

Postmodernist Transformations of the Problem of Scientific Literacy

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ABSTRACT: Postmodernist proposals for transforming science education would not only emphasize connections between science and society but also radically alter our conceptions of the value of experimentation and disinterested inquiry. I propose alternative loci for the study of science and society issues and argue for a less utilitarian vision of science literacy.

Introduction

Educational policy makers and members of organizations such as the American Association for the Advancement of Science have long been troubled by indications of scientific illiteracy such as the poor performance of United States students on standardized tests and the amount of money spent on extremely dubious alternative health procedures, ranging from the relatively benign old-fashioned homeopathic remedies to new psychological therapies for recovered memory syndrome which can be extremely destructive. There is also concern about the salience of antirational and pseudoscientific mythologies in our culture (e.g., angel books, astrology columns, and TV programs on unexplained mysteries) as well as the persistence and success of the creation science movement. The history of science education since Sputnik is a story of attempts to ameliorate this situation.

Each of the postmodern approaches to science studies that figure as major players in the Science Wars also have prescriptions for transforming science education and redefining scientific literacy. Although they differ on details and degree, all are intent on transforming public perceptions of science through an agenda of radical educational reform. In this paper I show how various postmodernist accounts of science are now being uncritically absorbed into science pedagogy and argue that many of these proposals are counterproductive.

The term *postmodern* covers a wide variety of philosophical and political commitments, but in science studies it always connotes a relativistic epistemology. For example, the 1992 draft of the *National Science Education Standards* claimed to be based on a “contemporary approach, called postmodernism, [that] questions the objectivity of observation and the truth of scientific knowledge” (Holton, 1997). And in a recent book review in *Science*, Paul Forman, a historian of science at the Smithsonian, speaks approvingly of “our postmodern world” with its social constructionist epistemology and a “morality-based rather than a truth-based *Weltgefuehl*” (Forman, 1997). As these examples show, many science educators now endorse a postmodernist perspective on science. However, as the quotations in Sokal’s controversial paper published in *Social Text*, a leading cultural studies journal, illustrate, many of those who self-identify as postmodernist know little about science (Sokal, 1996). I will argue that postmodernist proposals to redefine the problem of scientific literacy should be more carefully scrutinized by those responsible for science education.

Traditional Perspectives on Science Literacy

The standard approach to the problem of scientific literacy has concentrated on two basic issues: How should we define the minimal aim of science education? and, Which pedagogic methods are most appropriate for achieving that aim? In specifying the aim of science education it has been traditional to focus on two dimensions, that of content and that of method. When I went to school the major emphasis was on content which included basic concepts (e.g., atom and acid), empirical generalizations (Boyle's and Charles' Laws), and explanatory theories, such as the Kinetic Theory of Gases or Valence Bond Theory. We were given a very perfunctory account of scientific method which emphasized the notions of hypothesis testing and controlled experiment.

Even the most traditional of today's science texts, however, would also include some discussion of scientific debates or unsettled questions, such as the cause of the extinction of the dinosaurs, and would give at least lip service to the idea that scientific theories are fallible and that scientific claims must sometimes be revised. The program of introducing history and philosophy of science into the science curriculum was intended to give students a less static view of science and a better understanding of the process by which scientific knowledge is constructed over time.

Science educators and even philosophers of science spent relatively little effort in trying to set down reasons for why students should be expected to learn the basic content and methodology of science. But if pushed, there were standard responses that could be given. Knowledge of the basic content of science was useful to any individual living in a modern technological society, not just for vocational purposes, but also for understanding why steam burns could be worse than those from boiling water and something about the transmission of diseases. Furthermore, the citizenry in a democratic society needed to be able to participate in discussions of social policy issues that involved science, such as the safety of nuclear power plants or controls on the use of insecticides.

The rationale for teaching students about scientific method was articulated even less frequently, but it was often popularly assumed that the scientific approach could become a sort of universal problem-solving tool that could be applicable to business management, agriculture, cosmetology, and, of course, educational theory. In addition, it was hoped that an understanding of scientific method could inoculate students against the blandishments of pseudo-science and give them critical habits of mind that would serve them well when they read newspapers or listened to politicians!

In sum, the justifications for the traditional characterization of science literacy assumed that science was a progressive force in human affairs and that the world would be a better place to live in if students not only learned the results of science but also its methods and values. As the DuPont advertisement used to proclaim, "Better things for better living – through CHEMISTRY!"

Science Literacy and Science Criticism

Given the present less optimistic mood about the possibility of progress and a current distrust of all institutions that at times borders on cynicism, it is not surprising that people who study science as a social phenomenon are now less sanguine about the positive potential of scientific inquiry and actively oppose what they perceive as cheer-leading for science or science boosterism. Could it not be argued that these days students and citizens in general need to become more skeptical of science itself? Cannot so-called scientific "experts" be found on both sides of any policy debate, be it about global warming, the health hazards associated with tobacco, or the reliability of DNA testing? Perhaps students would be better served by learning about how patronage operates in science, how

funding decisions are made, and how science journalism gives us a “sound bite” picture of scientific research. At the very least, no one today would buy the DuPont slogan. Chemicals are nowadays regarded as things to be feared, not as a means to an enhanced quality of life.

One response to the present concerns about the impact of science and technology on our quality of life is what I will call the Add Critical Thinking Approach. Here one admits the cogency of concerns about the environment and the misapplication of science but recommends that they be handled in supplementary courses specifically directed at the development of critical thinking skills. So, for example, many philosophy departments now offer introductory courses in “baby statistics” and informal fallacies. English departments do “writing across the curriculum” courses in which they analyze the rhetorical ploys of media presentations of research results. And courses for science majors now often include units on research ethics, especially in disciplines where there is legislation governing the use of animal or human subjects.

The basic argument is that science policy issues and questions about the role of science in our society are subjects richly deserving of study, but the proper place for them is not in science classes where we already have an over-stuffed curriculum dealing with the basic concepts and methods of science, but rather in social science or political science classes where these concerns can be put in the perspective of analyses of other institutions in our society. Ethical concerns should be dealt with in philosophy classes where they can be studied in the context of a more general value theory. Arguments about the overall value of technology could be raised in a social history class. No aspect of science and its impact on society is beyond criticism, but the critical evaluation should be placed in a disciplinary context where it can be conducted in a systematic and responsible fashion.

The Call to Transform the Core Values of Science

Postmodernists find the above approach inadequate because, although it recognizes that we are faced with serious policy issues, it nevertheless leaves the core epistemology and normative stance of science relatively unchanged. They propose instead what I will call the Transformationist Program in which science and society issues are considered to be so central to science education that all aspects of the science curriculum should be restructured in order to reflect postmodernist conceptions. In particular, students need to learn that:

- The so-called “laws of nature” are social constructions whose validity depends on consensus. The consensus is driven by interests, not epistemic considerations. “Science is politics by other means” (Harding, 1991).
- There is no legitimate universal science, only local ethnosciences which have been oppressed or colonized (Nandy, 1989).
- The call for scientific objectivity only serves as a cover for exploitation. Instead we need “advocacy research” and “emancipatory science” (Fuller, 1993).

These calls for a transformation of the public understanding of science are often accompanied by more or less hostile images of science. Andrew Ross (1994) speaks only partly in jest when he dedicates his book *Strange Weather* to “all the science teachers I never had. [This book] could only have been written without them.”

There is a general concern that students can too easily be seduced into believing that science gives us an especially reliable way of learning about the world.

There is an extensive literature of feminist critiques of science (for a critical overview, see Patai & Koertge, 1994) but here is an especially vivid exemplar: “Male science furthers the capitalist, imperialist tradition in which it was begotten: it exploits, rapes, destroys” (Overfield, 1981). Once again there is a real fear that scientific ways of knowing can not only be socially destructive but also dangerous to orders, do your work, and protect you from the ever threatening enemy. But it is clumsy and dangerous. Without control, a golem may destroy its masters with its flailing vigour.” (Fuller, 1993, p. 1)

Clearly postmodernists would have us revise our basic evaluation of both the epistemic reliability of science and its potential for relieving pain and drudgery or improving the quality of life. Again that is perhaps not too surprising, especially in developed countries where many of us have already reaped the benefits of a doubled life span and a standard of living which would be almost unimaginable to our great-grandparents. It is perhaps only human to ask, but what has science done for us lately! But what I do find surprising – and troubling – are the postmodernist proposals for radical changes in the core methods and norms of science.

To cite Ross again: “[We need] different ways of doing science, ways that downgrade methodology, experiment, and manufacturing” (1996, p. 4). Sue Rosser, a former Senior Program Officer at the National Science Foundation in the United States also would undercut the centrality of the experimental method in her search for a “female friendly” science: “Well-controlled experiments in a laboratory may provide results that have little application ... outside the classroom.” Instead students should investigate problems of a more “holistic, global scope” using “interactive methods” (1993, p. 213). It is one thing to emphasize the limits of experimentation. It is quite another to recommend not exposing students to its power in ideal circumstances.

And whatever sophisticated caveats one may wish to put on the viability of the fact-value distinction and however difficult it may be ever to live up to the scientific ideal of disinterestedness, it is quite another thing to call for the deliberate injection of politics into the very formation of scientific hypotheses as does Helen Longino: “I am suggesting that a feminist scientific practice admits political considerations as relevant constraints on reasoning If faced with a conflict between [political] commitments and a particular model of brain-behavior, we allow the political commitments to guide the choice (1990, pp. 191, 193).

Criticisms of the Transformationist Program

Postmodernist proposals for transforming the science curriculum have to be evaluated in a piece-meal fashion. Some of the suggestions for adding items to the science curriculum, such as the contributions of women and minorities, and placing more emphasis on the cultural and political context in which science is conducted strike me as relatively non-controversial. (There might be a question about emphasis or a concern about how much other material would have to be deleted.) However, their strong claims about the cognitive equality of ethnosciences and ethnomathematics and the corollary that “universal” science is politically oppressive are not historically well-substantiated and should not uncritically be taken as a basis for either pedagogy or curriculum content.

Postmodernist epistemological precepts, including strong forms of social constructivism, have been subjected to a variety of severe philosophical criticisms and in any case as a general rule it is unwise to revamp a school curriculum on the basis of the latest stop-press philosophical theory. As a thought experiment, imagine the result of trying to teach children acoustics based on a philosophy

that doubts whether there is sound in the forest if no one is around when a tree falls or psychology based on an epistemology that is skeptical about our ability to know whether other people even have minds! I am personally fascinated by sophisticated arguments about objectivity and realism and have followed with some interest attempts to introduce philosophy as a high school subject where students could also engage these issues. But postmodernist epistemological glosses in the context of a science curriculum can only be confusing and misleading. In their other classes students are constantly learning to distinguish fact from fiction, truth from error. What on earth are they to think when in their science class, of all places, they are told that there are no such things as scientific facts or true descriptions of the natural world? What an irony that it is science educators professing to be concerned with empowering their students who are so careful to put words like “fact” and “truth” in snicker quotes in the hopes that students will learn not to uncritically accept the results of science. But the other voices that students hear will not be so fastidious – religious leaders, politicians, advertisers will certainly not hesitate to baptize their doctrines as true. Is the best that we can hope for to make students cynical about the prospect of ever having good evidential reasons for accepting one claim over another? If even the gold of our best science is rusty, what can iron do?

It is relatively easy to notice and evaluate the political agenda which underlies many of the more radical challenges to ordinary conceptions of scientific norms and methods. What is perhaps more insidious is the rather bland sounding proposal that students should learn more *about* science (and less science proper). Collins and Pinch in a section called “Science and the Citizen” put the point directly. Saying that the idea that knowing more science would help the public make more sensible decisions “ranks among the great fallacies of our age” – they conclude: “Scientists at the research front cannot settle their disagreements through better experimentation, more knowledge, more advanced theories, or clearer thinking. It is ridiculous to expect the general public to do better” (1993, pp. 144-45).

It is very tempting to endorse the goal of teaching about science instead of basic scientific concepts. After all, have we not already expanded the concept of science literacy to include knowledge of the nature of scientific inquiry? Isn't science itself too complicated for the non-science major – hence the popularity of physics-for-poets classes? And isn't there just too much to cover anyway? Could we not argue that the specific content people really need to know they can learn on the job. And as for policy issues – well, as Collins and Pinch say, experts themselves disagree. Perhaps all the citizen can do is become savvy about analyzing political affiliations, not trying to address the scientific merits of the opposing claims.

There are two ways we might try to reply to this proposal that becoming familiar with the basic content of science is no longer a very practical goal. One is to deny that the goal is impossible and to argue that even a minimal literacy is still very useful. For example, although there was obviously a great deal of nonsense written in the aftermath of the cloning of Dolly, it struck me that here was a case where the literate layperson could, with the help of some of the better newspapers and magazines, get a pretty good idea of what the scientific situation was and start to think in a reasonable fashion about the ethical issues involved. But the layperson I have in mind would have to have some idea about embryology and the roles DNA does and does not play in development. Without the basic vocabulary of modern genetics they could not fully participate in the civil discussion.

But there is a stronger, more principled response to the postmodernist challenge to substitute the teaching about science for an acquaintance with the content of science itself. And this line of

argument suggests we need to rethink our traditional rationales for scientific literacy, all of which were utilitarian in nature in their emphasis on the usefulness of science for the worker and citizen. From the time of Bacon much of the worth ascribed to science has hinged on the power it gives us to predict and control nature. But there has always been another source of value and that comes from the ability science sometimes gives us to understand and explain the world we live in. The popularity of cosmology with its billions and billions of stars and children's fascination with dinosaurs are but two examples of our human need to explore the mysteries of the world we live in. It is not just theoretical scientists who are moved by the power of science to deepen and unify our knowledge of natural phenomena.

What if we were to design a science curriculum that began with the curiosity that children have about the world around them and then introduced them to the most beautiful intellectual aspects of the scientific heritage? What if we were to let scientific aesthetics be our guide instead of the latest stop-press environmental crisis? What if we were to highlight the intellectual virtues of science when it is practiced at its best? Stories about Kepler's struggle to find an orbit for Mars that was accurate to more than eight minutes of arc. Stories about scientists giving up their most cherished theories when the facts didn't fit. Stories about cooperation between scientists of different nationalities even when their countries are at war.

Of course, that's not the whole story. But in every other sphere of education we try to work with children at the level they are ready to comprehend and we try to teach them the highest values they are capable of understanding. So we tell them in preschool never to bite each other. We would never think of emphasizing that the rule is a social construction or that it has exceptions, although we know that sometimes people do bite each other and with good reason (I'm not thinking of Mike Tyson!). We know that it is instinctive to bite to defend oneself and so we put quite a bit of effort into socializing kids out of it. It is also a strong human tendency to let one's appraisal of what is the case be influenced by one's wishes or fears. When I poll my international students they all report that their language has a proverb similar to the English "if wishes were horses beggars would ride" or the German "der Wunsche ist Vater des Gedankens." Science is the best example we have thus far of an institution that takes as its central value the minimization of the intrusion of ideology on its claims. Surely that is a noble aim and one that students should learn to appreciate. Let us by all means introduce values into science education, but let them be as high-minded as possible. We do not need to set out to teach them to be cynics. That they can do on their own.

NOTE

More documentation for the points raised in this paper can found in Koertge (1998).

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