The Nature of the Ideal Environmental Science Curriculum: Advocates, Textbooks and Conclusions (Part II of II)

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Introduction

This is the second of two articles examining the nature of the ideal curriculum in K-12 environmental science education[1]. The notion of curriculum orientation is an interesting one with the most basic curriculum taxonomy containing three distinct types -- "ideal," "intended" and "received" (Cuban, 1992). The "ideal" curriculum is the one recommended or required by key members of the education hierarchy. The "intended" curriculum is what students are provided through the classroom experiences and the goals held for instruction by the teacher. The final version is the "received" or "learned" curriculum as experienced by the students themselves. As you can imagine, there are many filters in operation that modify the "ideal" curriculum into the "received" form.

The first of the two articles in this series (McComas, 2002) provided an overview of the history of ecology education along with a summary of the empirical studies that reveal students' misconceptions about environmental subjects. In addition, readers were acquainted with a summary of the ecology content recommendations from environmental scientists and contained in the National Science Education Standards (NSES). This article concludes the review of the ecology education literature by looking broadly at two additional information sources. The ecology content included in every major current secondary school biology textbook is summarized here along with recommendations for education from one of the principle environmental advocacy groups. Coupling these suggestions with those found in the previous article will provide significant insights into the nature of the ecology curriculum.

The goal of this project has not been to describe the kind of exhaustive ecology curriculum that might be found in a high school environmental science elective class or the semester-long equivalent in a university setting. Rather, this project has focused on what ecology elements should be included within the context of a traditional yearlong biology course and to a lesser extent what might be woven throughout the complete K-12 school experience. One hope is that educators will use this proposal for the "ideal" ecology curriculum as a way of evaluating their existing coverage. Perhaps this review will recommend some enhancements in the scope of the content included and in the skills and experiences provided to students to assist them in making environmental decisions.

Biology Textbooks and Ecology Education

In an attempt to elucidate the nature of the intended or ideal curriculum every major current biology text designed for secondary school students was reviewed. The number of pages of ecology content, the nature and extent of ecology readings and laboratory activities

[1] The terms "ecology education" and "environmental education" frequently have somewhat distinct meanings (a point that will be addressed at the conclusion of this article), but are used as synonyms in this article.

included in each text were noted. The specific content analysis itself consisted of a grounded strategy in which the books were reviewed individually without any prior expectation about what the books would contain. This resulted in a list of the ecology content included in all of the texts. This content list was then developed into a general checklist that was used to review all of the books again. This second review included a qualitative estimation of the extent of the content inclusion. The label *minimum* is used if the content appeared at a level less than in other texts with *extensive* used if the content appears at a greater level than is typical in the overall set of books reviewed. The results of this review appear in Table 1 and 2.

It should be noted that this content review focused solely on the degree of inclusion of particular content elements; there was no check on whether the content is appropriate for any particular audience or is scientifically accurate. With respect to this last point, it is useful to note that in a comprehensive study of the ecological concept of *succession*, Gibson (1996) found that many current biology texts feature both incomplete and outdated treatment. His conclusion was that even though a textbook contained information about succession, there was no guarantee of its accuracy. Clearly, content accuracy is important not just from the perspective of the textbook itself, but also from the standpoint of what is discussed in classrooms and internalized by students.

This content review of texts is both current and comprehensive but is not unique. Wilson (2000) analyzed biology textbooks to determine the extent of the inclusion of ecology topics through time. However, she used a different content unit in her work. For example, in the analysis reported here ecology topics such as *succession* and *habitat* were noted but Wilson was primarily interested in suggestions made regarding the role that students ought to take toward environmental issues and in content such as *forest* and *wildlife conservation*, *insects*, *birds* and *energy*. Using her rubric, she found that, "By the 1990s, the EE [environmental education] content [had] leveled off at approximately 10% of the text" (Wilson, 2000, p. 102). Here using a different unit of analysis, of those books that included a discrete section for ecology, this examination revealed that the current biology text devotes 9.7% of its pages on average to environmental science. So, two different researchers using two different ecology-related foci both found the level of environmental science included in the average high school biology texts at approximately 10%.

An examination of Table 1 reveals much about what current textbooks contain and present as the ideal ecology curriculum. The most striking conclusion is that the majority of the secondary biology texts contain very similar environmental science content -- although not all to the same degree of comprehensiveness. 10 of 13 books reviewed have a discrete chapter or section addressing ecology with the remaining texts integrating such content. Not surprisingly, the texts designed specifically with a ecology focus (*BSCS: An Ecological Approach* and *Biology: A Community Context*) take this integrative approach. Many have argued that synthetic topics such as ecology and evolution should be woven throughout the text. Almost half of the books include ecology in a discrete chapter or two at the end of the text almost guaranteeing that this important content will be relegated to coverage at the conclusion of the school year -- if time remains. One inescapable conclusion is that integrating environmental science content or including it earlier in the text could encourage its inclusion in the biology classroom.

As a broad generalization, all of the books examined include a measure of environmental science content. It was not a goal of this study to rank one book against another and I have resisted the temptation to do so. However, it is clear that some books present a richer and more comprehensive view of this scientific discipline than do others. In addition, some books add the important element of eco-ethical decision making while others stick very close to a fact-only approach.

Laboratory Instruction and Ecology Education

There is no doubt that the most robust and complete environmental science education program would include laboratory inquiry of ecological principles. Not surprisingly most of the texts reviewed supplied such opportunities by including a variety of ecology-related laboratory activities. In fairness, only the texts themselves were analyzed and it is likely that additional exercises were provided in the supporting materials including laboratory manuals that frequently accompany texts. However, it was revealing to see what the texts offered in the way of environmental science laboratory activities. First the theme of each included laboratory activity was listed and then grouped into categories similar to those developed for the content analysis. Table 2 provides the results of this examination of ecology laboratory exercises contained in the textbooks reviewed.

The most common activities provided address population size, population interactions such as competition and predation, biodiversity and aspects of environmental harm caused by human action such as pollution. For reasons that are not entirely clear, a surprising number of exercises targeted aspects of composting. Several of the texts included activities related to decision making with titles such as "Is everyone pleased with conservation efforts?, "A study of local human impact," and "Making decisions about land use." No book contained a full range of hands-on explorations linked to each of the major environmental topics, but some texts were more inclusive than others.

It is important to conclude this section with the same kinds of warning that were shared with respect to the textbook content reviews. The inclusion of labs in the science classroom is very much at the discretion of the teachers. Just because an activity appears in the text is no promise that it will be used in class. Laboratory work can be designed in many ways from the "cookbook" to the "true exploration" depending on the nature of the activity itself and when it is used with respect to the discussion of the content material. Most experts recommend that laboratory activity introduce rather than simply reiterate content discussions.

Instructional Goal-Setting by Advocates of Environmental Education

It has been useful to examine the guidelines for ecology education developed by the North American Association for Environmental Education (NAAEE) – one of the major advocates for environmental education. The NAAEE guidelines for excellence (NAAEE, 2002) in environmental education (K-12) are framed around several strands (Questioning and Analysis Skills, Knowledge of Environmental Process and Systems, Skills for Understanding and Addressing Environmental Issues and Personal and Civic Responsibility). Each strand is further subdivided with specific objectives and examples for students at grades 4, 8 and 12 with an appendix targeting such learning at the local level.

All of the guidelines were reviewed without regard to grade level and the recommendation for each specific content inclusion is noted in Table 1. The reader of the NAAEE guidelines is first struck by the lack of scientific vocabulary used in the main set of standards. Scientific terms such as community and food chain/web and others are not typically used in the guidelines but the concepts they represent are implied. For instance, learners are asked to understand that the living environment is comprised of interrelated dynamic systems. This term contains many elements of the concept of community, for instance.

The NAAEE standards are most comprehensive when it comes to action taking. Standards include the recommendation that learners understand the influence of group action on the environment, the role of political and economic systems, global impacts and links and the role of technology on the environment. There is also an extensive set of standards focusing on the skills necessary to take action. Such skills include the application of information and analysis to investigate environmental issues, skills in decision-making and citizenship, and issues related to the rights and responsibilities of citizens toward the environment. It is clear that the NAAEE guidelines emphasize the social responsibilities and action elements association with the study of the environment. Therefore, perhaps they have consciously decided not to concentrate on the underlying scientific aspects of ecology since those aspects are well described in traditional texts.

Another important role played by ecology-advocacy groups is that of curriculum development. There are few other examples in science instruction were one would be well advised to look beyond the traditional textbooks and laboratory manuals for sources of curriculum support. Environmental advocates have developed a wide range of supplemental curricula from local models developed at nature centers to the well-respected *Project Wild,* available nationally. In addition, these advocacy groups actively promote the teaching of ecology by providing teacher-training opportunities.

Conclusions and Recommendations

This review has revealed much about the nature of ecology education for K-12 learners. Knowledge of ecology makes use of many diverse scientific principles while helping to tie these principles together in a synthetically while providing explanations and the foundation for accurate predictions and informed decision making. In this fashion, ecology provides a thread linking together various sub-domains of biology in a way similar to that played by the study of evolution.

In addition to its potential to unite the biological sciences, environmental science also shares another attribute with evolution, that of controversy. Environmental science is frequently confused with environmentalism. There seem to be at least two contrasting visions of the focus of environmental education. First there is the "concept" orientation in which students are asked to learn the underlying scientific principles associated with the environment. The second orientation might be considered the "action" focus in which learners are encouraged to become involved in environmental activism. Not surprisingly the first agenda is frequently held by more traditional educators and offered in textbooks and formal science standards. The second view is more likely to be reflected in the goals provided by advocacy groups. In fairness, these are the polar positions and one can find some elements of either focus in almost all recommendations for the teaching of ecology topics from any source.

In this paper, the terms "environmental" and "ecology" have been used synonymously but a careful reading of all of the curriculum recommendations reveals a subtler distinction in the use of these words. Those in the "concept" camp are more likely to talk about ecology or environmental science whereas the "action" group seems to prefer the term "environmental." A recent investigation of teachers' attitudes toward environmental education by Holsman (2002) demonstrates that point strongly

> There was almost no immediate recognition by the study group [of teachers] of the value of environmental education (EE) for achieving general learning goals. The most apparent implication of the results suggests that the best way to talk about EE is to not call it EE. While this suggestion may strike some . . . as unacceptable, we should at least not lead with references to the phrase and instead stress the specific outcomes with education professionals. (p. 22)

This issue of "concept" versus "action" aside, when the various data sources are taken as a whole the shared goals for the study of ecology in the K-12 instructional setting and particularly in secondary school biology classes are clear. The ideal ecology curriculum for the K-12 learner would be driven by the rationales provided by the Tbilisi conference delegates (McComas, 2002) to the UN conference who were among the first to address the issue of environmental education (UNESCO, 1977). The survey of environmental scientists conducted by Cherrett (1989) (Table 1 in McComas, 2002) share many recommendations of the National Science Education Standards (NSES) (Table 2 in McComas, 2002). The review of current biology textbooks also demonstrates a strong sense of shared goals. Together, these document provide a strong recommendation for the nature of the ideal ecology content curriculum. In fact, the ecology domains provided here in Table 1 would stand as a worthy set of potential content goals in the general biology class context, but work remains on the depth of coverage of these issues and the place of these concepts earlier in the K-12 education continuum. The NSES are particularly helpful because this document provides recommendations for the placement of key content elements throughout the K-12 curriculum and emphasizes population ecology and human impact as overarching elements of environmental science instruction.

However, content recommendations are not enough. The ideal ecology curriculum should be guided by the recommendations of the NSES for the application of authentic inquiry through laboratory investigations (see Table 3). NSES also advocates the delivery of science content through the spiral approach whereby important concepts are revisited at several points at higher levels of complexity in the learners' school career. In addition, it is vital that the ideal ecology curriculum must be informed by the action-taking goals of the NAAEE guidelines. Strong decision-making strategies and role-playing activities should be included to provide guidance and experience in making environmental decisions. The environment can only be understood by appreciating the underlying principles that govern the multitude of relationships found in the natural world but if environmental education is reduced to a list of terms to be memorized and facts to be learned, the true value of this study will not be realized. The link between scientific knowledge, real world issues and concerns, and the notion that human intervention both causes and cures such problems must be established for the ideal ecology curriculum to be fully realized.

What science educators and environmental science experts recommend with respect to ecology education and what students actually learn in actual classrooms are frequently quite distinct. Remember the issues of the "ideal," "intended" and "received" curricula. For instance, with few exceptions (Table 2), ecology is typically included in the final section of the texts reviewed. As such, ecology may be ignored if time is short at the end of the school year. The potential misalignment between the ideal and enacted curricula lies at the heart of the problem and challenge for those interested in high quality ecology instruction. The ideal curriculum established here with its robust content, spiral curriculum, and laboratory investigations provides a rich potential to guide science education. However, only through an investigation of actual teachers in real world classroom settings will we know how closely allied the ideal and actual environmental science curricula are.

Ecology demands more from learners than almost any other branch of science while at the same time providing more in terms of strategies and perspectives. One of the oft-stated rationales for the inclusion of science in the curriculum is that doing so makes the students of today better citizens tomorrow. There can be no argument that this is the case when students study ecology from both the concept and action perspectives. An environmentalist who takes action without understanding the science behind his cause is just as uninformed as the student who scores high marks on the ecology test and fails to understand that there are rational causes worth fighting for.

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