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CHEMISTRY AND ENVIRONMENTAL EDUCATION

Environmental sciences are emerging as a new interdisciplinary scientific “discipline” and even beyond, within a process of distancing from specialized, compartmentalized, and disciplinary, into multidimensional, cross-boundary endeavor in the science-technology-environment society (STES) interfaces (Zoller & Scholz, 2003). This poses new challenges with respect to the intrinsic science and technology organization and to the way the relevant knowledge and processes will be put into action, guided by the superordinate idea[l]s of social responsibility and sustainability. Thus, the "battle cry" for sustainable development, worldwide, turns the latter into a major driving force in the rethinking and redesigning processes of STES-oriented science, technology and environmental education courses, programs, and assessment.

The essence of the current reform in science/chemical education, worldwide, is a paradigm shift from algorithmic/imparting knowledge-type teaching to higher-order cognitive skills (HOCS) learning. In the context of education in environmental chemistry (EEC), the ultimate target is the STES-literate graduate, capable of evaluative thinking, decision making, problem solving, and taking a responsible action accordingly. The issue is how to translate this goal into effective, implementable courses, teaching strategies and assessment methodologies, which are consonant with this goal of ‘HOCS learning’. Accordingly, the main recommendations of an International Workshop[1] – “Environmental Chemistry Education in Europe: Setting the Agenda” – were:

1. Environmental literacy requires the integration of environmental sciences into core chemical courses as well as the development and implementation of HOCS-promoting teaching strategies and assessment methodologies in chemical education.
2. The development of students’ HOCS for *transfer*, followed by assessment of ‘HOCS performance’; is the task ahead for meaningful EEC.

These require a change in emphasis in the way environmental chemistry is taught, – from a narrowly-focused applied analytical/ecotoxicological, or environmental engineering chemistry, to an interdisciplinary/multidisciplinary approach (Zoller, 2004). The essence of these challenges involves the dealing with uncontrolled complex global systems and the practicing of science, technology, research and education from social responsibility and open-ended culture perspectives. The main contemporary relevant paradigms shift have been identified and presented in the Table below (Zoller & Scholz, 2003, 2004).

[1] Sponsored/Organized by the Committee on Education in Environmental Chemistry (CEEC) of the Federation of the European Chemical Societies (FECS), Division of Chemistry and the Environment.

TABLE. *Selected paradigm shifts in environmental research and STES education.*

From:	To:
· Technological, economical, and social *growth* at all cost…	Sustainable development
· Corrective	Preventive
· Reductionism; i.e., dealing with *in-vitro isolated*, highly controlled, decontextualized components	Uncontrolled, *in-vivo complex systems*
· Disciplinarity	Problem-solving oriented, systemic, inter-/cross-/transdisciplinarity
· Technological feasibility	Economical-social feasibility
· Scientific inquiry (per se)	Socially accountable and responsible and environmentally sound
· Algorithmic lower-order skills (LOCS) teaching	"HOCS Learning"
· "Reductionist" thinking	System/lateral thinking
· Dealing with topics in isolation or closed systems	Dealing with complex, open systems
· Disciplinary teaching (physics, chemistry, biology, etc.)	Interdisciplinary teaching
· Knowing/recognizing/applying of facts and algorithms for solving exercises/tasks	Conceptual learning for problem solving and transfer
· Science & technology per se (in dealing with the environmental/sustainable development)	Integrative science-social science education in the STES interface context
· Teacher-centered, authoritative, frontal instruction	Student-centered, real world, project/research-oriented team learning

Ensuring sustainable development requires, to begin with, a radical change in the "environmental behavior" and "thinking environment" of individuals, groups, institutions, industry, social organizations, politicians, and governments. Therefore, *HOCS learning* constitutes a prerequisite. Thus, it requires a high level participation of scientists, engineers, economists, policy makers and, mostly, *evaluative thinkers* in the public at large. The question is how to contribute to this end in the context of chemistry and environmental education.

In view of the above, a 'call for papers' for a special Theme Issue of *Chemistry Education: Research and Practice* (CERP) was issued, inviting contributions on the theme of chemistry and environmental education of "two kinds: (a) research based, (b) practice-oriented papers, focusing on chemistry/science education-environmental education–environmental chemistry/ science relationships, and related (educational) issues in research, curriculum development and implementation, teaching-learning strategies, and assessment methodologies."

The following possible focus subjects for contributions have been suggested:

- Conceptual/theoretical frameworks.
- Science-Technology-Environment-Society (SETS)-oriented courses in chemical and environmental education.
- The common ground of chemistry and/or chemical education and STES-environmental education.
- The chemistry/environmental chemistry-science/environmental education relationships.

- The role of chemistry in environmental/STES education.
- The relevancy of environmental education in chemical education.
- Higher-order cognitive skills (HOCS) in environmental chemistry and STES education.
- Science and non-science students in environmental chemistry courses: Is there a problem?
- The nature (and future?) of integrated/combined STES-oriented courses.
- Chemistry and environmental education in the social context.
- Interdisciplinary/integrated environmental chemistry and science/STES education courses/curricula and/or special programs at all levels.

This peer-reviewed special Theme Issue is the result of the above call. It consists of seven papers, contributed by Eichler, Lubezky, Morgil, Petrou, Schallies, Scoullos, Tal, et al., constituting a spectrum of appropriate responses to the above subjects in different contexts. As such, they contribute meaningfully, so we believe, to the research, theory and practice in chemistry and environmental education, education in environmental chemistry and STES-oriented science education. The time is ripe for taking action accordingly in chemistry education.

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