On Science and Curriculum: A Conversation with James Rutherford

RON BRANDT

Are you pleased with the trend for states and school systems to require more science and mathematics?

The question is what students should be learning under the name of "science." A quarter of a century ago when we were mostly concerned with educating future scientists and engineers, the classical science curriculum—chemistry, physics, plenty of mathematics—still made some kind of sense. But now the need is very different. We're now talking about citizenship in a scientific world. We see that jobs are changing and that more workers need a technical background.

Are we talking about three kinds of people? There are future scientists and engineers. There are people whose only connection with science will be as citizens. And then there's an emerging middle group. . . .

I would say that middle group is probably the largest. For example, managers in business have to deal with technical matters, with quantitative information, with probability. Legislators, superintendents, have to make decisions about what students are supposed to learn and where to allocate their resources. Librarians have to deal with more and more technical material. Elementary teachers surely have a need. Professional people—lawyers, doctors—need more and more science and mathematics in order to do their work well. I think that's a stronger argument than the one that the worker of the future is going to have to be technically competent. Modern technology often makes it possible to do a lot of work with less training than before. The citizenship argument, of course, covers everybody.

And even if there are these three groups, in our nation it's pretty hard to tell who is in which group.

That's right. Fortunately our society is wealthy enough that we can put off decisions until fairly late. We don't know where talent is; we don't know where people are going to end up in life. The safeguard in our democratic society is to see that everyone gets the kind of education that permits them to move in any of these directions and, I would

From 1964–1971, F. James Rutherford was Co-Director and Executive Director of Harvard Project Physics, a national project to develop a "humanistically oriented physics course" intended to "attract a large number of high school students to the study of introductory physics."

Rutherford has been a science teacher, consultant, and professor, and has held positions at the National Science Foundation and the U.S. Department of Education. He is currently Chief Education Officer, American Association for the Advancement of Science.

add, to enjoy life. Science changes your vision. You see things in the world you don't see without it. It's very humanizing.

Some people would question that in light of the science education they themselves had.

Absolutely. We plunk kids down with books—and bad books at that—as though science is learning to recite a lot of words. That's a shame. Science is open, active, inquiring. I would ban science textbooks in elementary school. Students should be doing, collecting, pushing and pulling things, asking questions and working together, looking up information in reference books. They shouldn't have to know all the terminology; shouldn't have to have everything right. Science is asking certain kinds of questions.

Does that apply to middle school and junior high?

The emphasis there ought to be on figuring out how things work: how does an automobile work? A bicycle? How do stars work? How does the sun stay hot? How does water get to the top of the tree?

Some teachers might say, "You seem to be putting off the hard stuff. And there's so much to be learned that we have to get going with it."

Well, I would ask such teachers to test the kids a year later and find out how much they know of what they supposedly were taught. But I would get into the hard stuff. If you're going to grasp how our solar system works, you've got to find out about mass, gravity, how things move, geometric patterns, time scales, concepts of energy. I would get into those things, but only where they are related to interesting questions about aspects of the natural world and to technology.

What about at the high school level?

If students have become acquainted with the scientific approach in elementary school and had opportunities to investigate how things work in junior high, they should be ready by then to learn something about how the disciplines construct knowledge. A lot of people in education say that even in high school, students shouldn't have to confront the disciplines, but disciplines are powerful.

Science isn't just knowledge, it's organized knowledge. Now I'm not sure chemistry is needed in high school, because contemporary biology incorporates a vast amount of chemistry—and physics does too; contemporary chemistry is being explained in terms of physical principles anyway. But at least there ought to be strong courses dealing with the biological sciences and physical sciences. And there should be exploration of how the disciplines interact with the broader culture: questions about the quality of life, economic issues.

Do you see such a course for everyone or only for the nonscientists?

For everyone. As a matter of fact, maybe those who will become scientists need it more. The world needs technicians, but it needs educated technicians: those who see their specialty in some broader context. Now I'm not really advocating turning science courses into philosophy and sociology courses. That's why the whole curriculum needs looking at.

There are some interesting new relationships between the science and social studies curriculum.

History still deals too much with presidents, kings, and wars: things that haven't really affected people's lives that much. It was the impact of Copernicus, of Galileo, and Newton that changed our whole conception of ourselves and our place in the universe. And we're still trying to deal with the impact of Darwin—precisely because his ideas were so powerful . . . taking us out of being special and putting us in the great chain of life that is part of nature. Ideas are what make history.

You're saying that curriculum reform must go beyond separate subject areas: that we should look at the whole curriculum and how various topics are related.

Exactly. It ought not to be piecemeal. The time is right to take a fresh look in terms of the new learnings we need to fit ourselves for a new world.

What about educational systems in other countries? Can we learn anything from them?

We at AAAS are doing a volume that tries to take a careful look at pre-college science and math education in five countries: Japan, China, East Germany, West Germany, and the Soviet Union. Now, we couldn't do it their way even if we wanted to. Their cultures, their economic systems are quite different. For instance, Japan is a very homogeneous society. Most people have the same values, the same family structure, the same history. In America our strength is our diversity.

Almost all the countries except West Germany have always had centralized education systems. Their way of thinking and operating is completely top down. That has clear advantages—and of course disadvantages—but it's not something that could be transplanted here.

Still, we can find practices in those countries that might be adapted to our situation. For example, in Japanese elementary schools, it's the class of students that's the unit of concern. Teacher, parents, and the students work together to see that all the children progress. There's no thought of not promoting a child. In this country, it's currently popular to condemn "social promotion," but in Japan students stay with their class and move every year.

Americans probably have a different impression because they hear talk about pressures on Japanese children to do well.

Right. The pressure is external; it's that examination. But since it's a national examination, people in the school want everybody in the class to pass. For parents it's very different from wanting their child to compete with the other children day to day.

Another thing we see in those nations: all five of them are committed to getting highly competent teachers. Now, we're a market society, so that's how we must operate. Those countries have other ways of finding and training teachers—but whatever their ways, they work at it harder. They pay attention to status of teachers, how they are assigned, their work life, their inservice training, and so on. In this country, we've got to get past giving lip service to the importance of teachers and start actually producing substantial numbers of highly qualified ones.

Another example: in each of those countries, there is an external validation process. You know, when a university in the U.S. produces a teacher, it means only that the teacher has taken so many units of this or that. In other countries

the person would not get a teaching credential without passing an examination. I think teacher applicants in this country should have to pass an examination before they're permitted to teach—an examination designed not by their institution but by the ultimate authority, which in our case is the individual state.

The same principle applies to schools. There should be external measures to find out not whether students have taken three years of science, but what they have learned.

Another thing to consider is that all the other systems, even West Germany, have strong direction of some sort. Now, how can the U.S. provide for more national leadership and coherence? We don't want a ministry of education, so what do we want?

Do you favor something akin to a national curriculum?

I don't think there's any need to have spelled out in great detail what is supposed to be learned from week to week. I've seen that in countries and I'm not terribly impressed with it, or with some of the other examinations they are given. But we could use a delineation from the national point of view of goals for the schools: the kinds of knowledge, the kinds of intellectual skills and attitudes that are needed. The hard part would be devising ways to measure progress; we don't want federal examinations. Nevertheless, there could be instruments that states, school districts, schools, could use to assess their programs and the results of those programs.

The idea of national standards has never appealed to Americans.

But this is a national matter. The analogy I like to use is that after World War II we undertook to build a national highway system. It was justified, incidentally, on the basis of national defense. Now, we didn't say to all the towns in America, "Build your roads wider and better and let's see if they all join up. Let's hope that where the California roads stop on the Nevada border, Nevada hasn't built theirs somewhere else." We didn't do that at all. We said, "Look, we've got to have a system for the *United States*. We're not saying what you have to do about all the roads in all the towns in your state, but *these* roads have to join up, and we have to agree on construction standards."

"Most of the money we've been putting into education is just to keep it running. Missing are provisions for redesign and reconstruction of the system."

Good programs and materials can also do a lot to influence people without regulations.

Exactly. But somebody needs to make the investment—and local school districts—even most states—can't afford it. You know, most curriculum projects take five or six years and millions of dollars.

Most of the money we've been putting into the education system is just to keep it running—just barely. Missing are provisions for redesign and reconstruction of the system.

You're suggesting a renewed federal commitment to curriculum development, but a common view is that the curriculum reform effort of the 1960s accomplished very little, so the emphasis in the last few years has been on local curriculum development.

Any fair assessment of what was really only the first round in a new process is that it had very substantial effects, maybe more than should have been expected under the circumstances. The curriculum developers invariably overstated their case in order to get the funds, and then couldn't deliver everything they promised. But the promises were never reasonable. If you take a more realistic view of what can be accomplished in an enterprise involving two million people, 17,000 districts, tens of thousands of schools, then it's surprising to me that so many schools tried so much material and that teachers responded to retraining as well as they did. For a few years, we probably had the best science education the country had ever had, but we didn't keep the process up. Teachers hadn't really internalized things yet. So what was needed was: first, continuous redevelopment of curriculum with better systems of feedback from classrooms, and second, much more time for retraining of teachers. Instead, we stopped—for lots of reasons, including the notion that we had finished the job when we got to the moon, which was the wrong goal for science education.

What are the prospects for renewed national support for curriculum development?

I think the signs are right. We're getting legislation saying students have to take more science. Next there'll probably be grants for teacher workshops. It won't take many years to find out that those things aren't working very well. There will be confusion, dissatisfaction—and pressure to reexamine the curriculum. Even here in Washington, where "curriculum" has been a forbidden word for awhile, it's beginning to pop up again.

We at AAAS are planning to hold a series of conferences to address what in science and technology is most worth knowing. We intend to invite philosophers, journalists, scientists of all stripes, and people who apply science in medicine, engineering, and other fields. We hope the results will be a compelling conception of what people in our nation ought to be learning.

Then we expect to go to educators and say, "If this is what we want to achieve, what will it take?" We really don't want to hear why it can't be achieved. We'll want to talk about how we change the curriculum, what kinds of teachers it will take. Then we'll try to work out the blueprints, whatever the cost, for bringing about change.

And you expect to succeed?

Well, you know how things are done in this country. Right now, people are listening, but the question is whether we can sustain interest long enough to do the job. It will take decades, but it must be done. The world has changed, and American schools must be reconstructed to meet the new demands.□