Letters

Reaction to "Chemistry Is *Not* a Laboratory Science"

Stephen Hawkes has stirred us to reconsider whether, in fact, chemistry is a laboratory science by positing that lab work "does not enhance students' understanding of chemistry's centrality, but makes chemistry an irrelevance" *(1)*. This sweeping generalization of what some (maybe even most) labs do is further confounded by a fallacious premise; hence, the major thrust of the proposition likely will be—and well should be—viewed with utmost skepticism.

The assertion that "Chemistry is the combination of principles and facts that caused the formation of the earth and its layering, that governs the ecosystem…" is bad enough, but, following the assertion that "Chemistry existed before …there was life", it implies that the "principles" and "facts" are properties as substantial as matter itself. How many examples of rejected "principles" are needed to confirm that they are anthropomorphic creations, rather than inherent properties? And how many "facts" have to be modified, restricted in scope, or even retracted before they, too, are recognized as human efforts? If it is argued that such rejected concepts weren't really "principles" or "facts" (having been overthrown), then the argument requires that we have now reached the position of absolute knowledge of the physical world, in which case we should probably all go home and just let the computers figure out everything. At last report, that isn't quite the way things are working.

Labs don't have to be mainly cookbook experiments, although in baking a cake or doing a synthesis a tested set of directions is a great starting point. There are hundreds of labs now running that provide a realistic insight into what research is about, as a perusal of recent editions of this *Journal* will confirm. If non-majors are not included, that problem can be directly addressed, but there is also a continuing need for just the kind of lab experiment Hawkes has decried, namely hands-on experience. Among other benefits, a well-constructed lab course can provide opportunity to learn to keep accurate records of results in a research-type notebook; to write intelligible, cogent reports of the results; and to practice critical thinking through evaluation of experimental data. Suitably designed projects over several labs allow—make that *require*—students to apply concepts to new situations.

When computer programs can do all that, I would be ready to second Hawkes' call for their displacement of physical laboratories. That "the effectiveness…depends on the manner in which the work is taught" (quote by Hawkes from McKeachie) might well be considered axiomatic, but should it not be applicable to *all* phases of instruction in *all* areas? A better argument might be made that classroom presentations in many disciplines should be replaced by computerized lessons. Improving the effectiveness of the laboratory work in chemistry is where we should direct our efforts, rather than furnishing (even defective) ammunition to those already intent on finding less costly—and less effective—ways of learning an important aspect of this experimental science.

Literature Cited

1. Hawkes, S. J. *J. Chem. Educ.* **2004,** *81*, 1257, and reference to McKeachie therein.

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The author replies:

When the earth was formed there was much interaction between Lewis acids and bases to form rocks. Living organisms used DNA long before there were humans who could suspect its existence. That was chemistry and did not depend on laboratories and does not require us to duplicate the reactions in student laboratories. The principles and facts involved are not subject to revision. It is our obligation to pass our understanding of them to our students. That understanding is subject to revision, as Dr. Sacks irrelevantly points out.

The training of a nurse involves sufficient use of a syringe that he or she appreciates what one mL is, even if he or she did not acquire that perception in high school. There may perhaps be examples where chemistry lab experience improves the work of a non-chemist but even if they exist, this is not one of them.

Interpreting experimental results shown on a computer screen does not require consideration of whether the experiments were competently executed. This is an advantage over a lab course. Critical thinking skills and application of concepts to new situations are exercised by either computer-simulated or hands-on approaches. Computers can simulate many more situations than a student can execute, including experiments that students could not be trusted to carry out safely. Simulation could lead to writing a cogent lab report on the experiments shown and the conclusions drawn from them as Sacks suggests. Whether the teaching of chemistry to people who will never practice it should include interpretation of chemical experiments lies with the philosophy of the teacher. As does the question whether the objectives of such an exercise are met by the simple experiments that can be executed by beginning students.

A chemistry major needs to learn manipulative laboratory skills. It would perhaps be useful to explore just what manipulative skills he or she needs to learn, how we teach them, and whether they could be taught better or more easily. But we need to consider carefully how much of a non-major's time we expend learning those skills. This is especially important when so many departments require their students to take the chemistry major's course only because it is perceived to be a "better" course.

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