An educational moment?
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This is a time of extraordinary opportunity for the US physics community. We have successively been urged by reports from Congress, the business community, the National Academy of Sciences\(^1\), and the executive branch to expand innovation in the physical sciences, with the eventual goal of improving the economy. The proposed effort has two arms: increased activity in research and an enhancement of Americans’ educational attainments in math and physical sciences. There is a clear path toward the first goal based upon reversing the decline in federal and industrial funding of U.S.-based research. Here I make a few suggestions for how physicists might help improve education in the sciences and allied areas.

**US weaknesses.** First, look at the problem. In contrast to people in places like China, India, Korea, and Eastern Europe, many Americans have a rather limited view of the possible advantages of education. Being a sports star or a self-made man and having street smarts or exhibiting common sense are regarded as preferable to book learning, and as surer and better roads to social and economic advancement. For many, the purpose of going to school or college is found in sports, social life, and making contacts. Teachers, teaching, and learning are all given a very low status in popular mythology. Think, for example, of the classic American movie, “The Wizard of Oz”. In it one character morphs from nasty school-teacher into wicked witch. Another character is given a diploma to make up for his lack of brain. Attitudes like the ones displayed in this film steer potential students away from learning and discourage our best students from becoming teachers.

The outcome of the educational process is correspondingly disappointing. U.S. students, who match up to the best in the world in early grades, fall behind in middle school and find themselves rather poorly trained in science and mathematics in their high school years. Lists showing science scores in the different developed countries makes U.S. achievement look mediocre. The average scores of our fifteen-year-olds sit a little below the middle of

\(^{1}\) N. Augustin et. al. Rising Above the Gathering Storm, National Academy of Sciences (2005).
this list, with, for example, the Netherlands, Canada and France well above us. We fall into the same middling category as the Slovak Republic, Spain, and Italy. This picture is not awful. These countries and others in the lower categories have many excellent scientists. However, we are not anywhere near the world leaders: Finland, Japan, and South Korea—all counties which match their high educational attainment with a very considerable export of technology and technological goods. (These standings should not be expected to improve very soon. Achievement tests show that science-knowledge of U.S. seventeen-year-olds has not improved over the past decade.)

Part of the difficulty lies within the training of school teachers. Many teachers in earlier grades have gotten “only a meager introduction to basic physics concepts.” Anecdotal evidence suggests that elementary school teachers are often uncomfortable with even simple math. At the high school level, there is a substantial shortage of qualified physics teachers. In addition, many high schools are too small or too poor to employ someone who has been properly prepared to teach physics. These difficulties exist in some rich school districts; they are much more serious in economically stressed areas.

Other scientific subjects suffer from complementary difficulties. For example, biology boasts a larger proportion of fully qualified teachers, but they are often shackled by rules and policies that prevent them from presenting a full picture of their science. Most of biology is closely tied to evolutionary theory, which provides a framework for integrating the specific knowledge in the field. Many states, school districts, and parents associations discourage the teaching of modern evolutionary knowledge because it conflicts with strongly held religious beliefs. The Dover

2 http://www.nsf.gov/statistics/seind06/pdf_v2.htm Appendix Table 1-14.


Area School Board was particularly closely assessed because of a lawsuit about board strictures against the teaching of evolution. Judge John Jones's decision in that lawsuit noted, with opprobrium, that the board’s interference was related to a quasi-political effort by the Intelligent Design movement. That movement contains a wide variety of enthusiastic believers opposed to the dissemination of knowledge about evolution. Many of its adherents are even opposed to scientific discussions about the age of the universe. In this way, religion-based conflicts impede a full education in science.

Examples of Educational Programs. Many opportunities exist for the improvement of education. I know the UTeach program at the University of Texas in Austin because Michael Marder, one of the founders of the program, was a postdoc in my area at Chicago. The program description says:

Through UTeach's academic program, participants get rigorous preparation and training in math and science in regular academic departments while also receiving the opportunity to take education courses and obtain hands-on experience in the school of education. The program is open both to undergraduates, who can complete the program over the course of four years, and to graduates with degrees in math, sciences, or computer science, who are eligible to complete the program in three semesters.

The work begins with two courses on education and continues with extensive training in school classrooms. These learning experiences are all led by classroom professionals, picked for their skill in teaching pre-college students and for their ability to explain their teaching methods. Thus school-based knowledge is brought to a university audience. In addition, the curriculum contains rigorous science and educational theory, all taught by the appropriate academics. So the students get plenty of hard work. Apparently they eat it up. About 75 students graduated from the program last year, and were certified as teachers, with their academic achievement at or above the high level usual for UT Austin. Certified teachers of this quality may be expected to make a significant impact upon education in Texas if they can remain insulated from the usual mess of Texas politics.

See www.pamd.uscourts.gov/kitzmiller/kitzmiller_342.pdf for opinion of Judge John E. Jones III.

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This same idea of using pre-college teaching professionals is built into PhysTEC, an NSF and Department of Education program aimed at training more and better physics teachers. This program is organized by the three general purpose U.S. physics organizations: APS, AAPT, and AIP which then works within nine of our leading teacher training institutions. This program helps support the institutions, especially in hiring professionals, and in building cooperation among physics departments, schools of education, and school districts.

Another example: For the last four years, a museum administrator, a social scientist, a computer scientist, and I have provided leadership for a program at the University of Chicago which brought graduate students into the educational programs of local science museums. The students were drawn equally from the sciences and the social sciences/humanities with equal representation of masters and Ph.D. students. They worked ten hours a week for three quarters and each received roughly $1000/quarter. This work load was picked so that the students’ scholarly work could go on almost unimpeded alongside their outreach activities. The latter included producing preliminary designs for museum exhibits and/or designing and performing scientific demonstrations within the museums. The NSF and the University provided the money to free the science-students’ time. Some academic instruction came from University scientists, but the bulk of the training was provided by professionals—both those hired by the University and also those working for the cooperating museums. (Once again “a professional”—means a person who has spent considerable time presenting science to a broad public, often in a school or museum context.) The students seemed to like this program very much. They liked meeting people from other disciplines, getting away from the regular work of producing a thesis, and getting involved in helping young people learn science.

These programs, and also the similar NSF program called GK-12, emphasize bringing the best of our young people into science education. Many of the people so trained will become professionals in science education or outreach. Many will not. But they will all benefit from an experience broader than usual, and especially benefit from learning how to communicate ideas to people with backgrounds and attitudes unlike their own. Experience has shown that programs like these can gather up excellent graduate and undergraduate students, drawn in by both their altruism and their desire for a worthwhile experience.

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Bringing in the Professors
Recruitment of undergrads and graduate students is relatively easy. Recruitment of professors is much harder. Working on these kinds of programs will not help a person build a reputation for research accomplishment. Instead, these programs must grow on uncommon (and usually tenured) individuals with a perspective extending beyond the world of research. This work will likely not reward the individual in monetary terms. Nonetheless, I fully believe that scientists will increasingly devote themselves to education on all levels.

To see why we must look at the meaning and value of science. Our work is particularly valuable not for the wealth or power it produces--there are quicker roads to wealth and power. Instead science provides a method for generating evidence-based arguments aimed at finding provisional truths. If we carry our our professional responsibilities correctly and carefully, we might have the opportunity to develop evidence and to say things about nature that are very likely to be true: atmospheric CO₂ can trap heat, photons tend to clump in the same state, the universe is billions of years old, etc.. These kinds of statements can provide the hard facts upon which others may build the reliable instruments of our polity, or our economy, or our view of the world. That is our true value to the community--scientists can use evidence and critical thought to generate a good approximation to something true. We can serve as examples showing how others might, in their own lives, reach conclusions by careful assessment of evidence. Our scientific output stands in contrast to the self-seeking and evidence evasion characteristic of many people, high and low, in public life.

Educational activities enable us to communicate our professional values to the next generation. For some of us this work is the careful training of undergraduates and graduate students in the methods and standards of our profession. Some of us also have the opportunity to organize and add to other kinds of educational processes aimed at informal education, teacher training, and the broad dissemination of science to young people. Each of us, acting individually and through our professional associations, should consider seizing these opportunities above and beyond the usual consideration of “what’s in it for me”.

And, in the long run, there is something in it for all of us. Education aimed at
the evidence-based pursuit of truth can help the community gain tools for a better understanding of the world. Evidence based argumentation can help scientists, engineers, business people, national leaders, ...everyone... make better decisions.

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