Editorial

Environmental Chemistry:

The Disciplinary/Correction-Transdisciplinary/Prevention Paradigm Shift *

Uri Zoller**

University of Haifa, Dept. of Science Education and Chemistry, Oranim, Kiryat Tivon, 36006, Israel; e-mail: uriz@research.haifa.ac.il

The major problem of our so-called "Global Village" society is the unrealistic and/or unfulfilable expectations of people in a world of conflicting/competing values and interests, and finite, unevenly distributed resources. One of the ultimate results is the development of ever-increasing, over-consuming societies, particularly in the highly-developed countries, with all of the environmental consequences involved. The emerging battle cry, worldwide, is to "think globally and act locally" toward a sustainable world. This should be "translated" into policies that can lead to changes in the behavior of individuals, institutions, societies, governments and industries, and which will allow development and growth to take place within the limits set by ecological imperatives (DAVIS, 1993). This call for sustainable development – which means different things to different groups of people and societies – requires the selection of rational, but difficult choices which are to be made between either available or to be generated options or alternatives. Each such chosen and implemented alternative has its short and long-term consequences. In most cases, the long-term consequences have been ignored and not even pre-assessed, not only with respect to the environment but also with regard to people and societies with their frequently conflicting interests. In the process of the reorganization/redistribution of our resources/raw materials via supply systems, industrial production, marketing and selling within the context of development, and the growth of highly developed, under-developed and/or developing societies, any environmental issue boils down to: who does what for what price, at whose expense and in what order of priorities. The challenge, therefore, is how to ensure a sustainable development. The problem is that although science and technology may be useful in establishing at best what can be done, neither of them, solely or jointly, can tell us what should be done.

Dealing effectively and responsibly with complex problems within complex systems in the context of science-technology-environment-society (STES) interphases, requires *evaluative thinking* and the application of value judgments by capable science, technology and sociologically literate, rational citizens within a continuous process of problem solving and decision making (ZOLLER, 1990, 1996). It further requires a revolutionary paradigm shift: from the contemporary dominating traditional compartmentalized, disciplinary corrective science and technology to system, transdisciplinary approach (SCHOLZ & TIETJE, 1999) in environmental problem solving, within a framework of preventive orientation in the related management of raw material exploitation, industrial, production and marketing practices, as well as environmental, technological and social policies within given, local, socio-economic-political constraints. This currently evolving paradigm shift is a precondition for sustainable development and growth (not necessarily materialistic/wealth accumulation), to take place within the limits set by ecological imperatives.

The initially developed idea of sustainability with respect to the "environment" was based on three requirements: the maintenance of life-support systems, the preservation of biological (genetic, species and habitat) diversity (i.e. biodiversity) and the sustainable use of natural resources (IUCN et al. 1980). This implies an active participation of people in the management of their own environment and quality of life to begin with. The word sustainable, so far, has been applied to such cases of natural resources and the disposal of used materials/waste that do not put in jeopardy the long-term survival of the environment containing such resources and related life-supporting systems; nor do they constitute a health risk. In short, the "translation" of the above into day-by-day reality means that a sustainable development plan should balance the immediate economic and life quality benefits with the long-term effects on the availability, economical/technological feasibility and supply of resources which are safe to use (LESAGE & ZOLLER, 2000). The resolutions of such complex environmental problems will require a comprehensive consideration of the system as well as multidisciplinary systemic approaches (JORGENSEN, 1999; SUK et al., 1999). No longer would it be possible to

* DOI: http://www.dx.doi.org/10.1065/espr2000.03.019

** Dr. Uri Zoller is professor of Science Education and Chemistry at Haifa University – Oranim in Israel. He is a member of the FECS Division on Chemistry and the Environment and the first Chairman of its recently established "Subcommittee on Education in Environmental Chemistry (SEEC)".

focus solely on science, technology and classical marketability. Industrial ecology (chemistry included) is beginning to address sustainability through cross-disciplinary approaches and meta-disciplinary partnership (GRAEDEL, 2000).

In order to 'get it right', it is our contention that the reconceptualization and reclarification of distinctions concerning some of the fundamental, consensusally accepted concepts (and not surprising, derived slogans) which serve to guide chemical enterprises and chemical education in their response to the sustainable development/ "green" chemistry and clean technology challenges are in place .

What is in store for us concerning the sustainable development-environment-environmental chemistry challenge? Clearly, future developments and trends are contingent on the way that the relevant "guiding models" are going to be conceptualized.

Given (a) the environmental imperatives and (b) the limited economical feasibility of many of even the most innovative and advanced technologies, the switch from the currently dominant *corrective* paradigm to the emerging *preventive* practice in production/development/consumption, is unavoidable. This requires a revolutionary change in the guiding philosophy, rationale and models of society and industry concerning

- consumption, wants or needs, at whatever cost?
- the higher consumption or production selling better?
- raising the standard of living equivalent to raising the quality of life?
- the response to market trends or generating/leading these trends?

and

- the reliance on disciplinary or transdisciplinary science, research-based technology for rational management and sustainable development.

The role of environmental chemistry in the context of both sustainable development and public appreciation will be determined by the rate and directions of this change. Industry commitment to "customers' needs", for example, is currently a centrally dominant concept. A clear distinction between customers' "wants" and customers' "needs" has to be made. The former leads to over-consumption which is not necessarily beneficial to the consumers, although it is perpetually and aggressively being promoted by 'growth and profits at all cost'-motivated industries and businesses with all the uncontrolled socio-environmental consequences involved. The latter, however, should be targeted and responded to by responsible, environmentally-concerned industries, including the chemical industry as well. Only the orientation of people's *needs* offers the chance (albeit it is not guaranteed) of meaningfully contributing to sustainable development, not only in developing countries, but also in highly developed western countries. 'Needs'-orientation is mainly a promoter of life quality, having a consumption delimiting potential. 'Wants'-orientation, in contrast, is a standard of living promoters which is not only consonant with the existing trend of ever-increasing over-consumption but, in most cases, further accelerates the pace of this trend. The environmental consequences of over-consumption are apparent.

With respect to science and technology, virtually any discussions concerning the current and future state of scientific and technological research, and problem-solving, is typified by statements about the importance of enabling researchers and engineers to work seamlessly across disciplinary boundaries and declarations so that some of the most exciting problems, particularly the complex systemic environmental ones, span the disciplines. Moreover, transdisciplinary, applied research evolves from real, complex problems in the interdisciplinary STES context, which are relevant to societies living in different environments (SCHOLZ, 1999). Such problems have no disciplinary algorithmic solutions, or even resolutions. Yet, ironically, science and technology are becoming more specialized as researchers and engineers continue to focus their expertise into narrower fields of inquiry. It is growing increasingly difficult to establish the transdisciplinary basis necessary for addressing complex environmental problems. Therefore, the challenge for this kind of target-oriented research and technology development is to develop problem-solving methodologies which not only integrate different qualities and types of knowledge, but also envision the researchers and engineers (non-objective "insiders") as an integral part of the investigated system; or the system which is to be remediated ("corrected"). Sustainable development via appropriate environmental management and, in accordance, industrial production, marketing and business policies, are thus highly dependent on transdisciplinary research and development in the STES context. This will facilitate transfer beyond the subject(s) or discipline(s) specificity and, consequently (hopefully), a higher success in coping with previously unencountered complex problem situations. The relevance to environmental chemistry is clear.

In view of the compartmentalized disciplinary orientation in science and technology research and development (R&D), and the corrective approach in dealing with point and diffuse pollution problems in the different compartments of the environment, the lack of strengthening the links between the social/behavioral sciences, and advances in science and technology applied in different socioeconomical, cultural and environmental contexts, is of no surprise. However, the prevention approach to ensure environmental quality and the restoration of ecosystems requires, most of all, appropriate and responsible environmental behavior and action on the part of producers, scientists/engineers, and customers/citizens alike which, in turn, is contingent on an adequate environmental education (KEINY & ZOLLER, 1991). This implies an urgent need of strengthening the social and educational components within the corrective to preventive paradigm shift processes concerning the sustainable management of our environment. Therefore, a major goal of sustainable, development-promoting science, technology and chemical education, and training at all levels, should be the development of students' higher-order cognitive skills (HOCS) in the context of both the specific content and processes of science, as well as the processes/interrelationships related to interdisciplinary transfer capabilities. This means rational, logical, reflective and consequential EVALUATIVE THINKING in terms of what to accept (or reject) and what to believe in, followed by a decision - what to do (or not to do) about it, and responsible action-taking which follows accordingly. Thus, any meaningful response to the current leading challenge of sustainable development requires transdisciplinarity essentially by definition; that is, the development and implementation of policies and cross-disciplinary methodologies which can lead to the changes in the behavior of individuals, industries, organizations and governments, which will allow development and growth to take place within the limits set by ecological imperatives. The educational challenge is rather clear. It is a precondition for the required reconceptualization which, in turn, will ensure sustainable development and growth. We are dealing with an array of very complicated problems within a complex system, the components of which are natural, man-made and human environments and their related subsystems. Most of these problems have no "correct" solutions (definitely not algorithmic), but rather resolutions that can be worked out via the use of appropriate methodologies, simultaneously guided by a sustainable, development-oriented value system.

The disciplinary/correction-transdisciplinary/prevention paradigm shift concerning STES issues, the initial steps of which we are currently witnessing, are crucial for both sustainable development and our survival on planet earth. As far as environmental chemistry is concerned, this reconceptualization-based paradigm shift has to be translated into "sustainable action", in the context of chemical education within contemporary and future chemical education and training. This will be dealt with in the next editorial of ESPR. In the meantime, responses, reflections, comments and ... whatever you may feel to be appropriate, are welcome.

Selected References

Davis, S.B. (1993): Needed behavioral change: Steps towards environmental security. In: N. Polunin and J. Burnett (eds.), Surviving with the Biosphere. Edinburgh University Press, Edinburgh

Graedel, T.E. (2000): The evolution of industrial ecology. Environ. Sci. & Technol. 34(1), 28A-31A

IUCN, UNEP & WWF (1980): World Conservation Strategy: Living resources conservation for sustainable development. IUCN, Gland, Switzerland

Jorgensen, S.E. (1999): Environmental management in the 21st century. Environ. Sci. & Technol. 33(17), 376A-379A..

Keiny, S,; Zoller, U. (Eds.) (1991): conceptual issues in environmental education. New York: Peter Lang

Lesage, S.; Zoller, U. (2000): What is sustainable remediation? In: U. Zoller, J.B. Carberry & S. Lesage (Eds.) Sustainable Remediation of NAPL-Contaminated Aquifers. New York: Marcel Dekker, Inc. (in print)

Scholz, R.W.; Tietje, O. (1999): Integrating knowledge with case studies. London: Sage

Suk, W.A.; Anderson, B.E.; Thomson, C.L.; Bennett, D.A.; Vandermeer, D.C. (1999). Creating multidisciplinary research opportunities. Environ. Sci. & Technol. 33(11), 241A-244A

Zoller, U. (1990): Environmental education and the university. The problem-solving-decision making act within a critical system thinking framework. Higher Educ. in Europ. 15(4), 5-14..

Zoller, U. (1993). Lecture and learning: Are they compatible? Maybe for LOCA, Unlikely for HOCS. J. Chem. Educ. 70(3), 195-197.

Zoller, U. (1996): The development of students HOCS – the key to progress in STES education. Bull. Sci., Technol. & Soc. 16(5-6), 268-272

Received and accepted: March 4th, 2000
Online-First: April 4th, 2000

FECS DCE

FECS (Federation of European Chemical Societies)
Division for Chemistry and the Environment (FECS DCE)

Committee Meeting in London on March 4, 2000

John V. Holder (Secretary FECS DCE)

Faculty of Science, University of Central Lancashire,
Preston PR1 2HE, England; e-mail: j.v.holder@uclan.ac.uk

Education in Environmental Chemistry
The Committee met in London on Saturday 4th March 2000 at Burlington House when the host was the Royal Society of Chemistry (RSC). The major theme of the meeting was Education in Environmental Chemistry. Prof. Miltiades Karayannis, Prof. of Analytical Chemistry, University of Ioannina, Greece and Chairman of the European Chemistry Thematic Network (ECTN) Working Group on Chemistry and the