A CERG Seminar Summary

THE LOCS TO HOCS PARADIGM SHIFT IN SCIENCE EDUCATION: WHAT DOES IT TAKE?

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The essence of the current reform in science education, world-wide, appears to be a purposed effort to foster/develop students' higher order cognitive skills (HOCS) capability at the expense of the current dominant 'delivery' of lower-order cognitive skills (LOCS) and knowledge. This is reflected in the increasing shift in educational practice, from conventional algorithmic *teaching* by teachers, to 'HOCS *learning*' by the students. This learning takes place through question *asking*, critical thinking, system thinking, lateral thinking, decision making and problem (not exercise) solving; leading hopefully to evaluative thinking and, ultimately, the application and *transfer of knowledge*.

In accord with the above, the super-ordinate goal of our longitudinal research work and teaching practice has been the preparation of students, particularly science students, for rational, intelligent and responsible *active* participation in the democratic decision-making process in whatever role they might play in society. Our guiding rationale can be summarised as follows:

1. People have too high expectations in a world of conflicting/competing values and *finite*, unevenly distributed resources.
2. Modern life is a continuous process of problem solving and decision-making (PS-DM), and decision-selection among options (whether these options already exist, or need to be generated in situ).
3. Although science and technology may be useful in establishing what we can do, neither of them can tell us what we *should* do; the latter requires the application of *evaluative thinking* by socially responsible science-technology-environment-society (STES) literate rational active participants.

Given (a) the environmental imperatives, and (b) the limited economical feasibility of many of even the most innovative/advanced technologies, then a series of related paradigm shifts become unavoidable in the STES context:

correction => prevention
'wants' => needs
standard of living =>life quality
disciplinary => interdisciplinary

This process in turn, will be (and to some extent already is), reflected in the LOCS-to-HOCS paradigm shift in science education.

Given that the ultimate instructional educational goal of the HOCS-orientation in science education is the science/STES-literate student, capable of the 'STES PS-DM Act' (Zoller 1990, 1993), the issue is *how to translate the HOCS-promoting goals into manageable, teachable, STES-oriented courses and curricula*. This needs teaching strategies and an approach to assessment that will foster the goal of 'HOCS learning'.

Our research has been guided by the following questions:

- Does contemporary science teaching foster our students' capability of evaluative-critical system thinking in PS-DM situations?
- Is the goal of HOCS learning attainable, and if so, how?
- Are HOCS capabilities developed in one disciplinary context transferable into interdisciplinary contexts?
- How can we assess, qualitatively and quantitatively, students' progress and achievements on the different components of HOCS learning?

These and related questions raise a wide spectrum of issues, and seem to invite different responses depending upon context. In particular we seek research-based responses to the question:

How do we implement the LOCS-to-HOCS paradigm shift in science education in terms of teaching strategies and assessment methodology?

The essence of our three recent relevant national/international research projects was presented (at the CERG seminar at King's College) and critically discussed in terms of educational feasibility, transferability and goal attainment. These studies are:

1. '*Decision-making in the Science Teaching – Learning Context: The Teacher Perspective*' (Ben-Chaim, Herscovitz & Zoller, 2002)
2. '*Israeli, Italian, Greek and American University Science Students' Dispositions Towards Critical Thinking – A Major Component of HOCS*' (Zoller & Ben-Chaim 2001)
3. '*College Students' Self-Assessment in Chemistry Examinations Requiring Higher and Lower Order Cognitive Skills; An Action-Oriented Research*' (Zoller, Fastow, Lubezky & Tsaparlis, 1998)

Discussion of the results and conclusions of these studies, and their implications for HOCS-promoting science teaching and learning is beyond the scope of this summary. However, with respect to our key question (i.e., how do we implement the LOCS-to-HOCS paradigm shift in science education in terms of teaching strategies and assessment methodologies) these studies would suggest that the switch from the contemporary dominant algorithmic teaching to conceptual HOCS learning needs to be complemented by:

- restructuring of chemistry/science education at all levels/and science teacher training programs as well;
- teaching of how to deal with interconnected complex systems and situations;
- a much greater emphasis on inter/cross-disciplinarity in chemistry/science teaching;
- the development and implementation of instruments and methodology for contextually bound HOCS assessment.

This set of changes can be envisioned as the first necessary steps, from within education, on a path leading to changes in behaviour of individuals, institutions, industries, organisations, governments, and societies: changes that will allow development and growth to take place within the limits set by ecological imperatives.

Selected references:

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