EIR Science & Technology

America can still solve the crisis in science education

Dr. Bassam Shakhashiri, a leading advocate for science education, calls for a mobilization to confront the shortfall of nearly half a million scientists and engineers by the end of the century.

The National Science Foundation (NSF) issued a study last year which showed that the United States could be faced with a shortfall of 400,000 scientists and engineers by the year 2000. This calculation was based on the declining population of 19- to 24-year-olds, and the apparent waning of American students' interest in science and engineering.

When the NSF was established in 1950, it was directed to initiate and support science education programs at all levels in the mathematical, physical, biological, and other sciences, and engineering education programs at all levels. In its first two and a half decades, science education received, on the average, a quarter of the NSF budget. The average approached 40% during the late 1950s, as America responded to the challenge of Sputnik. In the early 1960s, this average was about 30%, and the NSF was a part of the effort to supply scientists and engineers for the space program.

Starting in the late 1960s, however, science education's share of the NSF budget began shrinking, virtually disappearing by the early 1980s. This decline followed the attitude of Americans toward science, as the space program was undermined following the Apollo moonshot, and the public was inundated with the propaganda of environmentalists who blamed scientific progress for the problems of the world.

But as the U.S. began slipping in the world market and as tests showed U.S. students failing dismally in math and science, relative to those of our economic rivals (the average Japanese student does better in math than the top 5% of U.S. students), some national leaders began to sound the alarm. So, in recent years, the requests for more science education funding fell on somewhat more receptive ears (**Figure 1**).

When Dr. Bassam Z. Shakhashiri came to the National Science Foundation as Assistant Director for Science and Engineering Education in 1984, science education at the NSF was begining to recover. Over the past six years, Shakhashiri has become the nation's leading advocate for science education. His lobbying effort is in no small part responsible for the increased funding and visibility of science education. The budget for education has gone from $55 million (in new funds) in 1985 to $204 million in 1990, about 10% of the NSF budget.

NSF director Erich Bloch announced on June 1 that he was replacing the Science and Engineering Education Directorate with a Directorate for Education and Human Resources—a change in name which may be a harbinger of an underlying policy shift. Dr. Shakhashiri was fired as head of education, but has taken a position on Bloch's staff. Shakhashiri's successor, Luther S. Williams, has been serving as Bloch's science adviser and executive secretary of an interagency committee on education. Williams had recently recommended dividing the duties and funds of education among the other directorates, a move some felt would derail science education at NSF.

Interview: Dr. Bassam Z. Shakhashiri

Dr. Shakhashiri, a native of Lebanon, came to the United States in 1957 at age 18. He graduated from Boston University with a bachelor's degree in chemistry and earned his master's and Ph.D. degrees in chemistry at the University of Maryland. He joined the faculty of the University of Wisconsin in 1970, where he founded the Institute for Chemical Education in 1983. He has co-authored several publications, including the three-volume Chemical Demonstrations: A Handbook for Teachers of Chemistry.

Among his many awards are two from the American Chemical Society—the James Flack Norris Award for Outstanding Achievement in the Teaching of Chemistry (1983) and the ACS Award in Chemical Education (1986).

Mark Wilsey of 21st Century Science & Technology *interviewed Dr. Shakhashiri on June 25.*

Q: What is the state of science education in this country today?

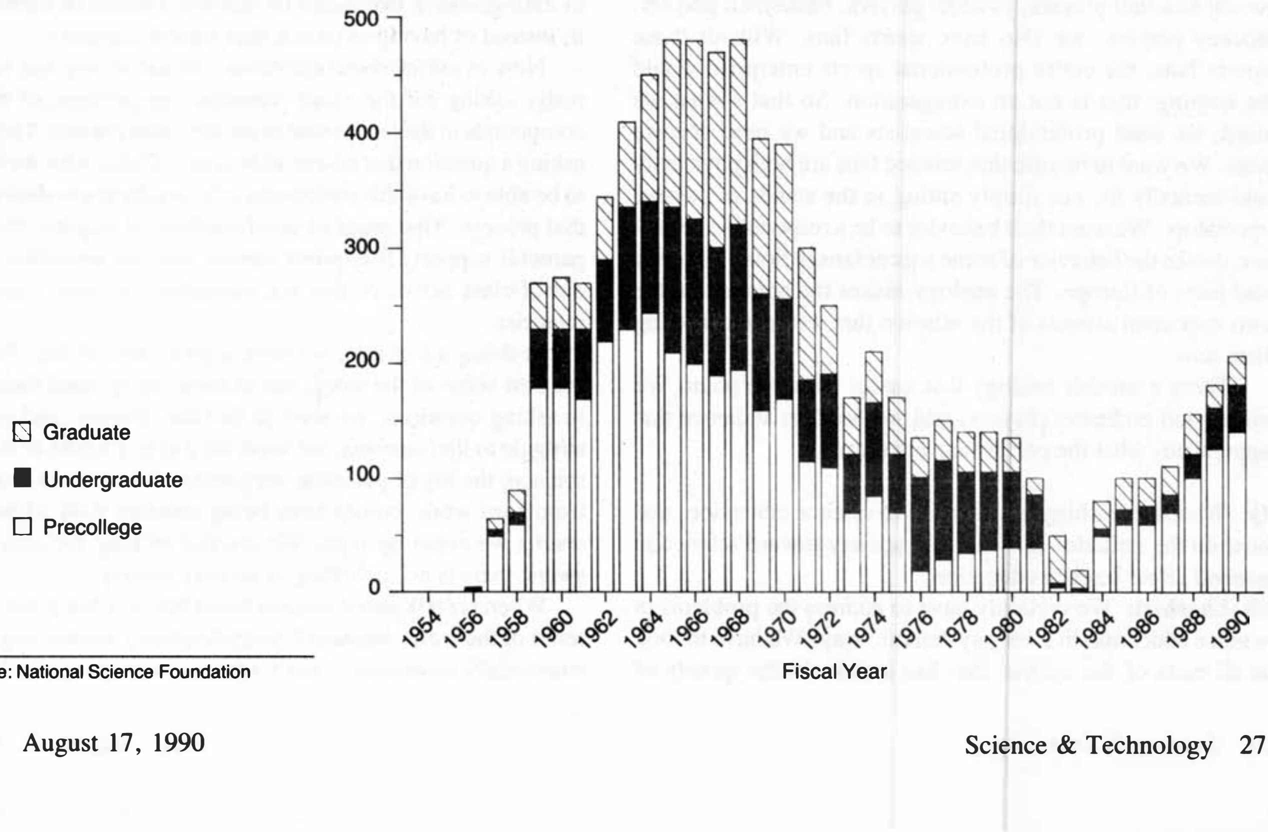
Shakhashiri: The situation that the country faces now in science, math, and engineering education, is by far more critical and more consequential than what we faced in the immediate post-Sputnik era. It's so for a variety of reasons; let me give you three.

First, the population of the United States in the past 30 years or so has increased by about 50 million people. To put that number in perspective, that happens to be the approximate population of all of Great Britain and twice the population of Canada. You might say, "What does that mean? So what?" It means that we have more students to teach and that we need more qualified teachers at all educational levels to teach them.

Some of the demographic data we have available to us now cause us to be alarmed about our ability to deal with this big change in scale that has occurred. So, the first reason can be summarized by saying that the scale of the population has changed so much and that all societal institutions, especially educational insitutions, are very sluggish in responding to changes of that type. This causes problems, not only in education, but in traffic, in waste disposal, in housing, in care for the elderly, in just about everything.

The second reason, is that for our country to maintain its international pre-eminence in science, in technology, in the global economy, in the arts, in the humanities, in all walks of life, we have to have a good supply of scientists, mathema-

FIGURE 1
What NSF has spent on education
Obligations (millions of 1990 dollars)



Source: National Science Foundation

ticians, and engineers coming though the educational system. That's what the National Science Foundation set out to do, in the immediate post-Sputnik era.

Nowadays, we are also alarmed about the flow of talent into those careers. The demographic data available to us cause us to be alarmed about our ability to cope with this situation.

The third reason as to why the situation is more critical and more consequential than it was 30 years ago—and in my judgment the most important of all three reasons—is that we now live in a much more advanced scientific and technological society than we did back then. We have to pay attention to the education in science and in technology of the non-specialist.

We need an educated citizenry that can distinguish between astronomy and astrology. We need the public at large to be able to successfully deal with the complex issues related to animal rights. We need our fellow citizens to be able to handle pollution and pollution-control issues. We want the population at large to benefit from the tremendous advances that we have in the nutritional sciences. We need to have our fellow citizens understand why burning the rain forest in South America is bad for the environment, and the list goes on.

To summarize, then, the present concern, we can talk about two parts: The first part is that we need to increase the flow of talent into careers in science, math, and engineering, and into careers of teaching science, math, and engineering. The second part of the situation, is that we want to make the public at large literate in science, literate in technology, literate in mathematics.

Let me use an analogy. In sports, just as we have professional baseball players, football players, basketball players, hockey players, we also have sports fans. Without those sports fans, the entire professional sports enterprise would be nothing; that is not an exaggeration. So that's what we need; we need professional scientists and we need science fans. We want to be sure that science fans are both physically and mentally fit, not simply sitting in the stands as passive spectators. We want their behavior to be a responsible behavior, unlike the behavior of some soccer fans in South America and parts of Europe. The analogy makes the point about the two important aspects of the mission that we're undertaking here now.

There's another analogy that makes the same point. We need good orchestra players, and we need an audience that appreciates what the performers are doing.

Q: What are the biggest obstacles to science education, and how do the attitudes of American society toward science in general affect science education?

Shakhashiri: We certainly have to address the problems in science education in a very systematic way. We have to look at all parts of the system that has a stake in the quality of science education, indeed, the quality of life.

The biggest obstacle is ignorance—ignorance on the part of the citizens about the world that they live in. The great advances in science and in technology are meaningless unless people know about them, and enjoy their benefits, and understand their potential risks.

The first obstacle is to see to it that we have enlightened leadership at the federal level, at the state level, at the local level; to see to it that the business community and its leaders pay attention to those problems; to see to it that parents, school administrators, teachers—all of these groups—work together to overcome this big obstacle, namely, ignorance.

For the most part I'm optimistic about our ability to do this.

Q: You have a motto, "Science is fun." How do we communicate this to childen? How do we make science fun?

Shakhashiri: Actually, you don't have to make it fun. It is fun! Why is it fun? Because kids of all ages are curious. We ask questions all the time. Why do the leaves change color in the fall? Why do the plants and flowers burst in the spring? Why is the sky blue? Why is it that when wind blows on a body of water, whether a lake or river, we see what we call whitecaps, and is the color of those whitecaps in any way related to the color of the stuff that floats up in the sky? How does the microwave oven work? How does the fax machine work? How does the suspension bridge get put together? The list of questions goes on and on.

What we have to do, is nurture that curiosity, by providing an environment that is conducive to asking those kind of questions, and to seeking the answers to those questions. In our school system, for the most part, at home, we succeed in extinguishing that flame of interest, instead of nurturing it, instead of having us pursue that natural curiosity.

Now in asking those questions, the kid of any age is not really asking for the exact chemical composition of those compounds in the leaves that cause the color change. They're asking a question that relates to *process*. That is why we have to be able to have this environment be conducive to deal with that process. That requires good teachers. It requires having parental support. It requires having in-class activities, and out-of-class activities that are supportive of these kinds of inquiries.

In doing all of this, we have a great deal of fun, fun in the best sense of the word, not in some cheap thrill fashion. In asking questions, we want to find the answers, and as we struggle to find answers, we work hard at it. The joy of doing science, the joy of pursuing our intellectual interests, comes from hard work, comes from being satisfied with whatever results we come up with. We are not looking for easy answers; there is no such thing as an easy answer.

When we talk about science being fun, it's fun in the best sense of the word, because it is intellectually stimulating and emotionally rewarding. That's what we want, to see to it that every child in America has an opportunity to pursue that all-important natural curiosity that they have.

Q: What would be needed to improve the science teacher's effectiveness, or to keep the science teacher current, and to integrate the science educator into the science community?
Shakhashiri: You can't teach something you don't know. You might pretend for a little bit, you might fake it for a little bit, but everybody will catch up with you. The number-one requirement is knowing what it is you're talking about. But that by itself is not sufficient—it's necessary, but not sufficient.

What you have to do is, be able to communicate that knowledge. To communicate it effectively, you have to have a sense of where the students are, you have to have a sense of what their backgrounds are, and, more importantly, where you want to take them. You have to set, as the teacher, expectations for your students, and you have to tell them what those expectations are. You basically have to set some standards of achievement. . . .

Q: How has science education expanded at the NSF, and what are the most significant initiatives?
Shakhashiri: The recovery from the great shutdown of 1982, when the programs at NSF were basically zeroed out—this recovery is nothing short of remarkable. We have succeeded in rebuilding the effort by having high-quality staff onboard. We have succeeded in expanding the number of programs available. The funding has gone up almost to $250 million; actually, the Congress is contemplating making that $285 million for fiscal year 1991.

The foundation is poised to take on additional responsibility, to see to it that elementary science, middle school mathematics, secondary science and mathematics, and undergraduate science, math, and engineering programs, are all moving on in a healthy way.

You asked about the accomplishments. There have been a number of outstanding programs that have been put in place. I'll mention just a handful of them.

The Young Scholars Program, aimed at middle school and high school students, to expose them to research experiences, and work in the summer in a setting that allows them to nurture that curiosity we were talking about before.

Career Access Centers have been established around the country, aimed at increasing the flow of talent from the minority population into science, math, and engineering. There is a center in Atlanta, one in Philadelphia, one in El Paso, one in St. Louis. There are about almost a dozen of them, scheduled to reach a dozen and a half this fiscal year.

The third major accomplishment, is the increased involvement of the private sector in those science education activities. We established a program called Private Sector Partnerships, whereby the private sector is called upon not only to participate in a cost-sharing manner, but actually to be a partner in an intellectual fashion. We're looking for two kinds of partnerships: intellectual partnerships and cost-sharing partnerships.

These are programs that take place in inner city settings, and in rural settings. There are a whole slew of them. We have a book that lists the grants that were made last year across all of these different programs.

At the undergraduate level, we have put in place programs that deal with instrumentation and laboratory improvement, programs that deal with faculty development, programs aimed at revamping the calculus curriculum. Under way now is a very major effort to revamp undergraduate engineering curriculum.

All of these activities are fairly young. The time has come now to look at them very carefully, to monitor them, to assess them, to evaluate them, to find out what works, and why it works, to disseminate those results, to find out what doesn't work, why it doesn't work, and share that information with others who are so keenly wanting to participate in this.

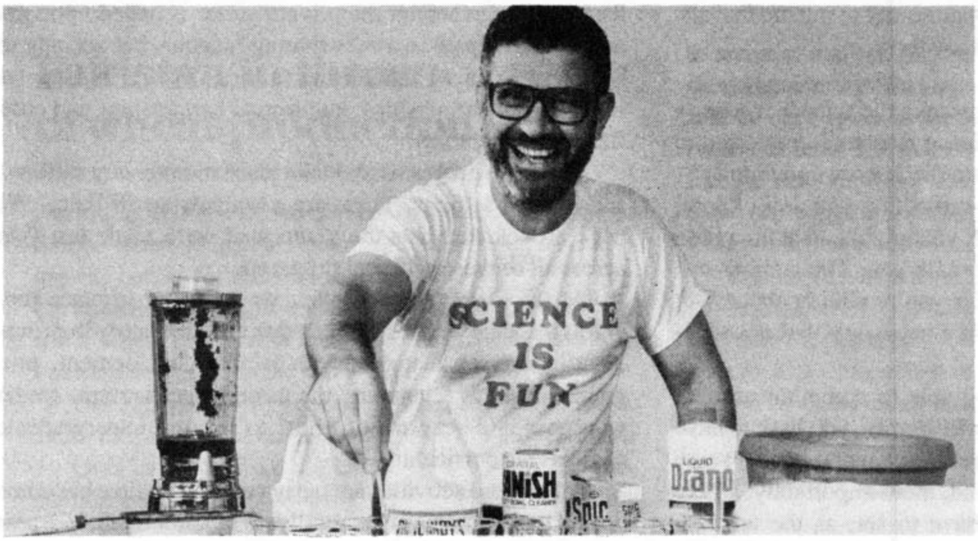
Q: What are the elements of a successful science education program, and how is success measured?
Shakhashiri: There are several elements. One is the extent to which the scientific community feels that this is a high-quality program. The judgment of the scientific community about the content of a curriculum effort, or the content of a teacher enhancement activity, is very important. That by itself is not enough.

The second criterion would be the extent to which these programs are being used, how widely are they being used, and how well they are being received. The dissemination and extent of use are other criteria.

A third criterion is the way in which students react to them. After all, these programs are aimed at altering the setting that the students are in. . . .

Q: Can programs be developed in such a way as to attract women and minorities into science and engineering, without a head-counting system?
Shakhashiri: I think you need to recruit women and minorities and retain them in that pipeline of science and mathematics. You have to do it in at least two ways: You have to do it in a mainstream way, but you also need to have a special target. The targeting is very important.

The NSF does that now in a number of ways at the middle school level, at the high school level, undergraduate, post-graduate, and so on. Let me give you a couple of examples. There is a graduate fellowship program for women in engineering. There are special efforts designed in the Young Scholars Progam to target females and minorities. In fact, over 50% of the participants in the Young Scholars Programs are females and about 42% are minorities. The minority num-



Once upon a midnight cheery, in the lab of Shakhashiri. . . . Dr. Shakashiri is known for his entertaining demonstrations, in which he seeks to impart the joy of discovery to students. "I believe in the hands-on approach," Shakhashiri says. "This is how we learn science."

ber is a disproportionate number to the population, but that is the result of the targeting.

You've got to target groups that have traditionally not been represented in science. I think that is very important. If you want to change the terribly low flow of talent among minorities into science, you've got to target it. You can't just do it in a general way. At the same time, it has to be done in a fashion that does not leave out the other segments of our society. Both mainstream and targeting approaches are important.

There are very important programs that are under way now, and will be launched, to target the participation of women and minorities. By the way, the strategies that are used to recruit and retain women are different than the strategies that are used to recruit and retain minorities—even among minorities themselves. Hispanics in the Southeast require different strategies than Hispanics in the Southwest. Inner city blacks require different strategies than suburban blacks. We've got to take into account the setting which the students are in.

The National Science Foundation for a long time has focused on the best and the brightest, and I think that is very important, there's no question about it, but that cannot be the sole focus.

My position, and my advocacy, is to expand that effort and deal with the bottom half of the student population, to see to it that their exposure to science is a good one. Now, why do I say that? Because I believe very strongly in the effective democracy that we belong to and I believe in having science literacy among all citizens—not only those who are college-bound, not only those who are going to become Ph.D. candidates in science, in math, or in engineering.

We've got to have the entire population brought up to speed in terms of understanding what science and technology are all about, appreciating what science and technology are all about, benefiting from those tremendous advances that I talked about before, and understanding the potential hazards that accompany such advances. That's why we've got to deal with the entire population, not only selectively with a segment of it.

Don't misunderstand. I'm not saying we should ignore the best and the brightest. We should help them as much as we can; but the strategies also differ there.

Q: In comparing science education in the U.S. to Japan, West Germany, or other countries, what could we learn from them, and what features wouldn't work here?

Shakhashiri: There actually is no single solution to these problems. Our educational systems differ from those of other countries. We have a diverse system of education. In some of the other countries you mentioned, they have a monolithic approach to education, a monolithic approach to life. I think we ought to take a very close look at what they do and how they do it. But we should also understand that the diversity of our system is both a strength and a potential liability.

What we have to remember, as we look at these international comparison tests where the U.S. students come out near the bottom, that the talent in this country is as good as it is anywhere else in the world. These tests tell us that there's something in our society, something in our educational system, that we ought to pay attention to.

I have no doubt that we have the capacity to deal with those problems. The question is, do we have the will? Do we have the determination? Do we have the resolve to address those problems and to learn about what our systems of education offer and what the other systems of education offer? We have got to get this national will going. We've got to get in the business of developing talent. That's what we're in, we're in the business of talent development. We're not in the business of weeding out students, which happens to be the case in some settings. What we have to do is take advantage of the fact that we have the students, and we want to help them fulfill their human potential, their human capacity.

We should learn what works in Japan, what works in Korea, what works in Canada, what works in West Germany, what doesn't work, and how it can apply to our own free enterprise system. Because what's really at stake is the quality of life in this society, and how we can perserve it. That is why my call is to have people who believe in the democratic institutions upon which this country was founded, participate fully in revamping the educational system, and using science as a vehicle to do that. Science is not the only problem we have; it's across all of education.

I would look very carefully at the way in which parents nurture the development of their kids in Japan, in Korea. I would look at the quality of television that they watch here, as compared to what they watch in Korea. I would look at the self-image that the kids have. I would look at the performance of kids in math, in science. It's not just knowing the subject matter, but knowing the process which is all important.

School prepares us for the rest of our lives, and most of what we learn most of the time we learn outside of school. The school years are critical to develop talent, are critical to develop attitudes, to develop behavior. For the most part, behavior is a manifestation of attitudes. That is what we have to be instilling in our youth, healthy attitudes toward life, toward education, toward science. We don't want everybody to become a scientist, far from it. That's not the point; the point is, we want people to enjoy the environment that we're in, and to protect this environment. I'm talking now about the global environment. I'm talking about global environmental issues. . . .

The President has said, and the governors have all agreed, that the U.S. goal is to have our students be number one in science and mathematics by the year 2000. I'm committed to that goal, and everything that I will do will be aimed at helping us achieve that goal. We want to be sure that goal is realized. That goal serves as a ralling point to galvanize the nation to act in a responsible, coherent manner. Otherwise, it becomes an empty goal. . . .

Q: There is the argument that if our students are deficient in science, then science education is at fault, and that the we should burn the whole system down and rebuild anew. During the Sputnik era, we revamped our textbooks and trained more teachers. There was the excitement about going into the Space Age. Isn't that a somewhat different process?

Shakhashiri: It is not really all that different, because when it comes to education, and you have a problem in education, you can't fix it once and for all. It's not like fixing a bridge and looking at it every 15 years to see if it has any cracks in it, or it needs repainting. In education, you have to have a continual, sustained presence. You have to pay attention to all of these problems on a yearly basis. You have to be concerned about the quality of the curriculum, but also about the effectiveness of the curriculum. You don't want to develop a high-quality curriculum and have it sit on the shelf; you want to have it used.

That's why you want to look at the outcome of the educational process. What does it mean to be the holder of a high school diploma, from any school in whichever state? What does it mean to be the holder of a bachelor's degree from any college or university in this country? I know what it means; it means that they have fulfilled certain requirements, but that's not what I'm talking about. I'm talking about the true meaning of having gone through that experience—that's what we're talking about.

The real challenge to us is how can we get youth to continue to be motivated to pursue both intellectual and other endeavors that they want to pursue. In this country, we attract students from all over the world. They flock to our shores to go to graduate school. It's the greatest tribute to our institutions of higher education. The challenge to us is, can we have our native-born students partake in paying that tribute? That's why I talk about the national will. That's why I talk about the development of talent. There is no doubt in my mind, whatsoever, that we have the capacity to do it, but I'm puzzled as to why we don't act more strongly in nurturing the talent.

I came to this country in 1957 from my native Lebanon with my parents and two sisters. We have enjoyed the wonderful hospitality and the great opportunities available in this country. We are very grateful for that. But it bothers me that native-born students do not partake of these same opportunities, develop themselves, and help fulfill their human capacity.

You asked before about ways in which we can try to deal with this issue. Let me mention one point to you. In our society, we have a science-rich sector, and we have a science-poor sector. Who's the science-rich sector in our society? Colleges and universities, parts of industry, the national labs. Who's the science-poor sector? Everyone else. The science-rich sector owes a lot to the science-poor sector. The science-rich sector has got to share their attitude and wealth of information with the science-poor sector. Otherwise, the whole enterprise will fall apart, the whole societal enterprise will fall apart. That's what it's going to take. It's going to take strong collaboration between institutions of higher education, the public school systems, parents, the private sector, civic leaders, all working together to see to it that the entire system is revamped.

That's what the Statewide Systemic Initiatives that the NSF issued recently is all about. It's a program aimed at engaging the states as political entities, to work together to form partnerships within a state among the groups just mentioned, to set goals for each state, and to help achieve those goals. . . .