Science Education Reform: What's Wrong with the Paradigm? ¹

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From previous and current efforts at science education reform, the author teases out a certain "culture of reform," a set of assumptions about educational change that are no longer (if they ever were) appropriate to another task, namely managing change. With reference to a group of programs in undergraduate science instruction that work, she finds the research model, the preference for innovation, the dependence on short-term outside funding, and above all, the seeking after some universal curriculum or set of pedagogies that will solve the problem for all time, to be naive in terms of the reality and the politics of change. She would substitute what Gerald Holton in "A Nation at Risk, Revisited" calls "cumulative improvement," and ends with some suggestions as to how such a model could be applied to the organization of college-level instruction in science.

KEY WORDS: Science education; educational reform.

The worst error of all is the one that doesn't appear to be.

— Descartes

INTRODUCTION

Since the launching of Sputnik 35 years ago, Americans have become obsessed with science education reform. Yet, despite task forces and studies, little in the way of reform finally makes its way from the edge to the center of the educational process. What is new and different — New Math, or Project Physics, or writing across the curriculum, or teacher competence — may be initially embraced, but is hard to locate only a few years after being announced. In education there appears to be a strong default mechanism at work. The system is ruled by inertia, which educational reform, as currently thought about and practiced, rarely diverts from its course.

Since 1983, some 300 individual reports on the quality and problems of American science and mathematics education have been published. While we can calculate their frequency (about one per week), it is harder to calculate their cost in human effort, dollars spent, and, with certain notable exceptions, like A Nation at Risk (National Commission on Excellence in Education, 1983), and Everybody Counts (National Research Council, 1989), harder to show that they have had much impact. The reports range from efforts to specify and deal with problems such as "the underachieving curriculum" in mathematics or that science is not yet a "liberal art," to glossy pep talks intended to cheer us on to unrealistic goals (America 2000; U.S. Department of Education, 1991). Some are richer in analysis than others, particularly those dealing with the absence of women and minorities from mathematics and science (Matyas and Malcom, 1991), and some acknowledge why change is so hard to come by in a nation that cherishes local autonomy at the school and college levels. Nevertheless, when these documents finally come around to describing solutions, they usually provide just a laundry list ranging from the difficult — improving teacher education —

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to the near impossible — changing public perceptions and attitudes toward mathematics and science.

Nor are they consistent. Certain experts advise us to start worrying about an anticipated shortfall in the production of engineers and scientists that we will begin to experience by the year 2000. Others assure us that we can, by some unspecified means, become a nation that is first in the world in math and science achievement in the same time frame. Whom are we to believe? What are we supposed to do?

New thinking begins with a critique of old thinking, which, in this case, seems to be mired in a dominant paradigm, a kind of culture of science education reform. I use "culture" here in the way it is defined by anthropologists David Schneider and Clifford Geertz, to refer to a group's shared meanings, its patterns of explanation and action, its intellectual ecology (Traweek, 1989). What is immediately striking about this culture of reform is how ardent and energetic reformers seem to be in inventing the new; yet how difficult reform is to implement, to propagate, and to sustain. That, in my opinion, is what's wrong with the process. They shake, one might say, but nothing (or, to be kinder, very little) actually moves.

"PROBLEMS" AND "SOLUTIONS"

One aspect of the culture of science education reform reflects the problem–solution approach that is dominant in experimental science. Trained in problem definition and problem solving, those who would reform science education tend to frame extremely complex issues in terms they are familiar with, namely, problems and solutions, but reform may not be a problem to be solved. What problem hunting and problem solving may lead to instead is reductionism. Indeed, when one looks closely at the work, one finds that such approaches tend to oversimplify extremely complex processes and to favor theoretical, universal solutions over more modest, incremental change. Moreover, since, in science, problems tend to have only one right answer, a problem-solving orientation may lead to rigidity in practice. Having found or at least identified some solution, reformers of this bent are not much inclined to compromise. Since their thinking is in terms of solutions rather than strategies, their recommendations are rarely couched in terms of options, each with its own benefit–cost computation, nor are they rooted in the pragmatic, the real, the here-and-now. As a result, such educational reformers do not, as a rule, offer practitioners, as one person I interviewed put it, any suggestions as to "what we can do tomorrow."

Another aspect of that culture is that the changes recommended by many educational reformers are often acontextual, both in terms of institutional constraints and in terms of the needs and abilities of the students (or faculty) they are destined to serve. This relative indifference to context may also reflect the problem–solution orientation because it seems to rest on an unexamined belief that, once articulated, the right way will be self-evident, teacher-proof, and appropriate to a wide variety of local conditions. In the course of my research, I met so many scientists and/or science educators, motivated by just such a vision, that I constructed their composite Weltanschauung. It goes something like this:

1. There is one best curriculum or set of pedagogies. They are out there, waiting to be discovered, like the laws of nature, like quarks. If we haven't discovered them so far, it's because we haven't worked hard enough. This curriculum or set of pedagogies is not only "right," it is universal, and will work best irrespective of teacher, irrespective of content, irrespective of place.

2. By pursuing abstract studies of the nature of knowledge and cognition, we can find this curriculum or best set of pedagogies and we can prove that they are the best, experimentally.

3. The evidence from 2 will persuade other instructors to adopt this program.

Yet, history proves the contrary. The much-heralded New Math, emerging from such a Weltanschauung and delivered to the public schools in the 1960s and 1970s, was, as later assessed by mathematician Morris Kline, a "disaster" (Kline, 1977). No one had foreseen the reluctance on the part of conventionally educated mathematics teachers to deepen their understanding of mathematics or to give up the teaching of computational skills at which they excelled. Nor did the designers of New Math anticipate the outcry of a public, itself schooled in the Old Math, when elementary students were found to be unable to add 9 + 8 and