

**Georgios TSAPARLIS**

*University of Ioannina, Department of Chemistry (Greece)*

## PREFACE TO THE SPECIAL SECTION

This Invited Special Section is the second and last of the series *Contributions of Educational Research to the Practice of Chemistry Education*. It contains three contributions by *Robert Bucat*, *Peter G. Mahaffy*, and *Avi Hofstein*. In their position papers, Bucat and Mahaffy deal with the connection of the *content of chemistry* with *the learner*. Bucat calls for the use of *pedagogical content knowledge*, while Mahaffy proposes the metaphor of ‘*tetrahedral chemistry education*’. Hofstein, on the other hand, reviews educational research on the role of laboratory in chemistry education.

### **Chemistry Content Knowledge and Pedagogical Content Knowledge**

Quoting from Herron and Nurrenburn (1999), I have previously pointed out (Tsaparlis, 2004), that chemistry education research focuses on “understanding and improving chemistry learning” by studying variables relating to “chemistry content” or to “what the teacher or student does in a learning environment.” It involves “a complex interplay between the more global perspective of the social sciences (i.e., the process of learning) and the analytical perspective of the physical sciences (i.e., the content)”. I have to comment here that these two perspectives are not independent of each other: knowledge of the *content* is a *necessary* but *not sufficient condition* for teaching chemistry (or any other subject); it is knowledge of the *process of learning* and *the learner* that provides the *sufficient condition*.

**Robert Bucat** maintains that “chemistry education research seems uncertain of its direction, while the main priority of research is to see immediate benefits transferred into the classroom and teaching lab”. A way out of this deadlock could be that of *pedagogical content knowledge* (PCK), that is the combination of *content knowledge* with *pedagogical knowledge*. According to the author, conducting research on student conceptual difficulties or finding out these difficulties through experience is only one aspect of PCK. Another richer aspect is dealing with these difficulties in the classroom. “Currently in the teaching profession, the accumulated PCK of each of its participants grows with experience, peaks at retirement, and disappears - often with hardly a contribution to the collective wisdom of the profession”. This ‘professional amnesia’ afflicts science teaching.

**Peter G. Mahaffy** starts with the ‘diverse forces’ that “shape the teaching and learning of chemistry at the beginning of the 21<sup>st</sup> Century”, such as the “fundamental changes” brought about “by new interfaces and research areas, changes in our understanding of how students learn, ... the implementation of computer and information technologies”, ... “and external forces, such as global concerns about energy and water resources and the

environment, and the level of chemical literacy and public understanding of science". To respond to "those forces, new dimensions to learning chemistry must be emphasized". Mahaffy proposes '*Tetrahedral chemistry education*' as 'a new metaphor'. It is an extension of Johnstone's famous triangle of chemistry, adding the *human learner* to Johnstone's three levels of chemistry (macroscopic, submicroscopic, and representational/symbolic).

### The laboratory in chemistry education

Theory and experiment are two aspects of the science of chemistry that are not independent of each other, and yet in teaching practice they are treated as if they were independent. A considerable amount of research concerning laboratory and other forms of practical work at secondary school level has pointed at significant problems, notably the ineffectiveness of laboratory instruction in enhancing conceptual understanding. Problematic also is practical work at university (essential for the training of chemists), being criticised for its 'cookbook' nature and the scarcity of inquiry-based activities.\* Lucid reviews of practical work in science are available (Hofstein & Lunetta, 1982, 2004; Johnstone & Al-Shuaili, 2001).

In this special section, **Avi Hofstein** reviews the contribution of educational research to the examination of the role of laboratory in chemistry education, with particular emphasis to his thirty years of relevant experience and research work. Throughout these years of involvement with "all facets of chemistry curriculum in the upper secondary schools in Israel", he covered most of "the domains that characterize practical work in the context of chemistry laboratory". In this paper, the author reviews the following aspects: (1) The chemistry laboratory: A unique mode of learning, instruction, and assessment. (2) Assessing students; performance and achievement using different modes of presentation in the chemistry laboratory. (3) Students' attitude towards and interest in school chemistry laboratory work. (4) Students' perceptions of the laboratory classroom learning environment.

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\* I take this opportunity to mention here a recent relevant work of mine, that implemented a modification of a conventional expository physical chemistry laboratory to accommodate an inquiry/project-based component (Tsaparlis & Gorezi, 2004).