to 18 percent minorities, and is projected over the next 25 years to become 35 to 40 percent minorities. Yet, the science community has not succeeded either in attracting or retaining minorities in this area, so we have got to find inventive ways, creative ways to fix this problem. We have to be invincible in our will to do that. It takes will and it takes wallet - they go together.

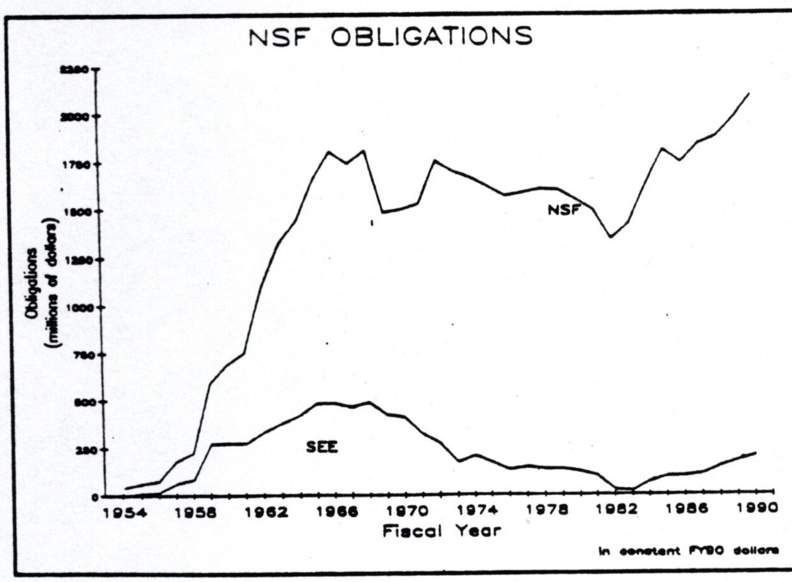
The next two displays show the NSF obligations since 1954, first in current dollars, and then in constant dollars. This is the 40th year of the National Science Foundation's support for research. The NSF support for science education is the line at the bottom labeled "SEE".

Looking at the same data in constant dollars, the NSF budget has not changed much since the mid-1960s, but the changes that have occurred have come recently.



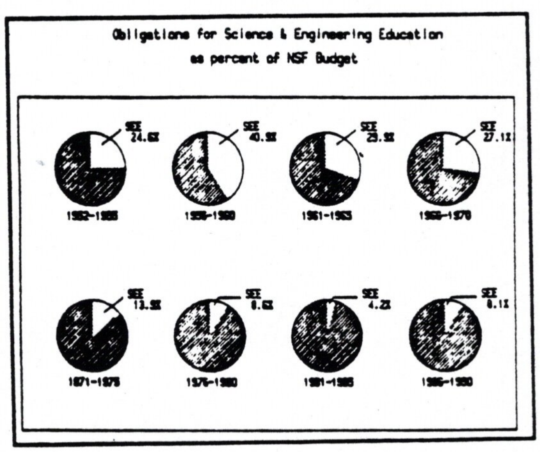
The President is committed to doubling the NSF budget. You see within the NSF budget, that the change that occurred during the 1970s was at the expense of science education. The underlying point of what I have said so far and what I am about to say, is that this says something about our value system as a society.

Looking at the data another way - in clusters of years - you can see that at one time, the science education budget was about 40% of the NSF budget. Now it is about 10%.

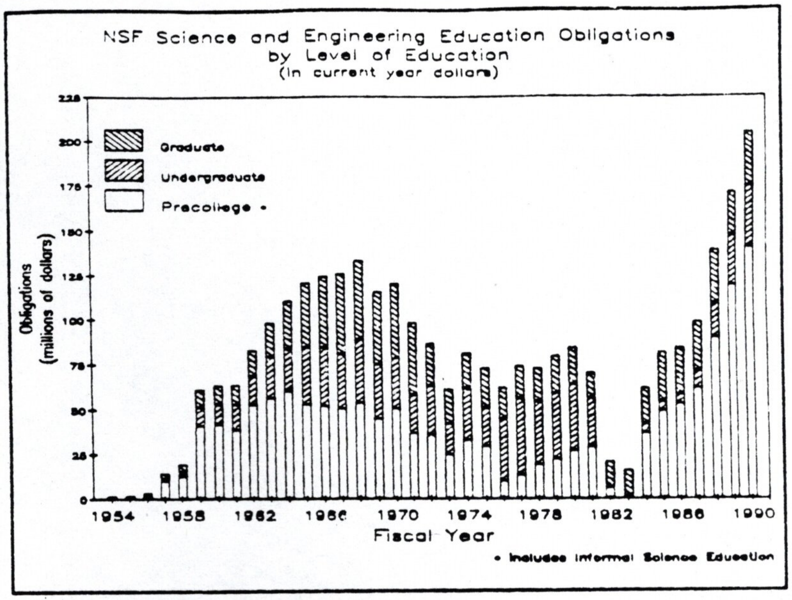


This is at a time when the population has increased by 50 million people, and when the complexity of science and technology requires a scientifically literate population.

The displays on the next page shows the Foundation support for science and engineering education by educational levels, first in current dollars and then in constant dollars. You see that since the great shutdown of 1982, (which also says something about our value system as a society), the emphasis has been very heavy at the pre-collegiate level. This is not to ignore the undergraduate level, since other parts of the Foundation support undergraduate activities, and that support is not shown in this display. The

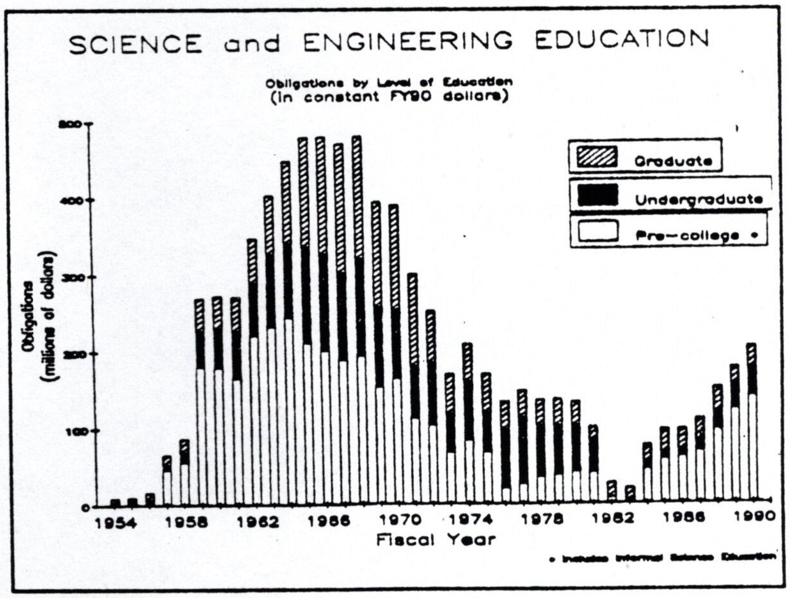


point is that we now have the highest level of support ever at NSF for science education, and I and my staff are very proud of that. We are even prouder of the investment that we are making with those dollars.



But we are still a long way from the dual goal of providing science literacy for all American students and insuring that the nation will have an adequate supply of American scientists and engineers. What must be done, and how can we go about doing it?

A lot of federal agencies have a stake in this, including NSF, the Departments of Education, Energy, Agriculture, Labor, Defense, and Commerce; and other agencies such as NASA. The NSF is the major player in this enterprise.



NSF plays a strategic role. We want science literacy for all students, not only for those who are going to be college-bound, not only for those who are going to become scientists, mathematicians and engineers, but for all students. We want the best possible career preparation for those who want to become skilled and professional in these fields. We want to increase representation; we support experimentation; we are interested in generating change - fundamental comprehensive change - not just fundamental change; and we want to assist the implementation. Our role is necessarily small - it's an analytical role. That is the strategic role of the Foundation in helping to stimulate change. What we want to do in this process is not simply look in the rear-view mirror to see what we did in the 1960s, 1970s or 1980s, but glance in the rear-view mirror and chart a new course. Those who are stuck looking in the rear-view mirror are making a fundamental mistake in terms of the strategy that is required to deal with these issues.

Our efforts toward change and reform include trying to deal with the content of science education; with the staff and the staffing; with the conditions for learning including the atmosphere or the environment for learning; and with the governance issues - i.e., what the PTA says, what the school board says, what the taxpayers say about education. We are concerned with resources: financial, physical and most importantly human resources. These are the components of change and reform that we must try and deal with.

Of course, we need a national strategy that has goals. Nearly everyone has read what the President and governors agreed to. This is remarkable, that all 50 governors and the President have agreed on national goals. The task before us now is how we begin to achieve those goals.

The national goals that we will deal with at the NSF have to do with student achievement; teacher qualifications; the environment for learning. The quality of the curriculum is of concern - we want to be sure that where science is offered, the students have hands-on experience. We don't want courses about science, we want courses in science. We are concerned about the quality of the curriculum, as NSF has traditionally been concerned, but more importantly, we want to insure the effectiveness of the curriculum. We don't want high quality curricula to be developed and only sit on the shelf. We want school systems, colleges and universities, two-year institutions, four-year institutions, comprehensive universities, to use what is developed. So these are the goals.

Standards should be established at each grade level from K through 16. Standards are used often, actually misused or misinterpreted. These standards should be established in pursuit of our national goals.

As we look forward, not backward, there are three issues that we should be concerned about. They are **mathematics, health** and the **environment.** Mathematics is the underpinning of what goes on in science, what goes on in business, what goes on in society, so everyone should become literate in mathematics. We would like to see the standards of the National Council of Teachers of Mathematics examined at the state and local level, examined and even adopted. We all know about the report, ***EVERYBODY COUNTS***, and we want action on it. It's not enough just to get a report and put it on the shelf. We want drastic action.

The components of health include human biology, nutrition and drug education. Why human biology? Because adolescents, as they develop, are curious about what goes on in our bodies, and that curiosity can be an important vehicle to sustain interest in science and in science education. The great advances in nutrition sciences allows us to learn a great deal. We need drug education, not drug enforcement or control.

What are the issues concerning the environment? Anything we do in the physical sciences, in the biological sciences, in the earth sciences, in engineering, in anything that has to do with science, can fit under the umbrella of the environment. If our curriculum development and our teaching strategies are focused on these various components under that umbrella, we have a much better chance of educating not only the specialists, but also the non-specialists, to see to it that the quality of life is enhanced, both in America and for our planet. Very frankly, that is what is at stake - the integrity of the planet. Those of us who are in the science-rich sector of our society should see to it that the science sector deals with those issues.

Those are the issues that I wanted to share with you. I realize many of you have listened to this previously, but I wanted to tell you about my strong conviction that these are the kinds of things that need to be done.

The Systemic State Initiative that is being approved right now by the National Science Board is an attempt to engage key decision-makers across the country in the effort. We need to engage the political entities in the states - the governors, legislators, business leaders, civic leaders, institutions of higher education, the public school system, the commissioner of higher education, the chief state school officers - working in collaboration to set up systemic state-wide restructuring and reform activities that will help the students in each state achieve the goals that the President and the governors have set. What they will try to do is use the dollar or two from the National Science Foundation to leverage the huge amount of money that the states currently invest in education to work toward a targeted approach to revamping and restructuring the system. Because we now know that what worked for us in the 1960s, 1970s and 1980s will not work for us in the 1990s and in the next century. There will be a program announcement for the new Systemic State Initiative coming out very shortly.

Bassam Shakhashiri is the Assistant Director for Education at the National Science Foundation.

DISCUSSION

Moderator Daryl Chubin noted that Dr. Shakhashiri practices an important pedagogical principle - he raises our expectations.

In the discussion, the following points were made:

■ Although the National Science Foundation has given some consideration to funding TV programs, videotapes, comic books, or other unconventional teaching vehicles to interest young people in science, not much has been done. NSF responds to what comes from the field, although they are trying in a very careful way to find some targeted activity. NSF has encouraged people in the past three or four years with any kind of ideas to come to them in a free proposal mode of interaction, writing a short letter outlining what the idea is before any formal proposal is submitted. The most important thing is to develop a coherent effort, not just get a number of good ideas coming from a variety of sources. The ideas must fit into a coherent scheme. NSF is trying to sensitize all the communities to see to it that an effective set of schemes is in place.

■ NSF has prepared a summary of grants made by the Foundation since 1989, and a copy of this publication has been sent to all symposium attendees. Examining the grants awarded shows that NSF has targeted particular segments of the population, such a PTA group, the Urban League, a Chamber of Commerce group - all of them working together to approach solving some part of the problem from the parental viewpoint. Although NSF is doing some of this, it is not enough.

■ The systemic state initiative is aimed at K through 16 levels, and it is up to the states to figure out what segments to deal with and how they want to deal with it. This state initiative is being handled very carefully because of the traditional view that the federal government should stay out of education; that education is a job for the states. NSF is simply encouraging those with good ideas either already underway or simply on the drawing board, to come forward. NSF is willing to put a few dollars into it. This initiative is not going to replace any of the NSF regular programs - it is in addition to them.

■ The activities of the federal agencies identified as having a stake in science and engineering education are being coordinated through the Federal Coordinating Council for Science, Engineering and Technology, established by Dr. Bromley of the OSTP. A committee that will deal with education and human resources is being formed now, and will be announced shortly by Dr. Bromley. Although NSF will be a participant in the committee, it will not be leading the effort. However, this committee will deal with **how** the federal agencies coordinate. What is more important is **what** they coordinate.

■ The Kennedy - Hatfield bill (S. 2114, the **Excellence in Math, Science and Engineering Education [EMSEE] ACT)**, which has many sponsors, shows the tremendous interest of the Congress in these issues, and reflects a growing national concern about science, engineering, and math education. The bill itself will be examined through a series of hearings; many agencies are commenting on it. This will keep the issue very much in the forefront. Probably the legislation will not be adopted as it is now written, but this bill is an excellent starting point.