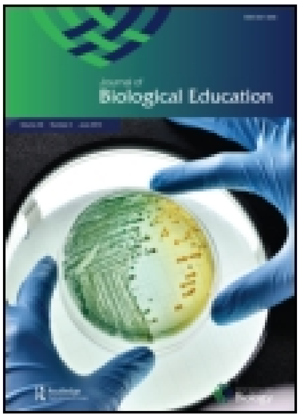

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The living world in the curriculum: ecology, an essential part of biology learning

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Editorial

The living world in the curriculum: ecology, an essential part of biology learning

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Observing organisms and their habitats, as well as their feeding and mating behaviour, is part of the early experience of children and forms part of their early learning before formal educational starts. A two-year-old boy had five words for plants and five for animals in his first fifty words (Tunnicliffe in press). In other words, ecology forms part of the conceptual framework within which a child comprehends the world from the very early stages of life. However, the science of ecology, *ie* the study of the relationships of living organisms between each other and their non-living environment, covers a rather tiny part of most national science education curricula. Indeed, most of the 'ecological' content of science textbooks is in fact about taxonomy, morphology or physiology, rather than ecology per se (*ie* patterns of population growth, dynamics of intra-specific and inter-specific relationships, structure and function of ecological systems, flow of energy and matter through ecosystems).

Moreover, or maybe as a result of the above, ecology teaching is characterised by what we could call teaching of 'ecological bytes' (echoing Tunnicliffe and Ueckert 2007) rather than a comprehending and thorough understanding of ecological systems' structure and function. Not surprisingly, research on students' understanding of ecology often ends up with comments such as 'it is clear that students can enter and leave ecology courses with naive understanding of ecology' (Stamp, Armstrong, and Biger 2006, p. 168). However, nowadays, an important body of research has been accumulated, offering valuable insights for improving ecology education. It is possible to create an integrated framework for reforming ecological curricula by putting together the different insights that ecological educational research is offering.

First of all, research has highlighted the importance of 'real ecology' in contrast with 'book ecology'. The outdoors is not just a setting which could add value to education; it is the starting point of ecological research: authenticity in ecology education has no meaning without field experiences. The first-hand study of the natural world should be the main part of education, especially in the pre-school and first schooling years. Such an emphasis would lay the foundations for sound future biology learning, based on first-hand observations and experiences. Through first-hand real ecology, students gain a 'feeling for the organism' (sensu Fox-Keller 1983), which provides a foundation for understanding more abstract representations of species and ecosystems. Indeed, abstract concepts such as food webs can be easily grasped by early primary school children if their teaching is based on the study of the organisms living in, for example, the pond or the lawn of the local park, and the ways in which such organisms cover their trophic needs (Demetriou, Korfiatis, and Constantinou 2009).

Field ecological education for pre-school and school-aged children is not just an outdoor recreational activity (not that walking long distances in the wild, or camping in a natural area is not a part of ecological research and therefore of ecological education). Nor is it an unstructured, loose activity of observing and collecting specimens in the outside environment. It is an educational activity which presupposes careful design and it deploys skills in advanced levels. It has been shown that students have to be trained in the use of equipment and techniques before they are confident and competent in making scientific-type observations in the field (Eberbach and Crowley 2009).

Modelling, *ie* the process of generating representations of ideas, objects, events, processes, or systems, is a major issue for science education in general, and ecology education in particular (Gilbert and Boulter

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2000). Models of all kinds are major constitutes of ecological theory (for many they are the theory), and modelling is a major part of scientific activity in ecology. The development of modelling skills is also an aim for current education (National Research Council 2012). This can be achieved from ecology education because (a) it can offer, for younger ages, a range of phenomena (such as food webs or the cycle of water) which children can easily model after their first-hand encounters and observations of 'real life' rather than vicarious observation from books; (b) a range of role plays and physical activities has been developed by educators, which allows children to model ecological processes (*eg* predator–prey relationships), such as those included in Project WILD and Project WET developed in the USA; (c) ecological scientific theorising, which is heavily based on modelling, and can offer appropriate examples for every age level of learners. Computer simulations offer the necessary means for studying more abstract ecological models, so that ecological processes which are difficult to observe in nature, or to study in a laboratory setting (patterns of population growth, seasonal oscillations, flow of energy, etc) can be successfully discussed and studied in this way.

Thus we argue that we should promote the idea of a 'progressive-spiralling' curriculum of ecology, which will include an essential portion of outdoor learning, especially at the early years of education and recognising the essential pre-school experiences. In such a concerted approach, outdoor activities will form, among other things, the basis for the development of models and modelling skills, as well as deep biological literacy and understanding. Gradually, simulations can be integrated in parts of the curriculum, allowing for larger degrees of theorising and comprehending of the explanatory patterns and the nature of ecology. In that way, an ecology curriculum will start in the field but may well end (during upper elementary and high school grades) in the computer labs.

We have not yet referred to the most 'typical' image of education in current school science: that of laboratory or classroom inquiry. It has become obvious from the above that laboratory inquiry alone is not enough for the teaching and understanding of ecology. However it is necessary and vital for both the comprehension of ecological processes and the interaction with individual specimens. Cultivation of a shrimp habitat in a bottle, keeping terraria or aquaria in classrooms, or cultivating plants in pots are exemplary settings for ecological experimentation. However, in many cases there is not a perceivable educational value in conducting ecological experiments in a hypothesis-testing, single-lesson manner. A rather 'project-like' fashion, with long-stay installments, starting with observations and integrating previous knowledge, allowing for multipurpose activities and an open agenda, has been reported to be more proper for ecology's teaching and learning (Tomkins and Tunniclife 2001).

We suggest that, in such a way, and through teaching the relevant content at the appropriate level and with an appropriate methodology, students can reach an understanding of natural systems, and of the role of their parts, their functions and associated concepts. The living world, *ie* the subject of ecology, is a system. In the new K-12 framework for science education just released by the US National Research Council, the importance is emphasised of organising science-teaching material around crosscutting concepts including that of 'system', 'system model', 'structure and function', and 'cause and effect' (National Research Council 2012). Learning about systems demands an integrated, though multifaceted approach, which will illuminate which are the elements of the system, which is the role of each element and of the system as a whole, as well as the behaviour of each part and of the system as a whole. In the case of ecology education, the outdoor part of a learning curriculum is absolutely necessary for developing a knowing of the 'parts' of the system (*ie* individual specimens, species, etc), and to start pondering their role. Long-term open experimental settings, such as terraria, are important for observing and comprehending roles (*eg* role of decomposers), but models and computer simulations are the most effective tools for comprehending the behaviour of the system (*eg* behaviour of an ecosystem after a fire).

Another important aspect of teaching ecology is introducing students to a discussion on the Nature of Science (NOS) in a somehow different manner than it is currently. NOS studies often create a picture of science that has axiomatic laws; progressing through controlled laboratory experiments and using simple hypothesis-testing exercises for testing predictions and creating explanations.

Without denying the importance of the above practices for science and science education, ecology provides authentic experiences of issues that are also characteristic of scientific practice, but are not often taken into account when teaching NOS.

Ecology also provides authentic examples of scientific theories that are not consisting of axiomatic laws, but rather from a set of models and general statements (not necessarily having the status of law) that offer a comprehensive explanatory picture of how nature works. Thus, ecology curricula could provide a more pluralistic approach to teaching and learning NOS.

Therefore, we believe that putting all the above pieces together, a transformed picture of school science teaching and learning is created that is not focused exclusively in classroom lectures, laboratory experiments and simple hypothesis testing. In that aspect we think in accordance with many recent calls for transforming school inquiry. Indeed, it seems that in recent years there has been a movement toward transforming school inquiry, criticising the overemphasis on laboratory-based experimental inquiry, and arguing for more modelling and theoretical and communication activities, to which we will add outdoor activities as well (National Research Council 2007, 2012; Braund and Reiss 2006; Roth 2008).

We suggest that ecology is the ideal candidate for implementing the proposed transformations in science curricula, and thus it deserves a larger part in school curricula. Ecology education is, in our opinion, the missing link in educational reform, integrating outdoor education, ICT, and systems thinking, connecting science with everyday experience, and developing scientific skills for very young children, encouraging modelling activities, and promoting greening of the curriculum.

It also provides more flexibility for teachers who want to engage their students in practices that fall outside of the typical conceptions of scientific endeavour. As Bower and Roth (2007) argued, we simply cannot model all science teaching on a few classroom or laboratory classes and continue to believe that we are offering a science for all. Understanding the practices of ecologists is an important step to elaborating the practices found in scientific research that have been long ignored in classroom curricula and in developing biological literacy in citizens.

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