An Overture

A Problem Posing Approach to Biology Education

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In a recent article entitled "Problem-posing physics: A conceptual approach", Wytze Brouwer (1984) suggests the following approach to science education: (1) an "interactional style of teaching" should *pose* questions on the conceptional foundations that students have about a subject; (2) "student misconceptions can often be related to earlier, once perfectly respectable, historical preconceptions about" the physical and biological world; (3) "the teacher must have a profound respect for the people with whom he interacts, a faith in their own ability to analyze, to develop, or recreate their conceptions of reality to become more fully active as human beings"; (4) "apply the new explanatory models in familiar and new situations"; and (5) "test scientific understanding both conceptually and quantitatively."

In 1962, Thomas S. Kuhn's *The Structure of Scientific Revolutions* transformed many scholars' fundamental understanding of how science works by instantiating the role of actual historical events in the transformation of science rather than the previous role of history, which had been reconstructed for philosophical purposes. In this book, Kuhn gave credence to the current nature of scientific textbooks as playing the fundamental role in educating students to be prepared to do "normal" science and, in this sense, Kuhn could be viewed as having justified the normative nature of scientific textbooks. On the other hand, I believe that the current scientific textbooks are usually inadequate (although I still use them in most of my classes), needing compensation in four major ways. This is because textbooks usually describe science only in the philosophically reconstructed form that Kuhn was criticizing. Textbooks rarely devote much space to helping students understand (1) why earlier scientific conceptions are incompatible with our observations, (2) how to solve problems, (3) what heuristics (not the so-called scientific method) are generally useful in recognizing types of and approaches to problems, (4) who is capable of solving such problems, and, especially, (5) whose interests are served and what solutions are possible if a problem is posed in a particular fashion. Truman Schwartz (1977) goes even further:

> I am not convinced that the production of normal scientists should be our highest goal. I resonate with the words of Karl Popper when he says: "In my view the normal scientist as Kuhn describes him is a person one ought to be sorry for . . . The normal scientist in my view has been taught badly . . . He has been taught in a dogmatic spirit; he is a victim of indoctrination. He has learned a technique which can be applied without asking the reason why." . . . I hasten to add that I am not such an impractical romantic as to spurn all normal science. After all, chemistry has been phenomenally successful at solving puzzles which were safely within the boundary conditions imposed by accepted doctrine. Most of us seldom, if ever, venture beyond these limits. What I do submit is that an honest, unbowdlerized historical approach—one which admits of error, approximation, and human foibles—is not necessarily detrimental to conventional chemistry. Moreover, it stands a chance of generating the imagination and insight required for scientific revolutions.

But back to textbooks. I believe textbooks can be compensated in the following six ways: (1) pose questions to students on how they think things work, on why they think they work that way, and on the consequences of thinking the way they do; (2) encourage students to carry out independent investigations as much as possible; (3) develop computer software that builds experimental universes which provide students with professional tools to develop long-term research-like strategies for scientific problem solving in a very short time; (4) encourage students to work in groups, think aloud, evaluate each other's work, and try problem solving daily; (5) articulate clearly why and how recent research developments in cognitive psychology, science education, artificial intelligence, and history, philosophy and sociology of science, as well as some classical aspects of logic and epistemology, relate to learning how to solve problems; and finally, (6) students should actively engage in *posing* problems rather than simply solving those problems which are formulated in the back of chapters of textbooks. Only by recognizing the variations in and prejudices which we each bring to posing problems are students likely to be sensitive to their own culturally bound "theory laden observations" (Kuhn 1962).

How could we determine if many of the ideas that we have developed are culturally bound to Western science education? We need perspective on how students approach problem posing and problem solving in different cultures. Paolo Freire's *Pedagogy of the Oppressed* (1970) states his belief that "problem posing education" inherently will lead to a more humanizing and liberating knowledge:

> In problem-posing education, men develop their power to perceive critically the way they exist in the

world with which and in which they find themselves; they come to see the world not as a static reality, but as a reality in process, in transformation. Although the dialectical relations of men with the world exist independently of how these relations are perceived (or whether or not they are perceived at all), it is true that the form of action men adopt is to a large extent a function of how they perceive themselves in the world. (pp. 70-71)

[and]

Students, as they are increasingly posed with problems relating themselves in the world and with the world, will feel increasingly challenged and obliged to respond to that challenge. Because they apprehend the challenge as interrelated to other problems within a total context, not as a theoretical question, the resulting comprehension tends to be increasingly critical and thus constantly less alienated. Their response to the challenge evokes new challenges, followed by new understandings; and gradually the students come to regard themselves as committed.

Lecturing in an interactional style that attempts to draw out students, encouraging them to become active learners, is a minimal approach to a problem posing approach. Facilitation of learning rather than didactic pedagogy may be effected through encouraging cooperation via group learning, collaborative labs and projects to develop student interaction in scientific investigation, and by being highly problem-directed rather than descriptive.

Will this approach work well in a different cultural context because the approach depends on identifying problems of interest to the students, encouraging the students to develop their own approaches to problems, and getting students to work with one another? In addition, if we develop a large number of physical materials which are visual and tangible rather than linguistic, will these help develop scientific reasoning? How can we play the role of resource persons rather than disseminators of a fixed, rigid form of knowledge?

How can curriculum be developed and/or adapted which would be consonant with a problem posing approach? First, it would seem that problem posing curricula would be marked by both flexibility and specificity. Students should be allowed considerable freedom in choosing concentrations at both the high school and the undergraduate levels. Can concentrations be defined whereby students learn both breadth and a sequential series of skills? Brown and Walter (1983), two mathematics educators, note that concentrations are not defined by their content but instead by the problems they pose:

The centrality of problem posing or question asking is picked up by Stephen Toulmin in his effort to understand how disciplines are subdivided within the sciences. What distinguishes atomic physics from molecular biology, for example? He points out that our first inclination to look for differences in the specific content is mistaken, for specific theories and concepts are transitory and certainly change over time. On the other hand, Toulmin comments:

If we mark sciences off from one another . . . by their respective "domains," even these domains have to be identified not by the types of objects with which they deal, but rather by the questions which arise about them . . . Any particular type of object will fall in the domain of (say) "biochemistry," only in so far as it is a topic for correspondingly "biochemical" questions.

An even deeper appreciation for the role of problem generation in literature is expressed by Mr. Lurie to his son, in Chaim Potok's novel *In the Beginning*:

I want to tell you something my brother David, may he rest in peace, once said to me. He said it is as important to learn the important questions as it is the important answers. It is especially important to learn the questions to which there may not be good answers.

Indeed, we need to find out why some questions may not have good answers.

If we return to my critique of science textbooks, I believe that this is where they fail us most; namely, by focusing on facts and problems formulated in a "normal" science tradition (paradigm), we fail our students most by not raising the questions to which we have no good answers. I furthermore would argue that we fail to attract certain students to science because they see science as fixed with all of its major problems already solved rather than a dynamically growing approach to difficult problems, some of which have not yet been even articulated. Dorothy Buerk (1982) states this well:

Many students of mathematics believe that the subject is only rules to be memorized, skills to be practiced, and methods to be followed precisely. I would like to propose that, for some adults, this view is not consistent with their more relativistic view of knowledge in general; this discrepancy in world view and view of mathematics causes discomfort with mathematics.

Can we write science books that are concerned with the unknown which lies within the range of "The Art of the Soluble?" By using prestated problems (dilemmas), we restrict our attention to some of the less exciting avenues of science for our students; furthermore, we "de-skill" our students. Daniel Pekarsky (1980) notes a similar situation in moral education:

To know how to solve a moral dilemma once it has been laid out is one thing; to be able to identify the morally relevant features of an everyday situation and thus become aware that there is a moral problem, and to do so in a way that does justice to the complexity of the situation, is quite another. A program in moral education that takes predesignated moral dilemmas as its starting-point fails to take seriously enough the dispositions and skills that are necessary if the morally problematic is to be uncovered in the midst of the everyday.

Let me take the liberty of simply modifying Pekarsky's last sentence to show its exact equivalence in science education: A program in science education that takes predesignated scientific problems as its starting-point fails to take seriously enough the dispositions and skills that are necessary if the scientific problematic is to be uncovered in the midst of the everyday. This problem posing approach seems to be a *sine qua non* for developing students critical of "normal" science in the Kuhnian sense and capable of asking questions about matters of concern to their immediate lives.

I agree with Hilary Rose (1983) that a good curriculum builds the brain, the hands, and the heart. Thus, it is important to combine an intellectually rigorous cognitive development program with the craftsmanship of scientific tool use and affective growth in moral judgment (Brown 1984). I am very pragmatic in this domain because I believe that curriculum must emerge from local needs and personnel. Thus, national curricular policies have to be locally adapted and developed, but not compromised. Effective local implementation involves the active involvement and interaction of teachers, students and context. Field testing with feedback modifications is the most powerful and lasting way to transform policy into action at the local level.

Inasmuch as the problem posing approach referenced in this paper has dealt primarily with reading, mathematics, and physics education, why hasn't it been applied to biology which is concerned with life and death matters? The ecological and evolutionary complexity of our problems is enormous and has tremendous consequences. Let us solicit the help of our students in posing the problems of future scientific agendas. Problem posing and problem solving are inseparable activities (Walter and Brown 1977). Research doesn't indicate, experiments don't suggest, evidence doesn't show, and data does not imply. These anthropomorphisms hide their authors' intentions and prejudices. A problem posing approach which makes the inferences in a direct manner where the authors are explicit about their role in drawing these inferences seems a more honest approach to communicating science to students and involving students in science. What are the questions that we should be asking in biology education?

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