Encounters between Ordinary People and Environmental Science – A Transdisciplinary Perspective on Environmental Literacy

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Abstract: *The aim of the present article is to review the different conceptualisations of the relation between scientific knowledge and everyday life from a fairly practical angle – aiming toward a reformulation of "public understanding" that is more empowering for ordinary people, yet maintaining the valuable ethos of the environmental literacy movement. On the basis of this review, the author reformulates the problem of public understanding, and makes some practical suggestions. Because the context of the ordinary person is unique, and requires knowledge from many different disciplines and walks of life, ordinary people need capabilities to make sense of expert knowledge. Because scientific and everyday models are often different, both scientists and ordinary people need to develop sophistication in recognizing the presence of such models in all knowledge claims. Most importantly, recognizing the difference between universal and local contexts provides science communicators and those receiving these communications the ability to contextualise the knowledge, and allows for a fruitful and transdisciplinary dialogue between locally-relevant and universalist claims.*

Keywords: Environmental literacy, public understanding, public participation, knowledge utilization, local context

1. Introduction

Since the 1980s, expectations toward the role of market actors in environmental policy have grown. At the same time, environmentalism has expanded from a deep but marginal social movement to a mundane moral obligation. Environmental concerns have come to interpenetrate our everyday lives on many levels: From media images of the Amazon forest burning to recycling bins at our workplace and environmental labels on the products we buy.

Advances in science have been central in the rise of popular environmentalism. Rachel Carson's *Silent Spring* is often mentioned as a central stimulus for the environmental awakening. *Limits to Growth* by the Club of Rome introduced the public to the idea of a limited planet, which has been echoed in popular images of "Spaceship Earth". These science-based images (e.g. pathways of chemicals in the food chain, global systems models) are central to modern-day environmental concern, which is all about problems that are 'invisible' to ordinary people and not directly perceivable without the use of special instruments and scientific concepts.

Yet science is a problematic source of advice for everyday life. It is not an immutable and overtly normative knowledge system (like religion), but fraught with controversies, new findings and divergent interpretations. It also draws on concepts, practices and knowledge-claims that are largely unfamiliar to ordinary people. "Public understanding of science" and "environmental literacy" have, in fact, been topical issues in European environmental policy. But scientific literacy is a problematic concept, and there are a variety of critiques of the "public understanding of science" literature.

There is a fairly integrated body of research on the utilization of environmental science in a public policy (e.g. Jasanoff 1996; 2005; Gudmundsson 2003). Research on *science utilization by the general public* is much more fragmented. On the basis of a number of recent reviews (Callon 1999; Barry 2000; Michael 2002; Elam and Bertilsson 2003; Wilsdon and Willis 2004), we can distinguish three different ways in which science and ordinary people interact: 'science consumption' (Barry 2000), 'citizen participation' and 'co-production' (Callon 1999; Barry 2000). 'Citizen participation' refers to the need to include the knowledge and values of ordinary people into the process of utilizing scientific knowledge. 'Co-production' refers to ordinary people who participate in the production of scientific knowledge. The 'science consumer' or 'user' perspective, however, is in my view the most poorly conceptualised one. For example, Barry (2000) has discussed it almost solely in the context of the consumption of science as entertainment or culture. While this is one important aspect of 'science consumption', I would prefer to highlight another aspect: the use of science-based advice in everyday life – i.e., what Stilgoe et al. (2006) refer to as 'ubiquitous expertise'.

The aim of the present article is to review the different conceptualizations of the relation between scientific knowledge and everyday life from a fairly practical angle of the 'ordinary science user' – aiming toward a reformulation of 'environmental literacy' that is more empowering for ordinary people, yet maintains its valuable ethos. I will not go into the discussion on the limited behavioural impact of information dissemination, or the related arguments for more forceful policies rather than liberal market solutions (e.g. Uusitalo 1990; Bickerstaff and Walker 1999). Even though more forceful policies are highly relevant, in a democratic society, all policy instruments also require information on their justification.

In considering how environmental science presents its advice to the 'ordinary science user' I start from the simple notion of 'public understanding', and elaborate it into increasingly complex, contextual and historically-grounded perspectives of science and everyday life that complicate the notion of environmental literacy. The review is mainly based on the literature, but also draws on my own and colleagues' experiences in applying these different approaches to environmental communications. On the basis of this review, the final section reformulates the problem of environmental literacy from a 'users' perspective', and makes some practical suggestions for improving the interaction between environmental science and everyday life.

2. Public Understanding of Science

The *public understanding of science* (PUS) movement originated in Britain with the efforts of the Royal Society to assess and improve the scientific literacy of the population. Scientific literacy was viewed as important for people to participate in contemporary society as qualified citizens. Scientific literacy has since evolved into a European concern, employing three main arguments (e.g. Fourez 1997): humanistic (people need to cope in a world permeated by science), democratic (people need to participate in public life and decision-making) and socio-economic (the economic development of the nation requires an educated and skilful population).

The *environmental literacy* of the population is an aspect of scientific literacy that has gained importance in policy making (e.g. Scott and Oulton 1999; EC 2004). A number of surveys in Europe and globally (Dunlap 1998; Eurobarometer 2001) have studied how ordinary people understand the causes and effects of major environmental problems.

The findings of these surveys have often been taken as alarming. Citizens of well-to-do Western countries with high levels of public education and free access to the media appear to have very shaky notions of the causes and effects of environmental problems. For example, a study from Finland found that only 29% of the respondents identified emissions from traffic and energy production as the main causes of acidification (most believed it was chemicals used in industry). Half of the respondents failed to identify energy as the main cause of global warming (Niva et al. 1997). Another, more recent Finnish study found similar departures from the prevailing scientific view in more practical issues related to energy use. More than half of the respondents in this study believed that cars using catalytic converters and new fuel formulations do not contribute to global warming (Melasniemi-Uutela 2000).

Yet this line of research has encountered a variety of critiques:

- It is unfair. A recent study that found that almost 200 scientists (from the UK; the US, Australia, New Zealand, and Asia) themselves, when confronted with questions used to measure the scientific literacy of the public, were often unsure of their answers or critical of the questions (Rennie and Stocklmeyer 2003). This raises the question of what it is useful or reasonable for anyone to know or claim about science at this level of generality.

- It has a naïve view of how people think. The measuring of scientific literacy appears to assume that people's minds are empty vessels, if they are not full of scientific knowledge – thus, it has been termed a "deficit" model of public understanding (e.g. Wynne 1993). The research fails to recognize that whether or not they have formal knowledge, people always have mental models, i.e., their own theories about how the world around them works.

- It is decontextualized, undersocialized and elitist. 'Public understanding' studies focus on 'textbook' knowledge (e.g. "ordinary tomatoes do not contain genes – true of false?"). This view of public understanding assumes that textbook knowledge is what people need in their everyday life (e.g. Fourez 1997) The focus is on individual facts, rather than the social interactions in which people's everyday understanding usually rests (Heiskanen 2005). It also privileges science over other forms of knowledge such as practical skills and experience.

- It holds an unsophisticated view of what science is. Science is implicitly assumed to be a unified, universal and immutable depository of knowledge `out there', rather than the contradictory, continually changing and negotiated, multi-perspective endeavour that empirical science studies indicate it to be (e.g. Jasanoff et al. 1995). While conventional views of science have assumed that scientists need to communicate the complexities in their research field better, it can also be the other way around: scientific culture denies the complexities that typical public culture is well aware of, such as the limits to predictive knowledge (Wynne 2005).

The PUS model has thus encountered intensive criticism since the early 1990s. In 2000, the model was 'officially' denounced by the UK government, and after a number of different labels (e.g., 'science in society', 'public engagement'), the term 'upstream engagement' emerged as the official dogma in the UK, even though its actual applications have remained debateable (Wilsdon and Willis 2004). These developments, as well as parallel ones in other countries, are discussed in more detail in section 6 of this article. Next, I turn to the second point of criticism above, and consider more sophisticated conceptualisations of 'how people think'.

3. Cultural Models and Social Representations

Ordinary people's indigenous, socially shared theories about nature and environmental problems have been studied especially in two research traditions. One is cognitive anthropology, focusing on the models of nature and its interaction with human culture held and shared by members of a culture or a social group (e.g. Kempton et al. 1995). Another research tradition derives from culturally-oriented social psychology, especially the seminal work of Serge Moscovici (1976) on lay interpretations of psychotherapy.

The idea of 'cultural models' or 'folk models' has been used, for example, by Willet Kempton to study how people understand energy usage and the workings of the thermostat (1987), as well as nature conservation, air pollution and climate change (Kempton et al. 1995). For example, Kempton and colleagues identified a general folk model of air pollution, which many people also apply to CO_2 emissions. Because the model assumes pollution to be smoke or particles deriving from smokestacks, the people using this model to understand CO_2 emissions tend to focus on filtering solutions and industrial pollution control in their suggestions for combating climate change.

The study of social representations stresses the social character of the process of trying to understand unfamiliar events. Social representations help people to orient themselves and to communicate with each other. Many studies in this tradition pay special attention to socially shared metaphors and symbols used in the process of making sense of new and unfamiliar things (Wagner 2002; Joffe 2003) – e.g. metaphors such as “Frankenstein food” for genetically modified foods.

The policy implications of these lines of research are somewhat mixed:

- Researchers have found that some ‘folk models’ actually work quite well. For example Kempton (1987) found that “unscientific” lay models of the thermostat often led to relatively frugal energy consumption. Similarly, models of ‘the balance of nature’ (Kempton et al. 1995), or lay understandings of climate change (Järvelä 1997), formed the basis for a preference for precautionary policies – which could be very similar to the outcomes of more scientific reasoning.

- Folk models and popular social representations can also lead to unproductive policy preferences. For example, the notion of CO_2 as a form of pollution that can be easily filtered out (e.g., Kempton et al. 1995; Melasniemi-Uutela 2000) can lead to assumptions that the problem is easy to deal with.

The study of cultural models and social representations may thus be useful in helping environmental policy makers to understand how environmental problems and potential solutions are conceptualised (Kempton et al. 1995) and how media and other communications may engage with these models in a productive way (Joffe 2003; Rennie and Stocklmayer 2003). An understanding of popular models and representations can also help policy makers identify the limits of market-oriented approaches to environmental protection – e.g. how much responsibility for environmental protection can be placed on ordinary consumers (Niva et al. 1996). Yet by focusing on mental and discursive processes, this approach fails to address the locally-embedded, political and contextual nature of knowledge utilization.

4. Local Understandings and Everyday Reasoning

Two quite different traditions emphasize the role of *context* in the encounter between science and ordinary people. One derives from critical science and technology studies, and is well represented by the studies by Brian Wynne and colleagues (Irwin and Wynne 1996). A very different tradition derives from empirical decision research stressing the usefulness of heuristics in real-life situations (e.g. Simon 1957). Both of these different traditions emphasize the local context and its demands, which may be quite different from the conditions under which disembodied scientific knowledge operates.

The local context may, for example, be that shared by the Lake District sheep farmers confronted with science-based advice on how to deal with the radioactive fallout from Chernobyl in 1986 (Wynne 1996). This advice (e.g. on where to graze sheep, and when to sell them) and the overall role of science in monitoring and evaluating the damages met with a lot of suspicion among the local farmers. Wynne (1996) interprets the farmers’ reactions as a clash between local culture and history, lay knowledge, and social relations and the specific types of culture, knowledge and social relations imposed on the situation by the scientists. Besides the cultural and social aspects, an interesting point is the local (ir)relevance of scientific knowledge: the scientists’ monitoring and advice was based on the assumption of a standardized environment, in which predictions could be made on the basis of pre-existing universal ‘facts’ (e.g. immobilization pathways and rate of caesium). In fact, it turned out that the local conditions were so variable that such predictions failed.

Another, very different local context is that of an ordinary Finnish consumer purchasing detergents and other laundry products (Timonen 2002). This context consists of the retail environment, television and other advertising, people’s own experiences of laundering, and the social sharing of all this information with friends and acquaintances. In this context, environmental instruments such as the Nordic environmental label – designed by experts to help people select environmentally preferable products – may not be used in the way expected. Timonen’s (2002) study adopted a phenomenological approach to everyday reasoning and the use of heuristics in decision-making. She found that consumers used ideas about how the market works, as well as personal and shared experiences of product use, to make judgments about the environmental properties of detergents. For example, the consumers deduced that there cannot be large differences between the detergents because large brand manufacturers would not take the risk of marketing significantly more environmentally harmful products than their competitors, and because advertising focuses on aspects totally unrelated to product characteristics.

Some points that can be gleaned from these lines of research include the following:

- Representations, activities and contexts are not separate. Without taking into account the concrete context in which 'knowledge users' operate, one cannot really judge whether they are rational and sensible in their use or non-use of scientific knowledge.

- Local communities possess relevant knowledge that reflects local conditions. Universalist, 'scientific' knowledge may not be relevant for the problem structure of many everyday life problems. Local conditions may be very variable, and require the integration of many different kinds of knowledge besides 'facts', or 'laws' derived from natural science (e.g. Fourez 1997; Bickerstaff and Walker 2003).

- In everyday contexts, simple heuristics and habitual, socially shared practices are often the most sensible and reasonable guides for action. Ordinary people cannot be professional scientists in all the fields of knowledge that pertain to their problems. They operate under time and resource constraints, and need to act quickly and confidently on the basis of the available knowledge. Because of the contextuality of the relevant knowledge, other similar 'ordinary' people and local conventions are often the most reliable sources of information.

- In studying the public understanding of science, the politics of science cannot be disregarded. The 'body-language' and view of knowledge maintained by scientists may impede communication with local and other 'user' communities. Furthermore, many of the practices of science, such as double-blind experiments, may be perceived as unethical and insensitive (e.g. Irwin and Wynne 1996).

In science studies, there has been in recent years a vibrant debate over the legitimate role of lay expertise in science-related decisions – which has also involved a lot of re-reading and reinterpreting Wynne's (1993) original study of the Cumbrian sheep farmers (Collins and Evans 2002; 2004; Wynne 2003; Jasanoff 2003; Jasanoff 2006). Although there are different views on what the general public would or could contribute without mastery of actually doing science ('contributory expertise)' in scientific and technical domains, the unique role of local expertise is uncontested. Local people have knowledge about the specific circumstances gained through 'contributory expertise' (e.g., practical experience of doing the things that science attempts to provide advice on) and through 'local discrimination' (i.e. a history of experience in the politics of a specific issue) (Collins and Evans 2004).

The idea of self-contained 'local' communities has also been criticized for disregarding more distal influences on local knowledge, such a mass communications and the Internet (Michael 2002; Nygren 1999). Yet the idea of the local as *a unique situation with special characteristics* is relevant for judging the usefulness of science-based advice. Science is developed in the laboratory, or using surveys and statistical measures. It is based on knowledge created by abstracting out specific characteristics of everyday situations and eliminating the diversity of local experiences (Lipschutz 2006). Applying science-based knowledge often requires that the everyday situation should contain knowledge on the same variables that were used in creating the advice (Heiskanen 1999; cf. Latour 1987). Practical examples include the questions: "Is our water 'soft' or 'hard'?" "How much CO_2 does our car emit?" Science-based knowledge is also usually based on probabilities, rather than 'hard' causality: you can never know whether the cause-effect relation will materialize in your case – and people are very aware of this ("My grandad was a smoker and he lived to be a hundred"). Thus, in everyday situations, scientific advice is in fact merely one type of heuristic that can be applied, and may or may not lead to the expected outcomes.

5. Co-production of Science and Society

The perspectives presented above, although increasingly sophisticated, only focus on the cognitive and discursive encounters between science and 'ordinary' consumers. But there are also very physical, material and pragmatic encounters, in which science is met as embedded into the organizational and physical structure of everyday life.

Studies of the *co-production of science and social order* (e.g. Porter 1995; Jasanoff 1996; Jasanoff 2005), have shown how science, technological systems and systems of metrology, statistics, law and administration have shaped the way environmental knowledge impinges on the lives of ordinary people. Porter (1995), for example, has shown how modern science has co-evolved with modern society. Many scientific disciplines and practices have evolved out of emerging modern administrative practices. For example, quantitative testing in psychology was an outgrowth of educational testing in schools, while clinical testing in medical science emerged from the actions of administrators such as the US Food and Drugs Administration (Porter 1995).

Science is also omnipresent in modern society in the form of technology (e.g. Michael 2002). A telling example of such colonization is recounted by Latour (1987) in the *Pasteurization of France*. Pasteur discovered the anthrax bacterium in his laboratory – in order to control it in real life, he needed to take the laboratory to the farm. Traditional practices needed to be converted into laboratory-like controlled systems in order to translate and transpose the work done in the laboratory into a large-scale sanitization of cattle breeding and care. We can see many other 'laboratories' in the everyday world around us. Weight Watchers have taught us to dissect the food we eat into calories and other nutrients, and our cars are complex systems of computers and sensors. We thus encounter science not only in what it says, but also in what it does.

Today, the scientific community itself is acknowledging its enmeshment in the practical interests of policy and industry (e.g. Gibbons et al. 1995). There is much talk of Mode 2 science, which means a shift from the disciplinary mode of knowledge production to a transdisciplinary, socially distributed, mode. The transdisciplinarity of Mode 2 blurs the boundaries between disciplines and institutions and across institutional boundaries. This brings new challenges to encounters between environmental scientists and ordinary citizens:

- Scientific knowledge and practices are strongly shaped by political, administrative and instrumental needs, rather than being a direct reflection of an asocial nature 'out there'. Environmental issues such as climate change are a case in point. It is, of course, helpful to understand what CO_2 is, where it comes from and what its increase in the atmosphere is expected to cause. This mechanism was already formulated by Svante Ahrrenius in the 1890s – yet the current global climate regime can in no way be directly derived from an understanding of carbon cycles in modern society. It is also necessary to have a working understanding of international climate regimes and their history, and of the economic, political and philosophical arguments mobilized in the debate (e.g. Shackley and Wynne 1995)
- Science is a tool with which we explore and control the world around and within us. It evolved in a period of administrative and technological moderization, when centralized control, economic progress and universal rationalism were the dominant goals of society (Porter 1995). Yet these goals are not always dominant for ordinary individuals, livings in a mixed life-world of pre-modern, modern and post-modern (e.g. Wenger 2003). Most citizens of industrialized, Western countries might view toleration of controversy as good (as opposed to the authoritarian knowledge of many religions), whereas the utilitarianism and instrumental rationality underlying modern science might be perceived as problematic, e.g. in the field of medical science or the economics of medicine (e.g. viewing the human as a set of organs or calculating the value of a human life).

The growing understanding that science, technology and policy are irretrievably intertwined is a forceful argument for the democratisation of science – which by no means implies an anti-science stance.

6. Reformulating 'Environmental Literacy' from a User's Perspective

The previous sections have indicated that whether or not people want to or are allowed to 'participate' in science debates, they are unavoidably 'users' of science in the form of both symbolic and material artefacts. It has also been shown how the simple notion of 'public understanding' or 'environmental literacy' is clearly insufficient, and is today approaching the end of its useful life. The perspectives outlined above have given rise to a reform movement in science communication aiming to create a dialogue between science and society, or science and different social communities. In the UK, and to some extent in the EU administration, this new movement goes under the name of "upstream engagement", i.e., the involvement of members of the public in early stages of science governance and public utilization. According to many commentators (e.g. Rennie and Stocklmayer 2003; Wildson et al. 2004), this movement is most obvious in the rhetoric employed by science communication institutions.

The ideal of upstream engagement implies that citizen or layperson representatives should be involved in the governance of science. This could help the ordinary 'science user' in a variety of ways: Laypeople can contribute to expert debates by challenging 'received views' that experts are blind to and by providing contextual information that is important to application (Stilgoe et al. 2006). Ideally (if not usually) laypeople can also ask question of "why this kind of research?" and thus question research trajectories from a 'public value perspective' (Wilsdon et al. 2005). Moreover, public participation or upstream engagement can stimulate scientists to question their own values and alert them to broader social and ethical issues (Wilsdon et al. 2005).

In practice, the 'public participation' or 'upstream engagement' movement is manifested in the organization of consensus conferences (Joss and Durant 1997), citizens' juries (Kenyon et al. 2003) and experiments with participatory assessment exercises (e.g. Bailey et al. 1999; Gausset 2004). While, for example, consensus conferences in Denmark have a clear role in knowledge utilization and the policy process (Einseidel et al. 2001), their role and contribution in other countries is often less clear (Klüver et al. 2000). Even though the rhetoric is being adopted beyond leading countries like the UK and Denmark, the practices of science governance in Europe are still very far from this ideal (Hagendijk and Irwin 2006).

Moreover, participation is not unproblematic for scientists or science communicators (Wilsdon et al. 2005; Stilgoe et al. 2006), and it is certainly not unproblematic for 'members of the public'. Issues of 'who should be represented' are far from solved in public participation exercises (Callon 1999). People also have limited resources (time, money, and psychological and social commitment) to expend on participating in a broad range of science governance issues (Barry 2000; Elam and Bertilsson 2003). Analyses of practical applications of 'public engagement with science' have also revealed numerous problems in defining the objectives of such exercises, giving members of the public room to set agendas, and feeding the results of the exercises back into decision making (e.g., Wildson and Willis 2004). There is thus still a long way to go until public participation efforts make a visible impact on "mainstream" environmental communications.

Apart from top-down 'engagement' exercises, people are nonetheless getting involved in science in many ways (see, e.g. Leach et al. 2004). For example, Stilgoe et al. (2006) have highlighted the role that the Internet has gained in for users of medical information. People arrive at their doctor's appointment with stacks of sheets printed from the Internet, they participate in patient group discussions, and gain information and mobilize support for countermovements on controversial science topics. The new kinds of interactions enabled by new technologies mean that: "Where people would once talk only to their friends and families, they can now tap into networks that cross borders, feeding this information back into everyday discussions. Local knowledge can become global in an instant, and vice versa" (Stilgoe et al. 2006, p. 50). Most important, nonetheless, are the conversations – among laypeople, and between laypeople and experts – that turn information into knowledge and allow the negotiation of different frames.

In spite of 'public participation' or 'upstream engagement' and the Internet, I would thus argue that the problem of 'environmental literacy' is still far from resolved – in fact, it is continually gaining new layers. The problems of the 'science user' are also not fully solved (at least for now) by involving laypersons in science governance. Most of the 'public engagement' exercises have dealt with issues that are already controversial in the public sphere, rather than the issues that are problematic in everyday life. Science and technology are nonetheless pervasive and ubiquitous in everyday life, including our relations with the natural environment, the products we use, and the way we live and work. The following personal recollection from the research process of a study (Heiskanen et al. 1998) provides one argument for why 'environmental literacy' is still important:

> We were conducting focus group interviews in 1996 on the possibilities for environmental improvement in product supply chains, involving groups of consumers, retailers, and people from product manufacturing. One of the focus group interviews was held with people present from the product development and marketing functions of Finnish detergent companies. From one company, there was both a chemist present (a lady), and a marketing manager (a young man, who had previously been marketing ice-cream). The discussion was very intense, and at one point the young marketing manager raised an issue he had been wondering about: "I understand that every species is important in its ecosystem and all that … but why are we so concerned in our company about water-fleas [*daphnia*]. We are always measuring the toxicity of things for water-fleas, what about all the other animals!". The chemist present might have told him that *daphnia* are used as an indicator species for aquatic eco-toxicity (i.e., they represent all the other animals, being cheap and reliable to conduct tests on). Hopefully, she filled him in after they left …

This young man's work might have made much more sense if he had understood why "the environment" was frequently reduced to "eco-toxicity to *daphnia*" in everyday work at his company. Yet it is not textbook knowledge that he would have needed, but some idea of the workings of the environmental science-policy-industry complex, and of how they relate to his specific, local situation. One could maintain that people have a right to this kind of knowledge, and also to information on the uncertainties involved in the process of constructing environmental standards, measures, labels, etc. Otherwise, the 'advice' that we get from experts may appear to be meaningless, pointless and disempowering. In short, people need environmental knowledge that is truly *transdisciplinary*, combining insights from the different scientific disciplines, the politics of science utilization and the concrete local contexts in which they operate.

The previous example, taken together with the review of the literature, illustrates some aspects of what a reformulation of 'environmental literacy' might look like. While the co-production model stresses the affinities between science and other human endeavours, it is also worth taking seriously the differences between scientific knowledge and everyday understandings (Table 1). Thus, while science aims to create universal knowledge, based, e.g. on probabilities or basic mechanisms, everyday understandings are unique and local: they pertain to a specific situation in a specific context. Transdisciplinary environmental literacy should be capable of making use of both kinds of knowledge.

Both science and everyday understandings make use of "black boxes", models and metaphors; for example, Fourez (1997) has pointed to the metaphorical nature of the term "cell" (a monk's chamber). "Black boxes" (cf. Latour 1991) are parts of a scientific discipline or technology that are taken for granted in a

Table 1. Similarities and differences between scientific and everyday knowledge of the environment.

Scientific knowledge on the environment	Everyday understandings of the environment
aims to be universal	unique, local
uses models and 'black boxes' developed by the scientific community and drawing on disciplinary traditions	uses models and black boxes based on everyday experience, social interaction & media communications
downplays the role of social and political considerations	actively draws on social and political considerations to make sense of 'scientific facts'
knowledge production primary aim and occupation	knowledge production secondary, or incidental outcome of everyday life

specific context – for example, the idea that *daphnia* are the correct indicator for aquatic eco-toxicity. Such "black boxes" are extremely useful and necessary both in the development of scientific knowledge, sound policies (Jasanoff 2006) and in the business of living one's everyday life. Moreover, while disciplinary science excludes social and political considerations that are outside its discipline, everyday knowledge is interdisciplinary (Fourez 1997). It is, however, necessary to acknowledge that creating knowledge is the work of the scientist, whereas in everyday life, knowledge-creation (learning, experience) is usually a by-product of something else (e.g. consuming, working, raising a family).

This reformulated view of 'environmental literacy' thus acknowledges the legitimate role of scientists as professional knowledge-creators. Yet, following Fourez (1997), we might consider a *sophisticated* use of experts an important element in environmental literacy: when to take expert views at face value, and when to seek a second opinion? This decision, in turn, may rely on considering the social and political context of the situation – which implies that science-based environmental advice should openly address these issues. The value of expert advice would thus be in offering a range of perspectives, serving as a conduit for accessing information and debates, and in openly addressing the diversity and conditionality of expert knowledge (Stilgoe et al. 2006).

Public participation in the form of different kinds of consultations is, of course, one way to promote the opening up of such issues, as well as to introduce a diversity of values into science-policy debates (Stirling 2005). Even when merely providing citizens with information, there are a variety of ways to create dialogue with local understandings. The previous review gives rise to the following suggestions that science communicators might consider in the context of communicating environmental issues to the public:

- *Making use of the 'non-standard' models and local understandings by creating dialogue between them and scientific models.* The perspective here would not be to replace ordinary people's and metaphors with scientific ones, but to consider when and where they may lead to problematic outcomes (e.g. notions of CO_2 as filterable). Connections to issues that are relevant for everyday life should be actively sought. There are today a variety of examples in which science-based advice has been developed into locally useful resources by involving members of the local community in developing relevant conceptualizations (e.g. Leggett and Finlay 2001; Zarcadoolas et al. 2003).

- *Developing communications that take seriously the inter- and transdisciplinary nature of everyday models of environmental issues.* Many people are more versed in social interaction and political analysis than in natural science, and use these skills in judging knowledge claims. Opening up the histories of environmental controversies, or even environmental tools such as publicly recognized environmental labels, can help people make sense of them. This also includes the use of experts – controversies and different points of view (even 'partisan science') should not be glossed over, but presented as openly as possible (cf. Grove-White et al. 2000; Stilgoe et al. 2006).

- *Opening 'black boxes' where necessary.* Even scientists use 'black boxes' – so much so that people with a scientific training often fail to recognize them as 'bracketed' assumption on which they base their work. The idea of using *daphnia* as a 'reference material' for testing ecotoxicity is a 'black box', a historically-developed scientific and legal practice. A meaningful 'environmental literacy' should mean that both scientists and 'ordinary consumers' become aware of the models and 'black boxes' they use – and understand them as such: tools for understanding and action. This becomes especially relevant when we attempt to translate the universal, decontextualized knowledge created by science into particular, local conditions. When thoughtfully introduced, new scientific knowledge can help people to question their current practices (e.g. Hobson 2003), but at the same time, experts need to revisit their understandings of their own roles (cf. Rydhagen 2002) and acknowledge the value of lay understandings (Rennie and Stocklmeyer 2003; Wildson et al. 2005).

- *Engaging the general public as co-producers.* Traditionally, co-production of science mainly involved state bureaucracies and large companies. Today, the balance is changing, with more and more publics calling for a role in this co-production process (e.g. Nowotny 2003; Elam and Bertilsson 2003;

Stilgoe et al. 2006). This is today most obvious in pharmaceutical research (Callon 1999; Wildson et al. 2004; Stilgoe et al. 2006). An active role for consumer and environmental NGOs is not unheard of in the environmental field, either. Yet this tradition could be taken one step further. Academic researchers might consider engaging members of the public (NGOs, local groups, consumer groups) more purposefully and intensively in the co-production of their research. Being involved in the research process can make a significant contribution to environmental literacy (in the transdisciplinary sense discussed here), while also alerting scientists to the problematic nature of universal, decontextualized and desocialized knowledge claims (Wildson et al. 2005) and perhaps enabling the researchers to find better ways to recontextualize their claims.

7. Conclusions

Current environmental policies emphasise the need to develop more sustainable patterns of production and consumption. Even though there is a growing recognition that merely providing information will not solve all the problems, there is still much talk about promoting the transparency of markets (e.g. EC 2004). One aspect of such transparency should be the connection between environmental science and the advice it provides to consumers and other non-experts on environmental issues.

The 'citadel' notion of science has been under attack from so many fronts that it has been shaken not only in academic discourse, but to some extent also in policy practices, which have attempted to open up to a more pluralistic understanding of knowledge. The emerging tendency to replace 'public understanding' with 'upstream engagement' and dialogue in science communication indicate that times are changing. The previous review has provided a number of reasons for why the communication of science should not be a one-way street – even when it is linked to the (still-worthwhile) aim to improve environmental literacy. There are also further justifications for more public engagement. Jamison (2001) has noted that the professionalization of environmental issues tends to make them joint technocratic project of science, industry and policy – with a very marginal role for the ordinary consumer, employee or citizen.

The present article presented a reformulation of 'environmental literacy' that aims to save its valuable ethos, yet expand the one-dimensional and deficient view of the public that it has traditionally embodied. The expanded view acknowledges the legitimate claims to expertise that scientists can make as full-time professional knowledge creators. Yet because the context of the ordinary person is unique, and requires knowledge from many different disciplines and walks of life, ordinary people as science users are in dire need of *skills in dealing with expert knowledge.* Contemporary science communicators have barely started to address the new challenges of communicating with a public that uses the Internet almost on a daily basis. People today are in no lack of information about the environmental problems that we are facing: rather, they lack communities that could help them make sense of the political, social and everyday aspects of these problems. They also lack clear and concise discussions about the uncertainties involved in expert advice, and about the reasons for and nature of those uncertainties.

Likewise, the 'reformulation' acknowledges the differences in scientific and everyday, or experience-based models of environmental problems – the differences that transdisciplinary understandings of the environment aim to surmount. In order to create such transdisciplinary understandings, both 'ordinary people' and scientists need to develop a *recognition of the presence of 'black boxed' models in all knowledge claims*. This recognition makes it possible to discuss and negotiate models, and the related observations.

Most importantly, developing a transdisciplinary understanding requires a recognition of *the difference between universal and local contexts*. This is the aspect of science communication or 'public engagement' that has gained the least attention. Scientific advice is not universally valid in all local contexts, and developing contextually valid advice is only possible by involving those with experience about the context, allowing for a fruitful dialogue between locally relevant and universalist claims. This is a huge challenge for both conventional science communication and the more progressive notions of 'public participation'. It involves the identification of the specifics of local contexts, which are not only geographic, but also occupational, temporal and activity-related. It is here that lay participants' contributions would be most useful for the 'science user', and it is here that scientists and science communicators should most intensify their efforts in engaging with (diverse) ‘publics’.

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