Chapter 2

THE HISTORY OF CHEMISTRY: POTENTIAL AND ACTUAL CONTRIBUTIONS TO CHEMICAL EDUCATION

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INTRODUCTION

What Does it Mean to 'Understand' Chemistry?

We define *understanding* as a dynamic epistemological status conferred on individuals by a consensually recognised referent group within a community of scholars, based upon criteria of intersubjectivity, parsimony, coherence, and conceptual transparency (Mintzes & Novak, 2000). Intuitively, teachers may think they 'know' that a particular instructional strategy has helped them in advancing their students' understanding of chemistry. However, the asking of a series of questions: are established meanings being used by the students?; is the teaching approach as simple as is practical?; is that approach internally consistent? ; can it withstand critical analysis?; can it yield external, community-based, less-subjective, indicators of student progress?, enable the teacher to judge the degree of advance in student understanding being achieved. Reform efforts, national standards, and qualifying examinations all presume that positive answers are possible.

The status of 'understanding' something is ultimately conferred by a group comprised of some recognised scholars of the day. However, in the case of the constructivist pedagogy-oriented chemistry classroom, the students themselves can model this process as well. They can arrive at agreement scientifically and collaboratively, under the teacher's watchful eye, with the teacher 'parachuting in' to assist as a last resort.

J.K. Gilbert et al. (eds.), Chemical Education: Towards Research-based Practice, 29–46.

What Is Meant by a 'Meaningful and Mindful' Understanding of Chemistry?

To understand something new, in a meaningful way, is to explicitly connect it to one's prior knowledge and experiences in a non-trivial way. This is in contrast to the opposite pole of a continuum: something learned verbatim, passively, by mere repetition, to be parroted on cue, and otherwise remain isolated in memory from any other knowledge to which it might relate.

Compatible with this view, Ellen J. Langer has written two books about what constitutes 'mindfulness' and about the value of 'mindful learning' is (Langer, 1989, 1997). Mindful learning, to Langer, means learning in ways that will make what we have learned more broadly transferable to new situations and thus continue to be useful both in meeting life's challenges and for further learning. She encourages learning by multiple approaches in varied contexts and from varied perspectives. This is to be done by use of a series of increasingly severe challenges, by taking multiple angles of approach to any piece of work, by varying tasks variations so as to minimise dependence on automatic responses, and by consciously monitoring one's current state of understanding or performance. She concludes that setting, and then enabling, an end-state goal of automaticity/routinisation of performance actually creates more problems than it solves, and that promoting fluid, flexible thinking, over a long-term, increases learning and performance levels. To Langer, the context of *how* we learn something is as important as *what* we learn.

We think the history of chemistry can help chemical educators to develop, use, and investigate materials and strategies that promotes learning in chemistry that is both meaningful and mindful. We agree with D.B. Gowin's definition that learning is a change in the meaning of experience (Gowin, 1981). The overall objective of chemical education is to help students to construct a meaningful and mindful understanding of the nature of matter and changes in matter. If this is so, then knowing from whence these ideas came, how they were constructed over time, how the record of human 'struggles to understand' can illuminate how we know what we know today, will only help learners. They will be enabled to *link* newly-learned chemical concepts and principles both to their prior knowledge and to the collective historical knowledge of the global chemistry community (Nakhleh, 1992; Wandersee, 1992).

THE HISTORY OF CHEMISTRY IN CHEMICAL EDUCATION

What Are the Key Issues About Infusing History of Chemistry into Chemistry Curricula?

Justi and Gilbert (1999), reflecting on Matthews' work (1994), summarise four arguments that support the case for a greater role for the history of science, and indeed the philosophy of science, in science education. The purported advantages are that doing so:

1. teaches students about the nature of science,
2. enables teachers to exploit any parallels between the development of personal subject matter knowledge and the historical development of subject matter knowledge,
3. enhancing students' capacities for critical thinking, and
4. enables teachers to readily address practical problems of instruction, such as the cogent organisation of course content and the facilitation of the cross-curricular integration of knowledge.

They see such advances as being dependent upon the presence of reference to sound historical sources and, insightfully, upon the warrant of a coherent triad of underlying rationales: an epistemological rationale, an ontological rationale, and a content rationale.

While compelling and preponderant research evidence for the inclusion of history of chemistry in the chemistry curriculum may be missing or scattered (Duschl, 1994), there is surely enough supporting evidence to justify further attempts to do so. Much of the research that has been peer-reviewed and published is prescriptive of approach, rather than being descriptive of implementation and bulwarked by evidence of effectiveness. We may be currently limited by this imbalance, but we hope that chemists and chemistry instructors will increasingly document their experiences in publication form. This has been done in the case of the inclusion of history of calculus in a traditional calculus course (Katz, 1993). Similar integrations were achieved by the use of pedagogical insights derived from the actual historical development of the physics concept of work (De Berg, 1997) and in the case of the injection of the history of phlogiston into a chemistry course (Allchin, 1997).

What Obstacles May be Encountered?

Naturally there are constraints that will impede the incorporation of history into the chemistry curriculum. Many of these will be the concerns usually voiced about new and potentially effective interventions of all types. These

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