provocative opinion

Something's Wrong with Chemistry Textbooks

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A comment made in a review of *General, Organic, and Biological Chemistry* by Feigl and Hill in *this Journal* compels me to respond.[1] The reviewer's comment regarding this health sciences chemistry text was "In Chapter 2, for example, the discussion of atomic structure totally neglects even to mention the origin and significance of quantum numbers, let alone define them."

On the surface this statement seems rather innocuous and common. On the contrary, I think there are two significant issues, one specific and one general, raised by this statement. In specific, I question the use of quantum numbers not only with health science chemistry students but with all beginning chemistry students. In general, I feel that such statements are indicative of the general state of mind of chemistry teachers and that state of mind is having an adverse impact on the quality of textbooks. My criticism is not directed at the reviewer but at all of us because I think we are all somewhat guilty of the mistakes I am addressing.

The Value of Quantum Numbers to Beginning Students

The Task Force on Chemical Education for Health Professionals recently published a syllabus for the course to which the Feigl and Hill text is directed.[2] Nowhere do they even mention, nor do they exclude, discussion of quantum numbers. They do state though, that "Many of them (students of this course) are poorly prepared for chemistry and particularly for the mathematical part of our science."

I believe that an honest description of quantum numbers is that they are *partial, approximate* solutions of an equation that *approximately* describes the energies of atomic electrons. The equation stems from a desire to create a mathematical model of atoms, and it requires mathematical knowledge beyond that possessed by health science chemistry students, general chemistry students, and most (if not all) college freshmen. On this basis, quantum numbers can only be used descriptively as part of an explanation of atomic behavior. But to be used in this manner, quantum numbers must be understood in the context of the mathematical model. This is a Catch-22—the students lack the necessary mathematical skills to understand the model. I can only conclude that quantum numbers have no meaning or value for beginning chemistry students. A substantial introduction to quantum numbers actually presents a barrier, rather than an aid, to understanding atomic behavior. A mere mention of quantum numbers in a text can only appear to be a sop tossed to those chemistry professors who demand such mentions; I can't believe there is educational value in just mentioning any term or concept.

If not quantum numbers, then what? What needs to be taught to provide an appropriate theoretical base for beginning chemistry students? What *is* important for beginning students to understand is that the energies of atomic electrons are *measurable*. The *measured* energies indicate that electron energies are quantized. And the periodic table makes it abundantly clear that a primary factor in chemical and physical behavior of the elements is simply the *number* of highest energy (valence) electrons in their atoms.

This paradigm is easily grasped by students because they intuitively understand that the highest energy electrons in an atom are found furthest from the nucleus and the farther electrons are from their own nucleus, the closer they are to other nuclei that might influence them. Understanding this prepares the ground for discussion of the Lewis theory of chemical bonding and for more technical treatments encountered in subsequent chemistry courses.

Why then do many of us insist on the inclusion of discussions of quantum numbers and similar esoterica in our textbooks even when doing so is clearly inappropriate? I can't answer this question, but asking it brings me to my second point—the impact this general state of mind has on the quality of chemistry textbooks.

The Quality of Chemistry Textbooks

The reviewer's comment points to one of a body of topics that have become sacred to chemistry teachers. I have often heard the comment, "I could never teach out of a text that didn't include . . . [fill in any pet topic here]." I perceive that we, as a group, have developed a very narrow view of what is acceptable in chemistry texts and that narrow view restricts our ability to teach. It is us who write, review, and finally order the textbooks for our students. Texts that don't conform to the norm get poor reviews. Texts that don't conform

[1] *J. Chem. Educ.* **1987,** *64,* A327–A328.
[2] *J. Chem. Educ.* **1984,** *61,* 620–621.

to the norm don't sell. The consequence of our narrowness is that there is little if any difference between textbooks for a given course. Are we so used to "clone" computers that we now accept cloned texts?

Textbook publishers are going to extremes to get attention for their texts in these markets in which they cannot distinguish their books by differences in content and presentation. Many general chemistry texts are now being produced in four colors, a costly process that escalates the cost of chemistry textbooks beyond the means of poorer students. Is there a benefit from all that color? I think not. The literature seems to indicate that color may even be an impediment. If there is a benefit, it is surely less than the cost of running an entire book through a four-color press.

Equally damning is that while we embrace something as pedagogically "iffy" as four-color texts, we turn our backs on old practices that work. In all of our newer texts, numerous diagrams, drawings, examples, whatever, cut across pages thus providing impediments to the reader. Chopped-up textbooks are physically harder to read. At a time when we, as a profession, are decrying the declining mathematical and verbal skills of our students, we should be making our books easier to read rather than more difficult. We should be requesting that text be wrapped around figures to lead the reader on. We should be judicious with the use of examples and the impact they have on readability.

We seem to be guilty of mistaking glitz for gold. We don't need cosmetic treatments for our texts. We need solid writers exploring new avenues of explanation. We need solid formatting based on sound educational practice rather than on marketing plans. By not allowing significant departures from "the standard" in our textbooks, we are not allowing experimentation with new and possibly better materials. We are not trying out new textbook techniques and paradigms that will help students learn. It is time for us to wake up and take a very close look at what we deem acceptable in our textbooks. *This Journal* has always provided a forum for such debate. I hope that teachers, writers, and publishers will participate. I urge you to.