Biodiversity as a Postmodern Theme for Environmental Education

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Abstract

Environmental education in a postmodern world will have to be sensitive to the ill-defined nature of emerging key concepts such as biodiversity and sustainability. Despite all the confusion about such concepts, one thing is clear: there is no one single way of looking at them or defining them. In other words, there is no one single perspective or definition of biodiversity or sustainability that accurately describes them in all situations or contexts. Although this "ill-definedness" renders such concepts useless or reduces them to a rhetorical instrument from a modernist point of view, it makes them attractive from a postmodernist perspective. When acknowledging the need for respect for pluralism (respect for different ways of looking, valuing, understanding, etc.), the ever presence of elements of ambivalence and uncertainty in environmental decision-making and the need for learning situated in a rich context, environmental educators in a postmodern world will find merit in the ill-defined nature of these emerging concepts. Using biodiversity as an example the authors illustrate the educational appeal of ill-definedness. Biodiversity brings together different groups in society in search for a common language to discuss nature conservation issues in relation to sustainability issues. The mere fact that these groups, with diverging backgrounds, focus on a common concept—even though what the concept means to each group varies—allows for a socio-scientific dispute to emerge. This socio-scientific dispute provides an excellent opportunity for learning about a highly relevant, controversial, emotionally charged and debatable topic at the crossroads of science, technology and society. Special attention is given to the role of scientific knowledge in such disputes.

Résumé

L'éducation relative à l’environnement dans un monde post-moderne devra être sensible à la nature mal définie des principaux concepts naissants, tels que la biodiversité et la durabilité. Malgré toute la confusion qui entoure ces concepts, une chose est claire : il y a plus d'une façon de considérer ces concepts ou de les définir. En d'autres termes, il n'existe pas une seule perspective ou définition de la biodiversité ou de la durabilité qui les décrive avec exactitude dans toutes les situations ou tous les contextes. Bien que cette définition approximative rende de tels concepts inutiles ou les réduise à un instrument rhétorique d'un point de vue moderne, elle les rend intéressants dans une perspective postmoderne.

En reconnaissant la nécessité de respecter le pluralisme (respect des différentes façons de voir, d'évaluer, de comprendre, etc.), la présence constante d'éléments d’ambivalence et d'incertitude dans la prise de décision environnementale et la nécessité d'apprendre dans ce riche contexte, les éducateurs en environnement dans un monde postmoderne trouveront une valeur dans la nature mal définie de ces concepts naissants. En se servant de la biodiversité comme exemple, les auteurs illustrent l’attrait pédagogique de la définition approximative. La biodiversité réunit différents groupes de la société à la recherche d’un langage commun pour discuter de la conservation de la nature en relation avec les enjeux postmodernes de la durabilité. Le seul fait que ces groupes avec des antécédents divergents se concentrent sur un concept commun, bien que la signification du concept varie pour chacun des groupes, ouvre la porte au débat socioscientifique. Ce débat fournit une excellente occasion d’apprentissage sur un thème hautement pertinent, litigieux, émotif et discutable au carrefour des sciences, de la technologie et de la société. Une attention spéciale est accordée au rôle des connaissances scientifiques dans des débats de ce type.

A Pedagogical View of Environmental Education

A general description of environmental education, which receives wide support from both practitioners and policy-makers, is that it is a multi-disciplinary form of education that focuses on nature, environment and society as interdependent and inseparable entities. There is a growing consensus about the fact that limiting the scope of environmental education to a subset of any one of these components, does not reflect the nature of environmental issues. From this general description it follows that by its very nature environmental education is multi-disciplinary. This multi-disciplinarity poses fundamental educational challenges. For example, it is not sufficient to take a piecemeal approach by attempting to integrate the various parts and components of environmental education in the different school subjects or science disciplines. The knowledge, awareness and skills to be developed in these subjects and disciplines will need to be developed in a coherent and interrelated way.

In both Israel and the Netherlands, the respective home countries of the authors, environmental education has first and foremost gained importance because of its potential to contribute to the resolution of environmental issues and not because of its potential to contribute to democratic and emancipatory human development. In other words: the environmental justification has, at least up until now, outweighed the pedagogical justification. Partly this is the result of environmental education being subsidised by governmental organisations and the business community and that allows for at least some control of its content and its goals. What often remains is an educational process aimed at creating a support base for environmental policy-making and regulations among the general public on the one hand, and attempts to change the environmental behaviour of citizens on the other. We could classify this manifestation of environmental education by using the adjectives "one-sided" and "instrumental." An instrumental approach to environmental education seems to contradict the whole notion of a democratic society in which citizens do not blindly copy pre- and expert-determined behaviour, but instead act as critical and emancipated citizens who, in the role of watchdog, check the government's policies and actions. An important task of the school, for instance, is to educate *for* and *with* democracy in order to develop socially competent citizens who are able to contribute to a democratic society.

From a pedagogical point of view it is undesirable that the goals of environmental education are one-sidedly determined by outside experts or authorities who are not an integral part of the community of learners who take centre stage in the educational process (Margadant & Wals, 1998). Following Langeveld's (1972) idea of taking an emancipatory approach to the raising and educating of young people, it is crucial that these goals are internally determined by this community of learners and its individual members. This idea does not ignore the ever present societal context in which education takes place, but the learner is the point of departure of the educational process, not the societal context. In other words: the point is not so much what people should know, do or be able to do which is the embodiment of authoritative thinking and top down management. Instead, the point is: How do people learn? What do *they* want to know and learn? What knowledge and skills should not be kept from them in their attempts to give shape and meaning to their own lives?

Unfortunately much environmental education in both Israel and the Netherlands, but also elsewhere in the world, has been developed with traditional attitude-behaviour models in mind (see for instance, Fishbein & Ajzen, 1980). According to such models people need lots of information about the state of the environment. This information will lead to an increase in environmental awareness which is an important prerequisite (along with, for instance, social motivation to comply) for changing one's environmental behaviour. There is, however, a growing body of research that shows that these models represent an oversimplification of reality and incorrectly assume a linear correlation between knowledge-awareness-behaviour (see for Dutch examples of this research: Pelikaan, 1996; Spaargaren, 1994). Just providing information simply is not enough to change people's behaviour.

Perhaps somewhat ironically, it is precisely the pedagogical approach with its emancipatory character which offers more possibilities in this regard. As we already pointed out this approach puts the learner at centre stage with his/her own meaningful interpretation and assessment of a particular situation, his/her own intentional acting and his/her own motivation to learn. The resulting involvement in the learning process can become the bedrock foundation for future actions and acting. After all, a pedagogical approach aims for carefully guided and facilitated education that allows people to decide for themselves if, when and how to take action for the environment, based on their own critical analysis of the issues at stake.

From a postmodern pedagogical perspective environmental education should enable participants to construct, transform, critique, and emancipate their world in an existential way (see also Stapp, Wals, & Stankorb, 1996; Wals & van der Leij, 1997). *Construct* in the sense of building upon the prior knowledge, experiences and ideas of learners. *Critique* in the sense of investigating underlying values, assumptions, worldviews, morals, etc., as they are a part of the world around the learner and as they are a part of the learner him/herself. *Emancipate* in the sense of detecting, exposing and, where possible, altering power distortions that impede communication and change. *Transform* in the sense of changing, shaping, and influencing the world around them. Let us illustrate this by discussing a rapidly emerging concept in science and society but also in many environmental education programs and policies: biodiversity.

Biodiversity as a Postmodern Concept for Environmental Education

The concept of biodiversity is receiving world-wide attention, most notably among scientists and politicians but also among environmental educators. In part this attention is a result of attempts by many national governments to translate the 1992 Convention on Biological Diversity into concrete measures and actions. The convention encourages and commits countries to act on the promise to protect biodiversity by using a variety of means, i.e. policy instruments, education, communication and research. The convention emphasises conservation in relation to issues of equity and sustainable use, thereby pulling people from diverging backgrounds into the debate.

A distinction can be made between political or more symbolical definitions of biodiversity on the one hand and scientific definitions of biodiversity on the other. The symbol of biodiversity refers to the environmental problem of the decreasing variation of life and to the normative demand that we *should* do something about it. But for biodiversity to be a symbolic concept there need not be anything "out there" one could identify and name "biodiversity." In other words, as a symbolic concept biodiversity has no empirical reference. In order to know exactly *what* is lost, and *what* should be done to stop "biodiversity" losses, scientific concepts or concepts referring to the variety of life with empirical reference, are essential. Such concepts refer to entities—phenomena out there—that can be identified and, indeed, somehow measured. One question we should pose as environmental educators is how to deal with this continuum of meanings that exists between political uses and meanings of biodiversity on the one hand and scientific uses and meanings on the other.

Results of a two-year study carried out in the Netherlands (van Weelie & Wals, 1998; Wals & van Weelie, 1998) indicate that biodiversity is an ill-defined concept. This ill-definedness can be characterised by the following features:

- tendency of being inclusive rather than exclusive (or hard to narrow down);
- can be interpreted in many different ways;
- value-laden or normative;
- hard to give meaning in a specific context.

This ill-definedness is not necessarily a weakness from a postmodern environmental education perspective. Learners are confronted with many concepts in every-day life that share this characteristic with biodiversity. Think, for instance, of sustainable use, sustainability, or sustainable development. Recognising the different political, symbolic and scientific uses of such concepts and making a critical assessment of their strengths and weaknesses could be an important learning objective in environmental education. Exploring the different meanings, values and uses of biodiversity could easily become a vehicle for developing critical thinking skills and respect for different ways of looking at the world.

Conceptual ill-definedness appears to be a phenomenon that is well worth paying attention to in postmodern environmental education, especially when:

- ill-definedness is seen as an opportunity to give a concept personal (or local or contextual) meaning, and when
- learners become aware of the ill-definedness that lies behind popular concepts that appear to be clearly defined on the surface.

Let us dig a little deeper into the pluralism of concepts and meanings of biodiversity and their implications for environmental education.

An educationally important assumption is that everyone has some intuitive perception of the meaning of biodiversity. Everyone essentially "knows" what biodiversity is and recognises biodiversity everywhere. Everyone's experience shows there are lots of living beings in the world that are very different from each other, at all levels, so that there is tremendous biodiversity. There is nothing wrong with this description. Educators who wish to base the learning about biodiversity on people's existing knowledge have a good starting point. Even young children may have a good intuitive grasp of some scientific notions, such as that of species (a cat is not an elephant, and a rose is not a tulip).

The same educators would attempt to lead people towards the construction of a less naive definition, by means of identifying the attributes of *the* concept of biodiversity. And they would find the task to be impossible. As stated by many authors, biodiversity eludes definition (see for example Magurran, 1988; Wood, 1997). There is apparently no universally agreed upon definition of biodiversity, in spite of the enormous use of the term in scientific literature (Harper & Hawksworth, 1995). Takacs (1996) obtained from scientists only very broad definitions like "the sum of the earth species including all their interactions and variations within their biotic and abiotic environment in both space and time" (p. 46). Erwin told Takacs in an interview: "You are talking about a subject which is literally as large as the world itself." But such broad definitions of biodiversity mean different things to different people. Or, in the words of van der Maarel, "People from diverse backgrounds talk about biodiversity. . . . [they have] all absorbed the term biodiversity and fitted it into their own jargon" (1997, p. 3). Magurran (1988) gives an overview of the different emphases a biological scientist can use in studying aspects of biodiversity (genetic, species, guilds, habitat, ecosystem, landscape diversity, with subdivisions). In a similar way, based on Salwasser's (1991) focal elements for the conservation of biodiversity through ecosystem management, Takacs (1996) shows how "ecosystem" may represent different things to different biologists. At this point we have not even entered terms used in the Rio-convention which blur the picture even more: equitable distribution, sustainable use, etc. (IUCN, 1994). Takacs in the end concludes that biodiversity is an intentional construct developed by a particular group of people at a particular time which means what its creators say it means. Its normative commitments are entailed in biodiversity as defined by its creators.

As suggested earlier this situation leads to the impression that biodiversity is an ill-defined or fuzzy concept. The term should be clarified further to avoid questionable educational implications. We should first note that a concept is a class of elements, concrete or abstract—objects, events, ideas, symbols—grouped together according to some shared characteristics, attributes or dimensions. A concept described as "ill-defined" may be perceived as one of which the attributes are fuzzy, not well defined or used in a loose way. This is not necessarily the case with biodiversity. Consider the term as used in the Magurran definition, or all the attributes of biodiversity suggested in Wood's (1997) references to various reviews: richness, evenness, equability, frequency, number of entities in a standard sample, composition, structure, function, ecological processes, cladistic hierarchies, phyla-genetic lineage, etc. Or, consider McNeely, Miller, Reid, Mittermeier and Werner's definition (1990, also quoted by Wood, 1997): "Biodiversity encompasses all species of plants, animals, and micro-organisms and the ecosystems and ecological processes of which they are part . . . number and frequency of ecosystems, species or genes . . . three levels: genetic diversity, species diversity, and ecosystem diversity" (p. 252). There is nothing fuzzy in the use of those terms by scientists. Their use involves the stipulation of careful definitions. Although it can be argued that even the careful stipulation of definitions and their concepts also involves social construction and is therefore subject to interpretation and disagreement.

Mathematical and scientific concepts are generally regarded as "well-defined" in the sense that their attributes or dimensions are defined, and that they can be transferred across situations or contexts without changes in their definitions (for example Tennyson, 1996). Ill-defined concepts on the other hand are more culture bound, and they have characteristics that vary with the context or situation in which they are used. The latter definition is closer to the view of biodiversity as perceived by many authors. The concept varies with the approach of the scientist. It is not the attributes or the dimensions that are badly defined. Instead it is the approaches which are different, thus bringing about *different selections of relatively well-defined attributes*. In fact, the overall picture of biodiversity, when studied by different scientists, has been carved into different, most of them equally legitimate, puzzles. All the pieces of the different puzzles cannot be used simultaneously, although each piece tends to fit one of the puzzles better.

Implications for education

"The main difficulty in defining biodiversity," suggests Wood (1997), "is its *multi-dimensional* character, along with the fact that the dimensions are not commensurable; they cannot be reduced to a single statistic" (p. 252-253). Biodiversity appears not to be one ill-defined concept, but a number of neighbouring concepts, under the umbrella of a common term. This notion is not unlike Wittgenstein's idea of "family resemblance" (Wittgenstein, 1985). With such a view in mind, the task of the environmental educators is quite clear: *to teach meaningfully a concept that cannot be reduced to one idea and the dimensions of which cannot be reduced to one common statistic*. Such an approach to the educational task means that the basic concepts that make up the core of biodiversity must be taught, and put in the context of various approaches, so as to make them functional. By "functional," we mean that people recognise when a concept makes a difference. In other words, when people realise that a different comprehension of a particular concept would lead to different conclusions or implications, and when they realise that the use of the concept is irrelevant or out of context (Dreyfus & Jungwirth, 1989).

This implies that people have some understanding of the scientific and technological concepts that may allow them to assess the implications of *human technological interventions in nature and the validity of sug*gested solutions, according to various views. It also means that the various views of biodiversity, conservation and related goals and objectives (e.g., endangered species, habitat, ecosystem integrity, process of evolution, etc.) should be presented. Only then would people would have true opportunities to make their own judgements—as enlightened citizens in a democratic country—concerning the importance of biodiversity, the reality or validity of claims concerning damage to biodiversity, and the implications of such damage. Educating for a particular end, in such a view, does not mean partisan indoctrination, but the development of the knowledge, and the intellectual skills and flexibility which make people able to appreciate diverse approaches to science- and technology-laden social problems. The latter is sometimes referred to as the development of respect for pluralism (Brennan, 1992; Firth, 1995). It means developing the level of ambivalence (Gardner, 1987; Dreyfus & Roth, 1991), and the ability to appreciate opposing arguments, necessary for a sound appreciation of complex problems, and at the same time, developing the ability to work towards consensus and make decisions concerning priorities and action.

Values of Biodiversity

> *Conservation biologists as objective discoverers and portrayers of the truth of the biodiversity crisis are fictional beings—they are no more privileged presenters of "facts" than are scientists at the Tobacco Institute or lobbyists for Handgun Control, Inc.* (Burnett, 1998, p. 204)

It would be beyond the scope of this discussion to review the numerous instrumental, anthropocentric or anthropogenic values that different authors have attributed to biodiversity: scientific, ecological, economic, cultural, aesthetic, etc. All these approaches focus on biodiversity as a biological resource for the well-being and survival of humankind, a resource that must be conserved or preserved. The approaches do not, however, focus on the value of diversity itself. The weakness of these views (Ehrenfeld, 1988; Wood, 1997) is that such a resource may be "traded off" for the very development projects which deplete biodiversity, i.e., for allegedly more useful or more immediate resources. As McPherson (quoted in Wood, 1997) points out, people have competing interests, and "no single group . . . has proposed a group of reasons which are sufficiently compelling and appealing to generate the necessary support to ensure that all of the biological diversity they value be maintained" (p. 253).

Wood (1997) classifies these arguments into three main types. Biological entities are valuable as:

- resources: the biological materials which are consumed or exchanged in markets, or the organisms and ecosystems which are valued for their recreational, cultural, or aesthetic purposes,

- potential resources, i.e., "opportunities for the discovery of new and valuable resources" (e.g., knowledge, materials, genetic resources), and
- contributory factors, "in the sense that they contribute to the functioning of healthy ecosystems, which in turn produce organisms and services . . . ." (p. 255-257).

People should be made thoroughly aware of the strengths and weaknesses of these types of arguments. However, in view of the environmental crisis and of the human-induced rate of species extinction (Ehrlich & Wilson, 1991), they should also be made aware of a more abstract type of argument, which attempts to show the *instrumental* value of diversity itself. And the understanding of this type of argumentation requires some sound scientific literacy.

These arguments refer to the danger of reducing biodiversity itself. Wood (1997) sums-up this type of argument in the following way: Current biological resources are vulnerable to insect and disease pests, to adverse climatic conditions, etc., because they lack genetic diversity. An abundant supply of wild genetic resources is required to prevent the depletion of current resources, which are essential if the exploding human population is to survive. For many reasons, biotechnology is unable to supply the necessary diversity of genetic resources (Baumann, Bell, Koechlin, & Pimbert, 1996) or has disadvantages that may ultimately outweigh its possibilities (for example, Westra, 1998; Mannion, 1995). Nature continues to change in non-predictable patterns, and some of these changes may be human-induced (i.e., depletion of the ozone layer, global warming, etc.). Humans are vitally reliant on nature's ability to adapt, and biodiversity is a precondition for adaptive evolution. Humans are therefore in a state of "obligatory dependency on biodiversity." For various reasons, biodiversity appears to "beget biodiversity" and is a necessary precondition for the self-augmenting maintenance of itself. Biodiversity is therefore a necessary precondition for the availability of biological resources, and cannot be traded off. This appears to be its quintessential value. And the conclusion is relatively abstract: any "resource" may be traded off by any society, to fulfil its socio-economic interests, or its survival needs, *provided that biodiversity is not depleted* (Wood, 1997).

As both Takacs and Wood notice, the ecological argument, which assigns an inherent instrumental value to biodiversity itself, has its detractors. Nevertheless, when recognising the acute potential danger to humankind or when paying attention to Wilson's (1992) "one planet, one experiment" warning, it is conceivable that citizens should be provided with the opportunity and the tools to appreciate Wilson's question: If enough species are extinguished, will the ecosystem collapse, and will the extinction of most other species follow soon afterwards? After all, by the time we find out, it might be too late.

Implications for education

The tools necessary to develop knowledgeable and somewhat rational opinions, whatever they may be, concerning this issue, and to develop relevant empowering skills, can come only from a thorough "biodiversity education." The argument may appear to be somewhat circular: if nature is biodiversity, then claiming a priori that nature must be taken care of, is equivalent to claiming that biodiversity must be conserved. But the educational argument is slightly different: in a democratic society, the defence of biodiversity requires literate, and even ambivalent, citizens who understand the various dimensions of biodiversity. Citizens have to be able to grasp the contradicting claims concerning the central importance of biodiversity and understand the ways human activity and technology influence biodiversity. From the point of view of both education and democracy, it is more appropriate to help citizens become well-informed, critical and competent than to help them become well intentioned, but ignorant and fanatic.

The discussion has been based intentionally on the unlikely extreme case in which people reject the intrinsic values of nature or of biodiversity. This is not necessarily true. However, without underestimating the possible validity of such intrinsic moral values, and without neglecting or rejecting them *a priori*, most environmental educators would not consider them to be convincing enough as a basis for environmental education, and would search for more human-oriented grounds. As basically "non-behaviourist" educators, they would not ignore the "socio-scientific dispute" character of biodiversity, and as a result, recognise the need for scientifically, technologically, and socially *literate* students.

Science, Literacy and Socio-scientific Disputes

Scientific and technological knowledge has always been recognised as a basic component of environmental education and environmental literacy (see for instance the report of the Tiblisi conference, UNESCO, 1978; Hungerford, Peyton, & Wilke, 1980, but also, Huckle, 1991). However, *scientific knowledge* is referred to mainly as a source of well-established *information* to be used in discussions, experiments, decision-making processes, etc. In spite of Rubba and Wiesenmayer's (1988) claims or recommendations, foundational competencies, such as the understanding of the nature of science, scientific laws and explanations, and of the power and limitations of science, are rarely overtly treated in environmental education materials. A scientifically literate person, according to Bybee (1991a, b), understands, among other things, the nature of modern science and modern technology, the nature of scientific explanation and of technological solutions to human problems, and the limitations and possibilities of science and technology. Miller (1990) made an important distinction, especially from the point of view of environmental education, between "learned" people, who possess knowledge, and "literate" people, who are able "to read about, comprehend, and express opinions on scientific matters." In order to express an opinion "a *minimal level* of scientific knowledge is thought to be required, buttressed by a suitably positive attitude *towards science and scientists*" (emphasis added, Solomon, 1990, p. 107). Ramsey (1993) believes empowerment involves "knowledge and processes of both science and democracy" (p. 243). Bingle and Gaskell (1994) suggest that scientific literacy's main component is the ability to make decisions and solve problems where science, technology and society interface" (p. 186).

We have tried to show that biodiversity is both a descriptive and normative term. Let us briefly compare biodiversity with another ambivalent phenomenon that shares similar qualities: health. It can be argued that conservation biologists can and should prescribe personal and public actions. However, this analogy fails for two reasons, according to Burnett (1998). First, the knowledge and understanding of biodiversity and all its interacting components is in its infancy relative to medicine's understanding of the standards and threats facing human health. Second, "even if the knowledge bases were comparable, neither medical practitioners nor conservation biologists have any particular insight into or authority concerning what decisions citizens and public officials—who must balance competing concerns and make collective trade-offs—ought to make" (p. 205). Here the socio-scientific dispute character of such concepts surfaces again, and it is time to explore this characteristic further.

Let us first consider Huckle's formulation (1991) of the technological component in his inventory of goals of environmental education: it "should consider the development of technology in different societies and its impact on environment . . ." (p. 51). Referring for a moment to biodiversity and to Western students studying the impact of technology in the Western world, we obtain "the development of Western technology and its impact on biodiversity." In other words, people could benefit from an understanding of the *scientific grounds* for the impact of a science-based technology on biodiversity. But the impact on *what* biodiversity? The answer, depending on the type of approach to biodiversity, is extremely science-laden. After all, *biologists* are proposing various approaches that people, as suggested earlier, must understand. First, people must understand *what impacts what* and *in what way*? These are very science-laden questions. At the same time they must also be able to understand possible answers to a no less science-laden and no less crucial additional question: *why does it matter*? The term science-laden does not, by any means, suggest that the answer is *exclusively* scientific, but that it has an important scientific component that can neither be ignored nor be underestimated.

Second, because of the nature of scientific knowledge, people must understand its role in the socio-scientific dispute. This objective goes far beyond Huckle's formulation or that of the Independent Commission on Environmental Education (ICEE, 1997): "The field should place its emphasis on building environmental knowledge. . . . Environmental educators should place primary emphasis on the acquisition of knowledge" (p. 2-3). However, it meets to some extent the Independent Commission on Environmental Education's claims that environmental educators often mix science, or education, with advocacy.

An environmentally literate citizen should be sufficiently scientifically literate to understand the contributions of science and technology to the creation and the solution of human problems, and vice versa, the influence of human problems on science and technology. Let us return now to the term "socio-scientific dispute." Having decided to teach biodiversity, one cannot escape the feeling that its "socio-scientific dispute" character represents a golden opportunity to educate literate and enlightened citizens. According to Bingle and Gaskell (1994), a socio-scientific dispute is born when uncertain knowledge associated with science-in-the-making inhibits consensus as to the scientific facts. In such instances, citizens find themselves facing divided expertise—qualified scientific experts who have produced different scientific findings on an issue or who disagree over the interpretation of the same findings.

A socio-scientific dispute can even arise in the face of scientific consensus. Such a dispute arises when the consensus is challenged from the outside. This is the case, for instance, when the personal experience of citizens is in conflict with "scientific" evidence, when citizens feel that certain scientific knowledge is so new that any consensus on its factual nature must be considered tentative at best, or when certain interests are seen as having undue influence on the consensus position (Bingle & Gaskell, 1994). Socio-scientific disputes are issues about which decision making is most problematic. They are in fact a main topic of environmental education since they are truly at the interface between science and society. They also represent a common situation, since where there is no dispute, there is no longer any issue at stake and there is only an accepted or an imposed solution.

The topic of biodiversity—when considered to be a classical, crucial, contemporary socio-scientific dispute that is potentially relevant to every person's personal or social environment—indeed represents a golden opportunity to educate and empower citizens. Teaching about biodiversity without its socio-scientific dispute aspect would be tantamount to indoctrination about desirable behaviours as well as to presenting hypothetical scientific knowledge or claims as certain. All this being said, it is clear that the role of scientific knowledge in socio-scientific disputes cannot be trivialised or underestimated.

The Role of Scientific Knowledge in Socio-scientific Disputes

We will not discuss here the relativistic and the tentative character of even well-established knowledge, and the influence of reality on the formation of knowledge. For the purposes of environmental education, we will accept, along with Driver and her colleagues (Driver, Asoko, Leach, Mortimer, & Scott, 1994), Harre's (1986) idea that scientific knowledge is constrained by how the world is, and that scientific progress has an empirical basis, even though it is socially constructed and validated. We too will adopt the view that once such knowledge has been constructed and agreed upon within the scientific community, it becomes, for all practical purposes, part of the accepted way of seeing things within that community.

This *accepted* knowledge is the first type of knowledge that an environmental education programme must address. The *ready-made science* knowledge (Bingle & Gaskell, 1994, based on Latour & Woolgar's [1979] approach) is knowledge that is taken for granted in the scientific community, and is seen, at least temporarily, as *uncontroversial and unrelated* to the specific contexts of its development. In the context of environmental education this knowledge essentially consists of basic scientific concepts, such as principles of ecology, reproduction, etc., or basic technological understandings, in as much as they are necessary. It should be noted, however, that (environmental) science faculties around the world are increasingly becoming engaged in the discussion of what basic scientific knowledge is; in other words, in postmodern science even the foundations of ready-made science are being challenged.

What we can say now is that learning about the topic of biodiversity should at least lead people into areas of disagreement between specialists, i.e. disagreement about the perceptions of the dimensions of biodiversity, its meaning, the impact of technology on biodiversity and the hypothesised implications of such impact. This is the area of *science-in-the-making*, in which "statements about scientific knowledge are seen as *claims*: they are contestable and subject to revision" (Bingle & Gaskell, 1994, p. 187). Concerning biodiversity, as explained above, it is not a question of fuzzy or badly defined basic principles, it stems rather from different interpretations and approaches. Although based on sound knowledge and thinking, claims are sometimes largely unverifiable because of questions of time and space, and because of the difficulties in designing experiments to test them. It is of great importance that people become aware of the socio-scientific dispute character of science-in-the-making, i.e. of the development of theories, their powerful impact, as well as their limitations. Only then can people understand the relation between the nature of scientific knowledge and the role it may play in making decisions concerning socio-human problems. Such an education is indispensable for the development of literacy and empowerment.

The claim that knowledge is socially constructed—which in itself represents a dispute among social scientists—has important implications for strategies of teaching and learning, which we will not discuss here. However, it must be stressed that the notion of socio-scientific disputes arising when personal experience is in conflict with the "scientific evidence," has immediate conceptual and pedagogical implications. Scientific entities and ideas are not direct representations of reality. They are socially constructed conceptions of reality, and as such, are unlikely to be discovered spontaneously by individuals (Driver et al., 1994). Individuals' conceptions of biodiversity-related entities and processes are generally quite different from the scientific conceptions. According to constructivist views, the resulting cognitive conflicts are at the basis of one of the main channels of meaningful learning, and of the people's *initiation into scientific ways of knowing* (1994).

A sound grasping of the uncertain, hypothetical character of the "science-in-the-making" knowledge has important implications for public decision making. As Bingle and Gaskell (1994) say, a socio-scientific dispute may arise when citizens feel that scientific knowledge is so new, "that any consensus on its factual nature must be considered tentative at best" (p. 188). Accordingly, great prudence is advisable when making crucial decisions based on such "truths." This is exactly Takac's argument (1996) when he suggests that the claim that diminished biodiversity means diminished prospects for human survival is "not necessarily untrue, [but] why not err on the side of caution?" (p. 202) However, such a feeling is valid only when it comes from a scientifically literate citizen, not from a scientifically ignorant one.

Implications for education

Clearly, sound, relevant scientific knowledge must be acquired through environmental education, not only as a basis of information, but as a part of people's understanding of:

- the social construction of scientific knowledge—especially in the case of an abstract, complex definition of biodiversity, and
- the role and position of scientists and scientific knowledge in public decision making and, as a result, why it has become a part of their environmental education.

This does not mean that environmental education in schools, for instance, is open only to students of science. According to the Independent Commission on Environmental Education (ICEE, 1997) environmental education should be "an upper-level multidisciplinary capstone course integrating what students have learned in science, social science, and other upper-level courses" (p. 3). There is no reason that science majors should not benefit from their knowledge or to prevent such "capstone" courses from being developed for science majors, but this would only marginally contribute to our ambitious goal of teaching *all* citizens about biodiversity, as a part of their environmental education. As Aikenhead (1994), based on Fensham (1988), has shown, the emphasis on science and social aspects in science, technology, and society curricula can vary from a situation in which most of the emphasis is on the scientific content, to one in which such aspects are mentioned only to establish a link with science. On the continuum between these extreme cases, various decisions can be made, and this is true for environmental education as well as for science, technology, and society education. The main idea of many science, technology, and society educators is that science, as a part of everyone's general education, cannot and should not be taught in a "top down" manner, by those who know to those who do not. Instead science should be taught in a relevant context, as a functional tool (Solomon, 1994; Aikenhead, 1994). Biodiversity can provide such a context in which knowledge can be acquired when required.

Fourez (1997) showed a great awareness of the problem of the role of scientific knowledge in education for scientific and technological literacy.

In his view it is quite understandable that even involved and literate citizens lack in-depth knowledge about various areas in which public and science issues are linked. No one is a specialist in everything. As implied by Smith (1998), the goal of environmental education cannot be to make every citizen an expert, but rather to give them the ability to ask the right questions and evaluate the quality of available answers. Accordingly, environmental education should provide people with skills that make them able to meaningfully, critically, and selectively use scientific knowledge. Such use does not necessarily require a full and thorough understanding of all the concepts involved but rather a more functional understanding of what they do, and what they mean to us, in a meaningful context. People may have, for instance, a functional understanding of what photosynthesis does to our environment (adding oxygen, using solar energy to build organic matter, carbon cycle, etc.) without understanding the complex biochemical processes involved in it. In fact, photosynthesis remains, for most non-specialists, a kind of black-box. The main idea is that of showing abstract principles and "theories-in-action" in a concrete situation, instead of dealing with proofs for their existence which remain in the black-box (Olsher & Dreyfus, 1999).

Fourez (1997) also stresses that people must be literate enough to be able to make good use of specialists. This includes being able to consult experts, being able to translate what specialists say, moving carefully from one context to another and discerning any abuse of knowledge. This is a skill that, so he claims, can be taught "to strike the balance between our dependency on their knowledge and our own healthy critical minds" (p. 930). These are the kind of science-related skills which environmental education should try to include yet tend to be ignored in discussions about environmental education in a postmodern world. Treating the topic of biodiversity within the framework of environmental education requires the ability to use functional scientific knowledge in uncertainty-linked decision making.

Conclusions

Environmental education in a postmodern world might be tempted to focus on the development of somewhat fashionable—albeit fashionable for good reasons—postmodern ideas related to things like empowerment, respect for pluralism and diversity of thought, action competence, contextual of local knowledge, grassroots decision-making, colleborative and issue-based learning, and so on. Indeed a focus on these components of environmental education is useful and may launch a new generation of environmental educators which is more sensitive to emancipatory learning goals and the contextual, open-ended, and uncertainly-linked nature of the creation of pathways towards sustainability. We believe all this is important, but at the same time would like to stress the importance of the role of scientific knowledge in general and citizen participation in socio-scientific disputes in particular. Biodiversity, as an examplary theme for postmodern environmental education, illustrates that traditional environmental education approaches fall short in dealing with uncertainty, normative aspects of decision-making, and understanding the importance of learning on the edges, that is learning at the cross-points of conflicting worldviews rooted in varying traditions, norms, and values.

The topic of biodiversity has great potential for postmodern environmental education when considering its ill-defined meaning, its socio-scientific dispute character, and its ability to link science, technology and society. Its ill-defined meaning requires a procedure for making it meaningful in a specific context. Its socio-scientific dispute character requires a procedure for dealing with controversy, uncertainty, diverging values and interests, and moral dilemmas. While its potential to explore, critique and utilise separate ways or systems of knowing and understanding requires a procedure to create a rich context for learning that links scientific, technological and societal expertise and common sense. These aspects are explored in far more detail in van Weelie and Wals (1998) and in Wals (1999).

We realise that by placing emphasis on the rationality and justification of learning about ill-defined concepts and on the role of literacy and scientific knowledge, we have somewhat unfairly marginalised the importance of the emotional foundation for such learning. At the same time we have neglected another line of reasoning in favour of learning about such ill-defined environmental concepts: the education for democracy, sustainability and social equity line of reasoning. Those lines of reasoning, to which we have only alluded here but which have been explored elsewhere, provide another case for concepts such as biodiversity and sustainability as suitable themes for environmental education in a postmodern world.

Notes on Contributors

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