

THERE'S NOTHING WRONG WITH THE RAW MATERIAL

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In the Institute Lecture I was privileged to deliver at the Los Angeles AIChE Meeting last November, I spoke about the quality of American students. I reviewed the dismal statistics on standardized test scores and the anecdotal evidence that many American students can't read, write, or do mathematics and science anywhere near their grade level or find anyplace in the world on a map. I might have added that too many of them are also without dreams or ideals: their ambition goes as far as getting through school, landing a high-paying job, and buying the large-screen television with HBO and MTV that will meet their educational and cultural needs for the rest of their lives.

Teaching these young people in college can be a pretty joyless experience. Intellectual curiosity, creative thinking, and excitement over ideas simply don't show up, in or out of class. Most students won't offer ideas or respond to questions because they don't want to risk being wrong, and they almost never ask questions themselves except the ever-popular "Are we responsible for this on the test?"

In Los Angeles I speculated on the causes of this situation and concluded that while a complex array of sociological factors have played a part, the American precollege educational system must accept the principal burden of responsibility. I also cited some evidence that the problems only become visible at the fourth- or fifth-grade level and get progressively worse through high school.

Not long ago I got some first-hand evidence supporting the latter observation. As part of the NCSU-Wake County Scientist-Teacher Partnership, I visited a fourth-grade class in a rural community outside of Raleigh. I spoke a little about what scientists and engineers do, ran some chemistry demonstrations, had the students do some experiments on detection of acids, and talked about acid rain.

It was a remarkable experience—I couldn't hold those kids back. Early in the class I divided them into groups of four and gave each group two small closed vials containing colorless liquids, one labeled "H" (which contained water) and one labeled "V" (for vinegar). Before I gave them the vials I told them we would do some experiments to figure out which one was acid and which was just water. As soon as they got the vials, they took off. They shook them, sniffed them, held them up to the light. One child saw that one of the liquids was somewhat thick and bubbly when she shook it and the other behaved more like water, and she guessed that the first one was the acid. Another student in the same group saw the H on the second vial and said "Yeah, that probably stands for H₂O. Someone in another group detected a faint aroma coming from one of

the vials, saw the V on it, and said "This one's vinegar—hey, is vinegar an acid?" I hadn't opened my mouth yet!

The whole class went like that. The children flailed their hands in the air after every question I asked, hoping I would call on them. They debated vigorously about the experiments they were performing and came up with possible interpretations that hadn't occurred to me. They asked questions about acids (including "If I poured some of that on his head, would it go all the way through to his feet?"), and acid rain, and what scientists do. They asked if they could do more experiments. When I finished they swarmed around me, showing me work they had done in class, asking more questions. They told me they wanted to be chemists, physicists, veterinarians. Not one mentioned anything about getting an engineering degree followed by an M.B.A. and starting off at \$50,000 a year.

I left the classroom exhilarated and remained charged up for the rest of the day. I conclude that no matter what's wrong with our educational process, there's nothing wrong with the raw material. But I also keep thinking that in two or three years, maybe fewer, the lights will start to go out in those bright eyes, and by the time they get through high school most of those excited, curious kids will have become classroom zombies. What a shameful, inexcusable loss, both for them and for society!

Interest in educational reform is at a high level at the moment as SAT scores continue to decline and U.S. students continue to get trounced by European and Asian students in science and math tests. However, the commonly proposed remedy is to go "back to basics," which to most people means increased drilling in elementary reading, math, and science. Let's find out what they need to know on the SAT's and cram it into them with a trowel. If they can't do multiplication when we give them 15 repetitive problems a week, then let's give them 50. Let's hit them with more and more drill on vocabulary and "science facts" and get them to repeat the words and facts often enough to be sure they can do it on the California Achievement Test. They're not learning enough in five and a half hour days and nine-month academic years? OK, let's do the same old stuff but keep them in school six hours every day for 11 months—that should do it!

It won't, of course. Neither will "freedom-of-choice" schemes that let those who can afford it send their children to better schools, overcrowding those schools and leaving the others as dumping grounds for the underprivileged. What *might* do it is attracting large numbers of our best and brightest young people to join the woefully inadequate number of inspired educators out there now at considerable personal sacrifice. Meeting this goal requires above all paying teachers a decent salary, reducing their class sizes, removing their nonteaching responsibilities, and empowering them to take an active role in determining academic policies and procedures. We must also find ways to provide *all* of our schools with the resources they need to do their job effectively—modern instructional materials, laboratories, computers, multimedia facilities, and in-service training on how to make classrooms exciting centers of learning and creativity. Industry-school and university-school partnerships can play vital roles in these efforts.

There can be little doubt that all of these steps would move things in the right direction. Unfortunately, they all cost money—much more than loading on more drill and cramming in more facts, which may be economical but won't accomplish anything useful. Equally

unfortunately, finding the necessary money will among other things probably require—forgive me—*raising taxes*, while providing a mechanism for assuring that the money goes where it's needed and not into creating additional layers of administration.

Polls show that Americans are willing to invest more in the future of our children and our country, which expenditures on education represent, but our "education president" and many of our other elected representatives don't want to hear about it. However, if we follow their lead and persist in limiting ourselves to solutions that cost little or nothing, we will get little or nothing in return. We will still be complaining about student quality in the next century, and the lights will still be going out in our children's eyes. I hope we are unwilling to let that happen.