Supporting 'HOCS Learning' via Students' Self-assessment of Homework Assignments and Examinations

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The essence of the current reform in science education, worldwide, is the shift from the contemporary dominant traditional algorithmic lower-order cognitive skills (LOCS) teaching, to the higher-order cognitive skills (HOCS), promoting *learning*; that is, the development of students' capabilities of question-asking, critical/system-*evaluative thinking*, decision-making, problem (not exercise) solving and *transfer* within both the science disciplines and real life interdisciplinary situations in the science-technology-environment-society (STES) context (Zoller, 1999). Clearly, such a paradigm shift in the educational goals of both teaching and learning of science requires not only the application of new teaching strategies but also *alternatives* to traditional assessment strategies; that is, new examination and evaluation methods which are not only consonant with the new goals, but also foster them (Zoller, 1993; 1999; 2001).

A major issue of concern is the development and implementation of appropriate teaching and assessment strategies which would indeed support and promote effective 'HOCS learning' in traditional disciplinary science courses at all levels (Zoller, 1997). Within our longitudinal research-based and teaching experience-based efforts to promote our science major students' HOCS, we have incorporated, among others, the following four teaching-learning assessment methods in our freshman introductory, general and organic chemistry courses:

1. Self-study of pre-class lecture material; namely, students who have the course outline, scheduling, objectives, requirements and assignments in their hands, self-study the relevant 'material' *before* it is 'covered' in the class, to which they bring *their* questions for discussion

2. No specific course textbook(s) are assigned; rather, the students are provided, at the beginning of the course, with a list from which they can choose textbooks and reference books, to use for the study of any relevant topic, as they find appropriate for their needs, during the course

3. Several homework assignments — mainly problems (not exercises) which require HOCS for their 'solution' (e.g. Zoller *et al*., 1997) — to be worked out by the students (preferably in groups) and submitted, *individually*, for feedback and grading by the teaching assistants, former 'graduates' of these courses

4. Students' self-assessment (Zoller *et al*., 1997) of their home assignments, pre-guided by the course professor. Needless to say, all the exams in these courses are of the open-book/HOCS-type (Zoller, 1997) which not only are consonant with this approach, but also promote 'HOCS learning'.

A pre-condition for successful HOCS-promoting teaching, is the provision, — to be made for students — to actually experience and practise these strategies. Indeed, this is the essence of the approach described here. The implementation of these strategies was closely, formatively and summatively, followed by action-type research. The results of one related 'case study' are given below.

The average students' grading of one of their mid-term HOCS-oriented homework assignments, in a freshman Introduction to Modern Organic Chemistry course for biology majors, was 82.8 (out of 100), whereas that of their teacher assistants in the same course was 83.8. Similarly, the average students' self-assessed score on their final oral exam, in this course, was 79.4 (out of 100), compared with 78.8 of their course professor (author of this article). The above, as well as other related studies, suggest that although the road to 'HOCS learning', in terms of conceptual learning, critical system thinking, problem solving, evaluative thinking and transfer in the higher education context, is rocky, it is attainable (e.g. Zoller 2003). It can and should be done.

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Biography

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