Environmental Literacy: towards a shared understanding for science teachers

C. G. GAYFORD, The School of Education, University of Reading, UK

ABSTRACT This article describes an enquiry into education for environmental literacy by a group of secondary school science teachers in the UK as part of a professional development programme. Using participatory action research approaches, the teachers explored ways of maintaining and enhancing the integrity of their subject discipline yet contributing to education for sustainable development. A knowledge- and skills-based model, with a hierarchical structure, was postulated to explain how science education could provide important elements to an overall environmental literacy for their students. Other educational qualities were identified as being essential and the pedagogical implications were explored giving examples of how these might be developed as specific methodologies. The final evaluation of the learning experience by the teachers showed that they found that the approach used here helped them to address their needs, particularly with regard to analysis of pedagogy.

Introduction

This study involved teachers’ understanding of environmental literacy. After much initial discussion, with various suggestions about its scope and purpose (see below), this was the topic selected by a group of science teachers as part of their own professional development. The context of the study is that it is one of a series of independent, but linked, pieces of action research (Gayford, 2000, in press), each of which also builds upon experience from the previous work. Here there is no claim that the teachers who participated are representative of science teachers in the UK as a whole. The approach adopted throughout is somewhat novel and the process is as important as the content. Furthermore the process indicates that it has wide application for the post-experience training of teachers. It is based on participatory appraisal methods (Chambers, 1992; Gayford, 1996, 2000), participatory action research [see, for example, Tandon (1989)] and co-operative enquiry (Heron, 1992). The literature (Reason, 1994) and experience indicate that approaches using these methods are more likely to be successful with professionals who are encouraged to feel relatively empowered and have the motivation to develop their practice collaboratively with their peers.

The basic principles of participatory action research and other approaches of this kind are that the researcher is cast in a different role to that adopted in most research studies. The researcher does not assume the role of an expert or leader of the group, but adopts
a ‘low profile’, acting as a facilitator who from time to time seeks to ensure that the participants keep to the task and continue to follow the rules set by themselves. The principle purpose of the research was to address an expressed professional need on the part of the teachers. Emphasis was on democratic means of setting the agenda, the direction of the research and allowing the participants to evaluate the outcomes for themselves. A learning experience was created for teachers that allowed them to set their own priorities in which their collective experience were integral to the way that their learning took place. The intention was to develop both knowledge and action that could be shown to have direct application for those participating through a process of collective self-enquiry and reflection (Fals-Borda, 1988). In other words, that it should enable the teachers to share their own knowledge and experiences about the topic and to appreciate the value of their own expertise.

To achieve these aims it was essential from the outset for the researcher to be as non-prescriptive as possible; to allow the participants to identify the exact nature of the topic to be pursued, the specific questions they wished to explore and to determine the direction that discussions should take. Statements that involved value judgements about what constitutes good practice, as far as possible, were confined to the participating teachers and were not made by the researcher.

**Background to the Topic—Sustainable Development and Environmental Literacy**

Discussion about the nature of sustainable development and sustainability is now many years old [see, for example, Redclift (1994) and Plant (1995)] and following on from this the nature and purpose of an education for sustainable development or education for sustainability [see Tilbury (1995), Sauvè (1996), Huckle & Sterling (1996), Jickling & Spork (1998)]. How this relates to current thinking about the educational content has been further explored by the Sustainable Development Education Panel (1998). Education for sustainable development is the preferred terminology given by the Department for Education and Employment (DfEE) in England, where among other areas of the National Curriculum it has been incorporated into the current science curriculum (DfEE & Qualifications and Curriculum Authority, 1999). All of this forms a background to this study, and whilst it is not explicitly discussed further, ideas from the debate in the literature inform both the study and the subsequent discussion.

Within the debate about environmental education there has been an important discussion about the idea of environmental literacy and how this relates to education for sustainable development or education for sustainability. A significant part of this literature has been developed in the USA and goes back at least a decade. For example, Marcinkowski (1991) provides a set of nine statements that identify the nature of environmental literacy. Some of these qualities are cognitive, others more affective. They range from knowledge and understanding of how natural systems function to active involvement on the part of students working towards resolving environmental problems. Roth (1992) created a framework based on knowledge; affective qualities, skills and behaviours, each applied to what he describes as nominal, functional and operational forms of competence. Again, there is a strong emphasis upon the education process producing students with a particular attitude towards environmental protection and improvement. In more recent times in the USA there has been a major project entitled *National Project for Excellence in Environmental Education* (North American Association for Environmental Education, 2000) in which an important outcome has been to set out
guidelines for learning for students in the fourth, eighth and 12th grades and these are regarded as the basis for developing environmentally literate students. Here the emphasis is on both providing students with a body of knowledge that enables them to understand and interpret their local and global environment and a range of skills that will help them to engage in problem solving and decision making about the issues around them. Within the context of these initiatives, science education is considered to make an important contribution. Stables (1998) has provided a further discussion of environmental literacy which builds on some of the ideas particularly of Marcincovski (1991) and Roth (1992), relating them to the situation in the UK. Later Stables and Bishop (2001) go on to consider a broader understanding of literacy outside of this field and to relate this to environmental literacy. Currently it is apparent that there is no generally agreed definition of environmental literacy, but the term has such wide use now that shared understandings are beginning to emerge.

The discussion that has been going on about environmental literacy and which concerns education for sustainable development and education for sustainability in many parts of the world is to be found in a literature which is largely unknown to teachers in secondary schools and is likely to be in a form which they will find difficult to adapt to their practical classroom teaching situation. Furthermore, in most of these contributions to the literature there is insufficient clear guidance to allow individual subject teachers to identify their own particular contribution. In fact, the study reported in this article approached the whole matter of environmental literacy from a different direction, beginning with the thoughts and needs of school science teachers, rather than from the perspective of the planners and managers of the curriculum or curriculum theorisers.

**The Study**

The study took place in 2000, involving 17 science teachers from four schools, local to each other and in the south of England. All of the teachers were volunteers and their experience ranged from newly qualified teachers to heads of department with up to 20 years’ experience. Some had backgrounds in the physical sciences and others in the natural sciences; but common to all of them was that they taught students of 14–16 years across the sciences. For the present study they met once as a whole group at the beginning and then divided into three groups, two of six participants and one of five. There was a final plenary meeting of all of the teachers to review and comment on what had been achieved. The decision to divide into smaller groups was taken by the teachers because it was thought to be a more effective way of encouraging everyone to contribute to the discussions. These smaller groups met on two occasions each, at different times, during one school term. To expedite matters some of the teachers volunteered to carry out additional work between sessions and bring their ideas along to the next group meeting.

Because the teachers were working in three groups it was important that in the first meeting: (a) the teachers addressed a topic that had been agreed by all of those involved; (b) there were agreed rules, formulated by the teachers, for conducting the sessions that would be followed by everyone; and (c) there were mechanisms for communicating the outcomes of each discussion session so that there could be a degree of sharing of thinking and the possibility of building on each others’ ideas. The groups elected their own leaders, which rotated each session. One person provided a brief record of the main ideas that were circulated to the members of the other groups, as well as acting as a reminder for their own group at the beginning of the next session.
The sessions were conducted using ‘flipcharts’ and these formed part of the continuing record of sessions.

At the first meeting it was agreed that they would consider their contribution as science teachers to education for sustainable development. As the discussion progressed it became clear that they wished to narrow this requirement further so that it addressed what was later to become described as ‘environmental literacy’, although at different times they described it as ‘environmental understanding’ or ‘environmental awareness’ before finally agreeing on the ‘literacy’ label. At this first meeting there was agreement that one of the ways that they would use the researcher was to ask for assistance when they thought it was needed. The sessions were clearly time limited and the number of meetings was specified at this early stage in the activity and the researcher’s co-operation in achieving these aims was agreed.

It soon became apparent that the teachers had four major concerns:

(1) The fact that they considered the science curriculum to be already overloaded, without adding education for sustainable development as a whole new dimension; although they appreciated that education for sustainable development was an important part of education.

(2) They considered that there were important aspects of education for sustainable development that could properly be taught within the science curriculum. However, a good deal of what they were expected to teach as part of education for sustainable development fell outside their area of expertise, and in many cases was not scientific.

(3) Aspects of education for sustainable development were being taught in other parts of the formal curriculum and also informally as part of the ‘whole school’ approach to the environment. There was a distinct possibility of replication, unless clearer boundaries were drawn.

(4) They did not wish to become involved in a process that seemed like inculcation. However well intentioned they thought themselves to be, they needed to remind themselves that many of the issues relating to education for sustainable development are controversial and there is no agreement among experts.

In an earlier session associated with this series of action research activities the question had been raised about the nature of education for sustainability and how this translated itself into classroom practice (Gayford, in press). The group involved in the research reported here took up a particular aspect of education for sustainability, considering the sort of science content that is appropriate for preparing their students to be thoughtful and effective citizens in the future with respect to the environment. Within this initial discussion there arose a broad concept of the notion of ‘environmental literacy’ and thoughts about how this might relate to possible outcomes and the process in arriving at these outcomes. This directly related to a concern over how this might affect their role as science teachers and their responsibilities towards teaching their subject.

During the first plenary session it was decided that it would be helpful if some targeted reading material was supplied which set out some of the ideas for them to consider. Therefore, between this session and the meetings of the smaller groups three items were selected and distributed for participants to read: Fien, J. (1998) Environmental education for a new century, in: D. Hicks & R. Slaughter (Eds) Futures Education, pp. 245–255 (London, Kogan Page). Fullick, P. & Ratcliffe, M. (1996) Teaching Ethical Aspects of Science, pp. 7–20 (Southampton, The Bassett Press). Simmonds, D. (1995) Papers on the Development of Environmental Education Standards, pp. 10–26 (Washington, North American Association for Environmental Education). The sessions with the small groups followed
approximately a similar pattern, although different groups took on their own individual character and contributed in different ways. The method devised by the participants for communicating the major outcomes of each group to the others was only partly successful and to compensate for this the researcher was frequently involved in providing a more elaborate explanation of what had been previously recorded. The sequence followed by each group was generally as follows. First there was ‘brainstorming’ for a few minutes to establish ideas about the scope of the field. They then went on to consider possible models for how education for sustainable development might work in relation to specific issues affecting the environment. This was followed by identification of the contribution that science makes to education for sustainable development and the specific skills and abilities that science education can contribute and the methodological and pedagogical implications.

From the beginning of the discussions it was clearly apparent that the teachers were of the opinion that their role as science teachers was not to inculcate in their students a particular view of what constitutes appropriate behaviour in relation to the environment or to instil a particular set of attitudes or values. Also, and perhaps equally important, was the idea that it is simply not good enough to take the view that it is sufficient to give students the ‘facts’ and then leave them to make up their own minds about these issues. It was thought that students must be given the skills and abilities as well as basic knowledge to be able to evaluate information and arrive at reasoned decisions. These skills, abilities and the relevant knowledge they thought needed to be further analysed.

The role of science education in developing environmental literacy was considered to be based on a hierarchical sequence of knowledge and abilities (Fig. 1). This was conceived as an iterative process and therefore it was not considered to follow a continuous unidirectional progression that might be suggested by the figure. Generally it was best approached through a process of individual or group enquiry. The first stage was learning basic terminology. The second involved understanding the concepts that provide meaning for the terminology. The third was the identification of unifying principles for the concepts so that a more coherent overview could be achieved. The fourth involved accessing new information, evaluating it by looking for scientific evidence and then assimilating it into their existing understanding to form a synthesis. The final stage involved making reasoned value judgements. The whole process was thought to function in conjunction with communication skills where the ability to express ideas and reasons was thought to be fundamental.

There were also a number of aspects that students needed to understand about the nature of science, which they considered important for the concept of scientific literacy and contributed directly to environmental literacy. These were that:

(1) science has an important contribution to make to environmental literacy, but only one contribution among several. It can help to decide what is possible, but there will usually be many possibilities that could be followed. From among the possibilities, judgements will then be made on economic, political, ethical or other grounds;

(2) scientific knowledge is not the same as ‘fact’. It is provisional and therefore likely to change with time; thus, it is not appropriate to criticise scientists, as is popular in the media, for changing their thinking as new evidence becomes available;

(3) the limitations of science need to be understood. In other words, there should be an appreciation of the sort of questions that scientists are competent to answer and those that are not within their range of competence.
Further still there were some general educational qualities that they considered contributed in an important way to environmental literacy and these are summarised as:

- an ability to be self-motivated learners who are able to access new information;
- maintaining a critical faculty that involves an appeal for evidence to support particular points of view.

The participants went on to explore further the meaning of environmental literacy by applying their ideas to the educational requirements that might relate to particular major environmental issues of the day. This, they considered, involved their students understanding the underlying scientific concepts needed to appreciate some of these major environmental issues. They considered it important to draw up a list of issues that they thought their students ought to know something about. This list quickly grew once they became involved in this part of the task. Included, for example, were the following: climate change and the greenhouse effect, biodiversity reduction, agrobusiness, energy use, transport, urbanisation, population expansion, pollution in its various forms, resource depletion, poverty, lowering of the water table in many parts of the world, the use of pesticides and herbicides, ozone depletion, waste disposal and recycling, nuclear power, deforestation and desertification. It was agreed that there is a basic scientific component to each, but also cultural, social, political, economic, aesthetic, ethical and
other aspects. It was also thought that the list was not exhaustive but probably represented most of the major global issues of the day.

For each of the above issues it was suggested that they should attempt to relate their teaching to the model in Fig. 1. For example, that there are a number of important terms and associated concepts which their students can use to link their understanding to overarching unifying principles or concepts, such as natural cycles and regeneration or the nature of energy. Students could then go on to access new information, analysing and evaluating evidence, forming a synthesis of their knowledge and making reasoned judgements. Each environmental issue, it was appreciated, is the subject of debate, or controversy. They thought that part of the problem for science teachers is dealing with controversy, that is issues about which experts do not agree. Therefore, these matters were seen as pedagogically problematic because the authority of the teacher as an expert in the subject is challenged. Thus it was also appreciated that teachers need to address these topics in a different way methodologically to that frequently adopted by science teachers in other topics within the science curriculum. They need to use approaches that are devised to help meet the pedagogical aims that had been identified for environmental literacy.

The teachers went on to consider examples of methodologies that some of them had previously used to address some of the objectives that had been identified earlier, but emphasis was on the sort of activities that science teachers were unlikely to adopt regularly in their science classes. These included:

1. Using newspaper stories and requiring their students to identify those aspects that are based on scientific evidence, or could be tested scientifically, those that are based on evidence of a non-scientific kind and those that are based on opinion.
2. Presenting their students with some of the conflicting views of scientists about some of the major environmental issues. For example, with regard to climate change and the impact of human activity on this process or the possible extent and causes of reduction in biodiversity in recent years.
3. Using role-play sessions or allowing students to construct scenarios relating to current environmental issues.
4. Interrogating the Web to find out different opinions and information about environmental issues.
5. Encouraging their students to express their own opinions based on what they consider to be evidence or reasoned value judgements.
6. Using pictures to stimulate free expression and story writing based on actual environmental issues.
7. Critically evaluating advertising material for those claims that can or cannot be scientifically supported.

The final part of the research concluded with a plenary meeting in which there was a general sharing of ideas and in which a small group of the teachers had been asked by their peers to prepare a general statement that summarised their conclusions. This would provide a rationale for their contribution, as science teachers, to the general environmental literacy of their students.

This is given below as written and agreed by the participants:

The important purpose of environmental literacy is to serve both the individual and society. To give the individual the ability to apply concepts, processes and skills to the life, work and culture of their society. Environmental literacy
addresses attitudes, behaviours and values enabling the learner to discriminate between what is proper or inappropriate. Teachers require an understanding of the nature and need for environmental literacy in relation to local culture and values as well as national socio-economic needs and aspirations. Within the process of development of environmental literacy is the need to identify issues of special importance for personal, local and national development. Therefore the purpose of environmental literacy is to enable individuals to understand the world in which they live so that they can fulfill their needs for their own personal development. It is also to strengthen their capacity to contribute to society, making it better and more sustainable. The goal of environmental literacy is to make people more knowledgeable, better informed, critical, ethical, responsible and capable of learning continuously, in order to make wise choices. It is also to promote greater consciousness and awareness, exploring new visions for the good of society as a whole. Thus environmental literacy:

- has a significant scientific component, since most environmental problems require this dimension in order that citizens can fully appreciate the issue. It should help to encourage an understanding of interactions between human populations and natural resource systems;
- requires understanding which is organised according to major unifying principles;
- enables students to appreciate the difference between opinion and scientific information based on evidence;
- involves the development of the ability to discover new knowledge and the ability to use available knowledge to solve problems;
- concerns the development of attitudes, approaches, ethics, skills and related knowledge and concepts which are necessary to cope with a rapidly changing environment and which are useful in problem solving and decision making in daily life;
- is an aspect of education for all. Environmental literacy is a requirement for every individual if they are to contribute to the society of which they are a member. It has the role of both enabling individuals to understand the world in which they live with a view of fulfilling their needs for personal development and strengthening their capacity as responsible citizens to contribute to society. The aim is to use environmental literacy to guide change, leading towards a better world and sustainable lifestyles.

There were a number of interesting questions raised from this but there was insufficient time to enter into a detailed discussion of these. Among them were such questions as ‘what constitutes ‘better’ in relation to society and the environment; also ‘how can citizens have a significant impact on sustainability when we are governed by politicians and global corporations?’

Finally the teachers were asked to evaluate the effectiveness of the style of sessions that they had experienced. What they had learned and what they thought had been neglected. This included collectively recording the six most frequently stated positive aspects and the six negative ones. The most frequently given positive comments were:

1. The fact that they felt that they learned better from each other. They valued and trusted opinions based on the experience of their peers. They felt that they could work more effectively in partnership with each other in the future.
2. They do not like being lectured by experts, as so often happens in their professional development sessions. Outside experts often do not appreciate the particular context in which the teacher is working. With the approach used here this did not happen.
(3) They enjoyed the informal atmosphere of the sessions and the fact that their opinions and expertise were of value. They were able to build on their own knowledge.
(4) They were able to set the agenda for the sessions to meet their own needs.
(5) They felt motivated to learn more and felt encouraged to try new methodologies in the future.
(6) They considered that the approach helped them to identify those aspects of education for sustainable development that could be taught properly in their science lessons and which made most use of their particular expertise.

The most frequently given negative comments were:

(1) In some cases they would have liked to the told what is the preferred opinion, rather than being left to make up their own minds.
(2) They would have welcomed more factual information about the environmental issues involved.
(3) They would have liked more time to discuss some of the issues that arose; such as ‘what constitutes better?’ when applied to the environment and sustainable living.
(4) They would have liked the opportunity to try out some of the different methodologies that had been mentioned and which had been used by some of their colleagues and to have had the opportunity to report back on their success or otherwise.
(5) They would have welcomed the opportunity to involve teachers from other disciplines in the sessions.
(6) They considered that education for sustainable development is an important matter and should be part of a whole school approach. They would have liked to have explored this idea further.

There was also an overall statement from the group that made it clear that they considered that the sessions were indeed valuable both from the point of view of clarifying their ideas about their contribution to education for sustainable development as science teachers and motivating them to continue to develop their ideas.

**Discussion**

Within this study the notion of giving students the skills and abilities as well as the knowledge to be able to evaluate information and come to reasoned decisions is also consistent with current thinking in the USA (North American Association for Environmental Education, 2000). However, contrary to most other work on environmental literacy, the teachers in this study did not think that it was part of their role to persuade their students to adopt a particular view on what constitutes ‘appropriate environmental behaviour’ or to encourage them to participate in activities which would either directly or indirectly help to ‘improve’ the environment. Any suggestion that there were well understood and universally held ideas about what could be described as ‘appropriate behaviour’ or ‘improving’ the environment was rejected in the context of their role as science educators.

By the end of the sessions most of the teachers were of the opinion that they could operate properly as science educators and at the same time fulfil an important role related to education for sustainable development. There was a strong consensus that they needed to resist pressures to continue to increase the content of the science curriculum and they were pleased to find ways of maintaining the integrity of their chosen discipline and at the same time make a worthwhile contribution to education for sustainable
development. They were generally clear that their role was not to inculcate a set of ideas or values, even though many of them held strong personal views about the desirability of certain attitudes towards sustainable lifestyles.

Most participants felt that by adopting the pedagogical strategies they had discussed they could maintain a position in which they did not simply give the, so-called, ‘facts’ but also enable their students to develop the relevant abilities to deal with information in a society where information is readily available and ideas are frequently changing.

The role of the media in forming public opinion was considered prevalent and they thought that part of their task was to enable their students to evaluate information from these sources. There were areas within this study where further discussion could have been fruitful. One example relates to the nature of genuinely controversial issues and their place in the educational process. Resolving environmental issues involves addressing ethical questions such as justice and the distribution and use of resources. These are questions to which we should not pretend that we know the answers and constitute some of the greatest challenges of our time. These are also questions that cannot be resolved without the involvement of everyone, including students in our schools, and we will have failed if we do not involve our teachers and their students in this great political challenge of our time (Wals et al., 1999). Wals et al. go on to place particular emphasis on the educational process rather than the environment. As Fourez (1997) explains, the purpose of education for sustainable development cannot be to make everyone an expert, but rather to give him or her the ability to ask the right questions and then to be able to evaluate the answers. Also within the science component of such an education it should give students the ability to use their scientific knowledge meaningfully, critically and selectively. As Dreyfus et al. (1999) explain, this does not necessarily require a full and thorough understanding of all of the concepts involved. For example, students may have a functional understanding of what photosynthesis does to the environment without understanding the complex biochemical processes involved.

One aspect to the whole debate about education for sustainable development, environmental literacy and the role of formal education is the problem that surrounds the reductionist approach to knowledge, particularly in subjects such as science. This contrasts with the literature pertaining to education for sustainable development which is permeated with discussion about the significance of post-modern and pluralist thinking. This thinking being that education for a particular end, such as sustainability, does not mean indoctrination towards a particular point of view, but the development of knowledge and intellectual skills which provide the flexibility for people to appreciate different approaches to problems which have a significant scientific and technological component. This is what Dreyfus et al. (1999) refer to as a respect for pluralism. For teachers in schools, the nature of the knowledge upon which education for sustainable development is based is often controversial and such pluralistic thinking is frequently alien to most science teachers. The knowledge of experts is frequently disputed. The ideas on which it is based are often complex and difficult for beginners to understand. As Payne (1999) explains, the implications of post-modern thinking for this type of debate are an important aspect of the way that controversial matters can be addressed in formal educational contexts. This is particularly relevant for modern-day problems where it is increasingly recognised that the solution does not lie entirely upon scientific evidence and draws upon cultural, economic, political, ethical and other considerations. In this way, post-modernism provides an alternative to universalist world-views that are based on a belief in absolute truths and are predominantly rationalist and technocentric (Connor, 1991).
This also relates to the pluralist views of the world as particularly set out by Berlin (1969) in which knowledge is not conceived as contributing to a single corpus which is governed by universal criteria. Berlin sees clearly the influence of culture and context in the rational solution of problems and criticises the notion that every genuine question has only one true answer.

The implications of this study for science educators in schools in the context of post-modern and pluralistic debates are not always clear. The process of the enquiry allowed for both insights into current thinking of a group of science teachers about their role in relation to education for sustainable development and also provided an indication of a possible way to empower teachers through their own professional development. However, the notion that science education has an important part to play in education for sustainable development is apparent and appears to be appreciated by science teachers. Their concern was that whilst they considered themselves competent to teach the important knowledge and abilities required for education for sustainable development which directly relate to their own area of expertise, there is also a responsibility on the part of the whole institution of the school to provide other essential dimensions in order to give a more complete education to their students.

Acknowledgements

The author wishes to thank the participants, who not only gave freely of their time and friendship throughout the course of this study, but also entered fully into the spirit of what we were trying to achieve and more than anything else worked to ensure the success of the whole undertaking.

Correspondence: Chris Gayford, The School of Education, University of Reading, Bulmershe Court, Reading RG6 1HY, UK. E-mail: c.g.gayford@reading.ac.uk

REFERENCES