CHEMISTRY EDUCATION: **EDITORIAL 2***
RESEARCH AND PRACTICE IN EUROPE
2000, Vol. 1, No. 1, pp. 5-7

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CHEMISTRY AND SCIENCE EDUCATION VERSUS EDUCATION: A TOP-DOWN AND BOTTOM-UP RELATION

** This is the text of the short introduction to the 5th ECRICE by the author in his capacity as chairman of the organising and advising committees.*

It is well known that the public may not be so interested in chemistry, let alone chemistry education, but quite often they are interested quite a lot about education in general. They talk about it as one of the greatest investments for the future. They worry about the school systems, the methods of teaching, and the quality of the teachers of our children. In the final analysis, how useful is educational theory, how useful are the various *didactics*, in our case chemistry and science education?

A top-down and bottom-up process

Science educators, through research, have considerably advanced our knowledge on how learners learn chemistry and science in general. By applying theories and methods of research from other disciplines (cognitive psychology, education, sociology, epistemology), that is by working in a top-down mode, they are leading our field into maturity.

At the same time, the reverse process, a bottom-up procedure is taking place. By carrying out investigations on how students understand the concepts and problems of chemistry, we are in a position not only to suggest better methods of teaching and learning of the chemical concepts themselves, but *also*, we lay the foundation for new methodologies that can be applied to other school subjects, as well as to the whole educational process. Our ultimate target, our ultimate mission, is to reshape, to restructure not only chemistry and science education, but also all education. If our fellow educators working in other fields (physics, biology, mathematics, language, history etc.) do the same, then some more fundamental change would be expected.

According to Professor *Uri Zoller (*5th ECRICE/plenary lecture):

> "*Modern life is a continuous process of problem-solving and decision-selection (making) from available or created (by technology, in most cases) options. Informed action requires the application of value judgments by socially-responsible, rational, active participants. The preparation (therefore) of students for rational, intelligent, responsible, active participation in the democratic, decision-making process is a major objective of sound education at all levels."*

Are all the above easy and feasible? Unfortunately it is not at all easy. In a recent study by Professor *Richard Kempa*, in Britain and Spain, which is published in this issue of *CERAPIE* as a *research communication*, it was found that teachers do not know much, nor they apply in teaching practice pedagogic and educational methods that are suggested in the literature. The large majority applies, as a rule, personal methods.

We have therefore to make a jump: the findings from research and the recommendations of educational researchers must find their way into everyday school practice.

The *5th ECRICE* included one hundred and one (101) contributions, involving one hundred and thirty five (135) authors. These were not only chemistry and science education research contributions, but they also referred to educational practice. The delegates were not only educators. Among them there were also researchers in chemistry itself, but - most important - *among them there were secondary teachers of chemistry*. All in all then, we hope that *5th ECRICE* has contributed to the attainment of the common target.

A diversion to chemistry education

Finally, let us focus more closely on chemistry, as a prelude to the opening plenary lecture by Professor *Mansoor Niaz*. Chemistry is the *molecular science*: a sub micro-world of molecules, atoms, and electrons. The revolutionary concept of the corpuscular nature of matter, that is of *atoms-molecules*, together with the equally revolutionary concept of *vacuum* (because one needs the vacuum if one should allow atoms-molecules to move) were first proposed by the ancient Greek philosophers *Leucippus* and *Democritus*:

> "Leucippus and Democritus consider as basic elements (*stoicheia*) the complete (*pleres*) and the void (*kenon*), the first existent (*on*), the second non-existent (*me on*), one filled (*pleres*) and solid (*stereon*), the other empty (*kanon*) and thin (*manon*). These two are the causes (*aitia*) of what exists (*on*) as matter (*hyle*)."
>
> Aristotle, *Metaphysics*
> A΄ 4.985β4

<< ΛΕΥΚΙΠΠΟΣ ΚΑΙ ... ΔΗΜΟΚΡΙΤΟΣ *ΣΤΟΙΧΕΙΑ* ... ΤΟ *ΠΛΗΡΕΣ* ΚΑΙ ΤΟ *ΚΕΝΟΝ* ΕΙΝΑΙ ΦΑΣΙ, ... ΤΟ ΜΕΝ *ΟΝ* ΤΟ ΔΕ *ΜΗ ΟΝ*, ... ΤΟ ΜΕΝ *ΠΛΗΡΕΣ* ΚΑΙ *ΣΤΕΡΕΟΝ*, ΤΟ ΔΕ *ΚΑΝΟΝ* ΚΑΙ *ΜΑΝΟΝ* ... *ΑΙΤΙΑ* ΔΕ ΤΩΝ *ΟΝΤΩΝ* ΤΑΥΤΑ ΩΣ *ΥΛΗ*>>

Αριστοτέλης, *Μετά τα φυσικά*
Α΄ 4.985β4

Chemistry then deals with a small world and at the same time a *large* world. That is both a privilege and a drawback! The positive side is the esoteric beauty of chemistry, for those who can see that beauty. A well-known Greek theoretical physicist, *Dimitris Nanopoulos*, was asked

recently about his favourite school subjects; they were mathematics and chemistry. In chemistry, he was impressed by the world of atoms. However, the molecular-atomic-electronic nature of chemistry is a large pedagogic drawback, the most important factor for its learning difficulties.

According to Professor *Alex H. Johnstone*, chemistry is characterised by three main components-levels: the *macro* level (learning about solids, liquids, metals, non-metals, acids, bases, fuels, etc.); the *symbolic-representational* that deals with symbols, formulae, and chemical equations; and the *sub micro* level of molecules, atoms, electrons. The first level (the macro) *is* concrete, tangible and accessible to the students. The other two *are not*; they are remote, abstract and complicated.

Teaching and learning about atoms and molecules is a heavy task for both teachers and pupils. Research in chemistry education has a lot to say about this! Professor *Niaz* is going to present a comparison of the teaching of the atomic structure as a rhetoric of conclusions and as heuristic principles. This comparison is going to be made from the history and philosophy of science perspective (Niaz, M., *Science Education,* 1998, *82*, 527-552).