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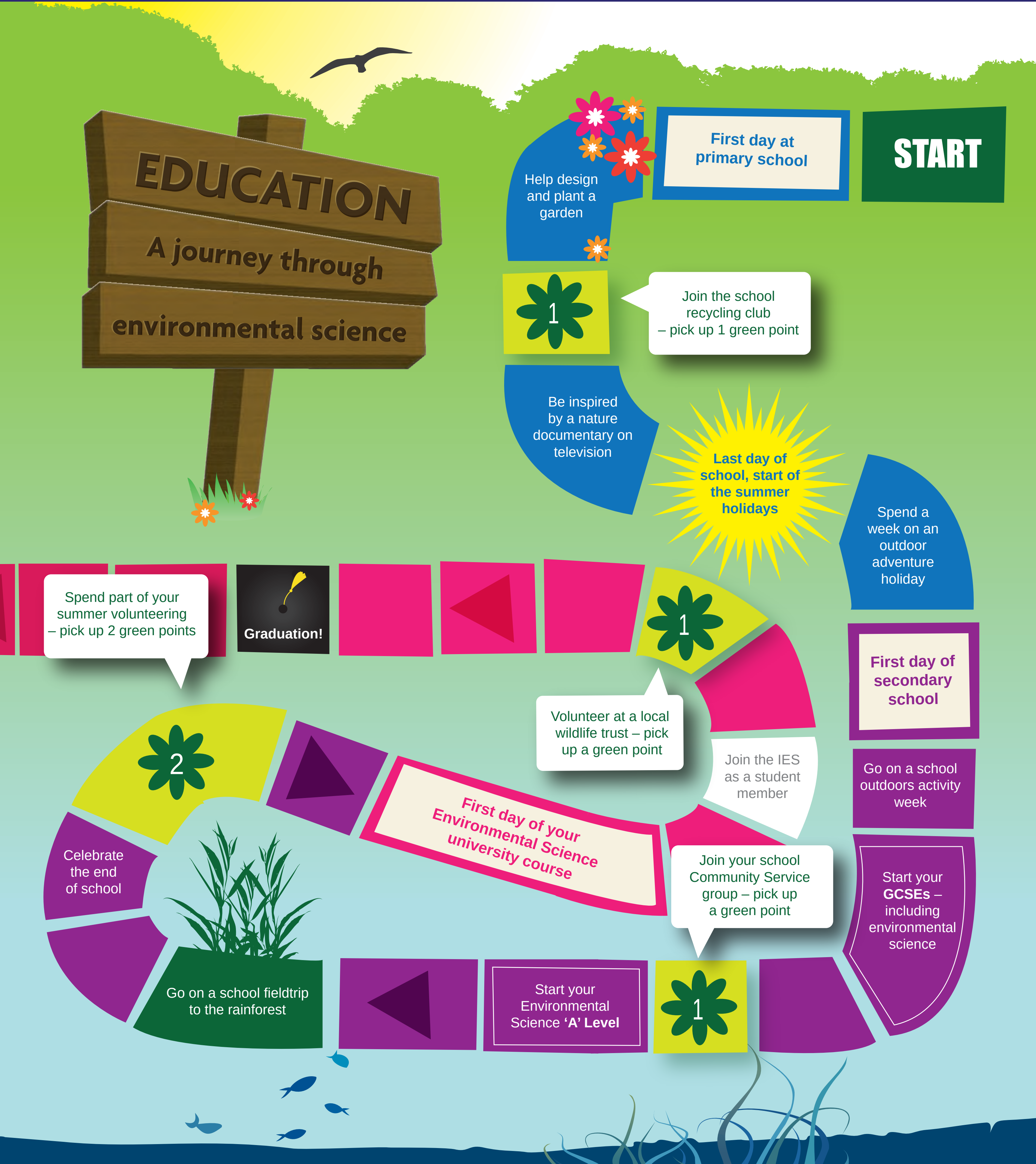

EDITORIAL

The shape and future of environmental education

Most readers of the Environmental Scientist would likely agree that the dedication and abilities of a large body of skilled environmental professionals have led to marked improvements in managing and mitigating human impacts on our environment. But why do talented individuals choose to follow a path to the environment sector? How are individuals alerted to the needs for environmental scientists and inspired to pursue such a career?

Many factors prompt our journeys to environmental science, but it is almost inevitable that our education has presented us with ideas, knowledge and understanding that have provided inspiration and aspiration. Ultimately, the skills we gain through our education can underpin and enhance our careers.

Our progress through the different stages of education presents us with varying opportunities: the papers in this issue consider when and how schools, colleges and universities - and the workplace - present environmental science to us, how we are influenced by our experience, and how our interests are fostered and facilitated. But education is dynamic, and our approach is undergoing changes.

There are intentions in the UK to revise the National Curriculum for children between 5 and 16 years old regarding which subjects should be compulsory and at what age. The forthcoming review, led by Tim Oates (director of research at Cambridge Assessment), is likely to recommend that schools and their staff decide whether and how to teach about how scientific processes impact lives, including climate change. There are attendant risks: allowing environmental issues to drift off the education radar may reduce children's awareness and deny them opportunities to pursue a line of enquiry that could lead to a career.

Radical changes are also taking place in higher education. Following the government response to the 2010 Browne Review, students in UK universities will pay much higher tuition fees; the full impacts of this change remain unknown. The intended wholesale reconfiguration will also push universities and their future students into a phase of rapid change. Revisions to the way that universities provide information to prospective students are also under way and will, in their new guise, include information on employment outcomes and professional body recognition. Such information is intended to help students decide which institution provides better prospects for employment within a given field, but also brings into focus sector-specific differences in employability and long–term career prospects. As the Higher Education Funding Council for England so eloquently put it:

"Decisions about what and where to study have the potential to be life changing, so accurate, relevant and accessible information is key, even more so now that decisions will have a greater financial impact on individuals and families than ever before."

The papers in this issue are timely, addressing key aspects of how and why education provides inspiration and opportunities for environmental scientists to develop and flourish. In a time of change, we need to ensure that the role and purpose of environmental science in education is both protected and enhanced.

"Decisions for education after the age of 16 tend to narrow the range of subjects studied and may influence or dictate career direction"

Peter Shaw is a Senior Lecturer in Environmental Sciences at the University of Southampton and Chair of the Committee of Heads of Environmental Sciences.

CONTENTS

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The journey to environmental science

Peter Shaw provides an overview of how and when education creates opportunities for individuals to recognise, foster, and pursue their interests in environmental science.

Although the past has seen much progress in environmental protection, regulation, management, mitigation and adaptation, society's collective needs for environmental scientists are unlikely to be rendered redundant in the future. Society will continue to need environmental scientists, and to create opportunities for would-be environmental scientists to develop and flourish.

There are many and various factors that lead to individuals taking steps towards environmental science, and experiences in education are almost certain to contribute. When and how though does education make individuals aware of the environment and offer opportunities to inspire them to focus on environmental science in their formal education and beyond?

One way of examining this role of education is to consider generic factors that might lead an individual towards environmental science (see **Table 1**). Links between these factors might be envisaged. Awareness may lead to inspiration and subsequently to aspiration; acquisition of environment-specific knowledge and understanding brings awareness and might also nurture inspiration and aspiration. Each of these elements would be expected to feature in an individual's formal education. Likewise, coherence and progression should be expected between the stages of education that enable individuals to make informed choices.

AWARENESS, INSPIRATION, AND ASPIRATION

How and when formal education might provide opportunities for individuals to take steps towards environmental science can be illustrated by the example of a notionally 'typical' pathway. Each stage of education provides opportunities for awareness, inspiration, aspiration, and attributes (see **Table 1**) which can be compared on a stage-by-stage basis (see **Table 2**). This example only shows a specific but common route to a career in environmental science, but this approach is nonetheless revealing.

▼ **Table 1: Key factors in the educational journey to environmental science**

<table>
<tr><th>Age</th><th>5-7</th><th>7-11</th><th>11-14</th><th>14-16</th><th>16-18</th><th>18-21</th><th>21+</th></tr>
<tr><td>Stage</td><td colspan="2">Primary</td><td colspan="2">Secondary</td><td></td><td rowspan="2">Undergraduate</td><td rowspan="2">Career</td></tr>
<tr><td></td><td>Key stage 1</td><td>Key stage 2</td><td>Key stage 3</td><td>Key stage 4</td><td></td></tr>
<tr><td>Qualification</td><td></td><td></td><td></td><td>GCSEs[1]</td><td>GCE A Levels[2]</td><td>BSc Honours</td><td></td></tr>
<tr><td>Professional status</td><td></td><td></td><td></td><td></td><td></td><td>Student member</td><td>Associate Member, Full Member, Fellow, CEnv[3]</td></tr>
<tr><td>A Awareness</td><td>A</td><td>A</td><td>A</td><td>A</td><td>a</td><td>a</td><td>A</td></tr>
<tr><td>B Inspiration</td><td>B</td><td>B</td><td>B</td><td>B</td><td>b</td><td>b</td><td>b</td></tr>
<tr><td>C Aspiration</td><td colspan="4">?</td><td>c</td><td>C</td><td>?</td></tr>
<tr><td>D Skills, knowledge and understanding</td><td>D</td><td>D</td><td>D</td><td>D</td><td>d</td><td>d</td><td>D</td></tr>
<tr><td>Broad-scale drivers, constraints, and guides</td><td colspan="4">NQF[4], National Curriculum</td><td>NQF[4], subject cirricula</td><td>NQF[4], QAA benchmarks, accreditation</td><td>Professional bodies</td></tr>
<tr><td>Local drivers, constraints, and guides</td><td colspan="5">School/college, teachers/lecturers, facilities, governors, friends</td><td>College, university, funding, academic staff, campus, other students, programme structure</td><td>e.g. employers, customers, clients, colleagues</td></tr>
</table>

▲ Table 2: an illustrative example of a 'journey' to a career in environmental science.

Levels of formal education are considered on a stage-by-stage basis, with emphasis on how each stage leads to an individual's awareness, inspiration, aspiration, and skills (see Table 1).

Upper case letters for awareness etc. indicate stages of education at which awareness, inspiration, aspiration and skills are to be expected or are statutory requirements; lower case indicates dependence on personal choices and/or situation.

[1] General Certificate of Secondary Education
[2] General Certificate of Education (Advanced Level)
[3] Chartered Environmentalist
[4] National Qualifications Framework.

Awareness of the environment is compulsory in primary and secondary education. Statutory programmes of study for key stages 1-4 are intended to provide the core for all pupils' learning and include environment within specified subject areas. The National Curriculum[1, 2] requires that children learn statutory subjects including science and geography, both of which include expressly environmental themes within prescribed subject areas.

When and how does education bring the environment to people's attention?

When and how does education capture people's thoughts and make them want to learn more about environmental science?

When and how does education alert people to the possibilities that knowledge and understanding of the environment could lead somewhere in the long term?

When and how does education provide people with opportunities to acquire and develop what is needed to become environmental science professionals?

Children up to the age of 14 must therefore encounter environment as part of the curricula for both science and geography[1, 2]. Within key stage 4 (age 14-16), science is the only statutory subject formally including environment[2].

Subsequent to completion of qualifications (usually GCSEs) in key stage 4, the educational experience of individuals is aligned with and directed by personal choice. The range of opportunities for learning at age 16 (see **Table 3**) is vast in terms of both qualifications and subjects.

More than 80 subjects can be studied at GCE Advanced level (A Level) alone[5], of which most students select three or four. The subjects available may be influenced by local factors. Awarding bodies for A Level qualifications offer different ranges of subjects, and provision by individual colleges or schools may be influenced by human and physical resources at a local scale. Relatively few schools and colleges offer an A level in environmental science or studies. Consequently, environment-related rather than environment-specific subjects are seen as precursors to and prerequisites for a degree in environmental science. An influential group of UK universities, for example, suggests that "Many [environmental science] courses will ask for two [A levels] from biology, chemistry, mathematics, physics and geography"[4].

Decisions for education after the age of 16 tend to narrow the range of subjects studied and may influence or dictate career direction (see **Table 3**). If individuals' choices at this stage are to orientate around environment, then firstly the awareness gleaned through prior education or experience must have led to inspiration and perhaps aspiration, and secondly further opportunities to pursue environment through education must be available to them. Opportunities contrast greatly at different levels. There is a general tendency for environment to be embedded within other subjects (e.g. science, geography, biology, chemistry) prior to higher education. Universities, by contrast, offer many and varied opportunities to focus on environment as a primary subject area (approximately 70 degree programmes specialising in environmental science[6]) in addition to a plethora of broadly environment-related programmes (e.g. applied ecology, geography, earth science etc.).

What exists, therefore, is a system in which individuals generally make key decisions at stages in their education before environmental science emerges as a subject in its own right. Selection of less than two science subjects at age 16 might exclude a progression to a degree in environmental science[4]. Equally, an individual taking science-based GCE A levels is not necessarily alerted to the potential for taking a primary focus on the environment in higher education and beyond.

This latter aspect is particularly striking. Awareness can lead to inspiration, but more is needed to facilitate a career pathway to environmental science. Choices that direct or assist career aspirations are informed by engagement with environmental science as a subject, but in combination with awareness of what environmental science is, what environmental scientists do, and what qualifications comprise a pathway to a career.

SKILLS, KNOWLEDGE, AND UNDERSTANDING

If an individual is to pursue a career in a specialist area such as environmental science, the National Qualification Framework (NQF) outlines expectations (see **Table 3**). Level 2 or level 3 qualifications may serve as exit points to employment, but it is expected that detailed or in-depth knowledge, understanding and skills will be acquired through higher level qualifications. This structure infers that performing a "specific occupational role" or "becoming a specialist" is dependent on education at NQF levels 4 and above[3]. For would-be environmental scientists, education after the age of 18 is important in obtaining qualifications of a sufficiently high level to pursue a career with a specialist occupational role.

With regard to skills, knowledge and understanding (see **Table 1**), the National Curriculum again provides a structured framework for primary and secondary education (see **Table 2**). Generic skills fall within the statutory curriculum, and levels of difficulty and attainment rise progressively through key stages 1 to 4. Likewise, there are progressive, stepwise increments in knowledge and understanding within prescribed subject areas through which aspects of environment are taught (such as science, and geography). The situation changes once decisions are made regarding post-16 education. Acquisition of knowledge and understanding with respect to the environment is essentially an artefact of the choice(s) made post key stage 4 (**Table 2**), and environment tends to remain embedded within other (mainly science) subjects.

For the aspiring environmental scientist, the progression between stages of education presents challenges. Progression from GCSEs to AS and A levels, for example, incurs a reduction (approximately 50%) in the number of subjects studied and may well involve adapting a different style of learning in a different location or setting. Progression from A levels to an environmental science degree again alters the mode of learning, incurring a need to adjust to a self-reliant approach. Guiding principles and constraints remain (**Table 2**); the adjustment to student-led learning contributes greatly to personal development but can be challenging.

▼ Table 3: A brief guide to the UK's National Qualifications Framework[3]

QUALIFICATIONS	EXAMPLES
Entry Level qualifications focus on a particular subject or area in which they develop basic knowledge, skills, and understanding, and are intended to "build confidence and help people to prepare for further learning, work and independent living."	Awards, Certificates, and Diplomas at entry level, Foundation Learning at entry level, Functional Skills at entry level.
Level 1 qualifications are intended to "improve basic knowledge, understanding and skills in a subject, a specific work area, or a broad economic sector" and prepare individuals for further qualifications.	National Vocational Qualifications [NVQs] at Level 1, GCSEs grades D-G, The Foundation Diploma, BTEC Introductory Certificates and Diplomas, City & Guilds Foundation Awards.
Level 2 qualifications are intended to build knowledge, understanding and skills within a defined area and prepare individuals for further qualifications; they are deemed minimum entry requirement by many employers.	Level 2 NVQs, GCSEs grades A*-C, The Higher Diploma, The BTEC First Diploma, City & Guilds Intermediate Awards, Young Apprenticeships.
Level 3 qualifications aim to develop detailed knowledge, understanding and skills within a defined area, and help individuals to "use learning in a wide range of tasks and situations." These qualifications prepare for further qualifications and are required of most applicants by universities, and may be deemed a preferred minimum entry requirement by employers.	Level 3 NVQs, AS and A Levels, The Advanced and Progression Diplomas, The International Baccalaureate, The BTEC National Award, City & Guilds Advanced Awards.
Qualifications at Levels 4 to 8 "involve in-depth learning about a specific occupational role or area of study" and are considered to lead towards individuals becoming specialists within a defined area.	Levels 4 and 5 NVQs, Foundation degrees, Honours degrees, Higher National Certificates and Diplomas, Specialist professional qualifications, Postgraduate qualifications.

"If individuals are to foster and develop their interests in environmental science and nurture their ambitions, decisions made at critical junctions need to be suitably informed"

A shift to environmental science in a higher education setting also increases the range of disciplines at hand; its multi- and inter-disciplinary nature extends beyond the confines of three or four A level subjects. The intellectual challenge faced by a student entering an environmental science degree programme is rather different to, for example, a student with physics, mathematics, and further mathematics A levels embarking on a single honours physics degree. A student with A levels in geography, biology, and chemistry will most likely widen and deepen their knowledge and understanding through an environmental science degree; how well they are prepared to face such challenges is a moot point.

TIMELY INSPIRATION

The experiences of pupils, students, and learners should provide all insights to the world of environmental science. How such experiences lead individuals to a journey into environmental science is both complex

“Decisions for education after the age of 16 tend to narrow the range of subjects studied and may influence or dictate career direction”

and variable. It is inevitable that decisions to pursue a long-term commitment to environmental sciences are shaped by both formal and informal experiences and influences. But what inspires people is highly specific to the individual, and who introduces them to the environment, how, and where (i.e. local and situational factors) may be influential. How many people can trace back their interests and career direction to friends, family, books, teachers, lecturers, holidays, or field courses that inspired them to find out more?

In formal education, the transition from one stage to the next is paramount. Decisions to pursue environmental science as a primary theme of education might well be made before the age of 16, in which case an appropriate pathway can be identified and followed. Should interests in environmental science evolve later, barriers may emerge; a lack of science A levels may preclude or delay progression to a degree programme in environmental science and a subsequent career. In this regard, the ‘embeddedness’ of environment within more established, notionally traditional, subject areas is problematic. Environmental science is rarely presented in its own right until degree level.

If individuals are to foster and develop their interests in environmental science and nurture their ambitions, decisions made at critical junctions need to be suitably informed. What is needed, therefore, is a long-term view; it is essential to guide would-be environmental scientists as to what they might achieve. Aspiration is imperative – how might anyone decide to become an environmental scientist without an idea of what they do, and what is needed to become one? The environmental science sector could do well to engage more and better with educators to promote earlier and more substantive attention to the environment, perhaps as a stand-alone element at more or all levels of primary and secondary education. It is essential to alert would be environmental scientists to their potential before they make key decisions. **ES**

Peter Shaw is a Senior Lecturer in Environmental Sciences at the University of Southampton and Chair of the Committee of Heads of Environmental Sciences.

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Developing future champions

Phil Wheater, Jo leach and **Penny Cook** review the benefits of embedding environmental education in primary school curricula and, through a case study, discuss using primary school grounds to promote environmental education, wider environmental benefits and community engagement.

Children are fascinated by their environment, and especially the natural world, even when their understanding is only partially complete[1]. Their affiliation with nature is particularly strong[2] and children are often keen to ask questions about the area in which they live, its features and functions. However, the complexity of environmental systems can challenge parents and teachers in explaining difficult concepts to young children. Lower attainment of assessment targets in environmental studies can be exacerbated in schools with more pupils from lower socio-economic groups[3]. However, for many children, awareness is enhanced when environmental education is placed centre stage, for example, through them exploring their local environment. Schools can develop citizenship and responsible behaviours through local environmental issues such as transport (to and from school), energy consumption (turning off lights), water management (turning off taps), food miles (where school dinners come from), and waste management (recycling and litter control)[4, 5, 6, 7].

In the UK, environmental sciences are not currently discrete National Curriculum subjects. In addition to the obvious core subjects of science and geography, environmental education can be taught in the non-statutory areas of citizenship and personal, social and health education (PSHE), and through art, design and technology, english, mathematics, and religious education[7]. Previously, education for sustainable development (later renamed global dimension and sustainable development) was listed as a cross-cutting subject, but is now absent from Key Stages 1 and 2 guidance[8]. Future National Curriculum changes may further limit the role of multidisciplinary subjects and pressures from such restrictions can mean that teachers give less space to cross-curricular issues including environmental education[9]. Notwithstanding restrictions on the environmental curricula content, delivery is (at present) under the direction of individual schools. This may be guided by senior staff, governor(s) identified with particular curriculum areas, key stage leaders, and/or classroom teachers, and supported by appropriately qualified teaching assistants. The availability of parents or community groups with particular expertise often determines the extent to which schools offer environmental education, since such experts can provide free support. Inspirational and involved teachers can be significant in developing

an interest in any subject area, but it is arguably more important when this crosses discipline boundaries.

Photo credit: Peter Shaw

It is not only through formal teaching that children can develop their interest in the environment. Giving pupils responsibility, personally and through environmental champions, can highlight the importance of individual and community responsibility in using and disposing of resources. Issues such as local litter control and energy usage can be starting points to discuss pollution and resource utilisation. The media can also be significant, and television programmes, films, books and computer games increasingly have an environmental focus. Using familiar social constructs and encouraging out of school interests within the curriculum can be a powerful reinforcement.

The environment that surrounds schools can be a great resource, with some building vegetable gardens or managing allotments or their own grounds to highlight issues of food production, sustainability and environmental management in an experiential rather than didactic way. The development of school grounds depends on the area available, how heavily used it is, and for what purposes. Even urban schools, with small grounds dominated by recreation, can manage them to enhance habitat diversity, provide microclimatic benefits, and reduce noise both from nearby roads and to neighbouring housing. The perimeters are often suitable for planting trees to provide shade in the summer, reduce impacts of airborne and noise pollution, as well as providing habitats for wildlife. Building small ponds can increase the diversity of insects, birds, fish and amphibians. Sowing (even small) areas that are not required for recreation with wildflower mixtures will attract pollinators. Any such management can enhance children's understanding of the processes involved, especially if they are actively involved in planning and managing the area (e.g. planting, litter picking). Involving children in monitoring can develop observational skills and promote scientific investigations into the impacts of management practices. School grounds are not just a resource for formal learning, but also provide environmental interactions during play[10]. Surveys show that there has been a decrease over the last few generations in the proportion of time that children spend playing outside and especially in natural places[11]. In urban areas, semi-natural habitats within school grounds may provide a

focus that is missing from pupils' home environments[12]. In rural environments, managing grounds to integrate them into the wider external environment can bring wildlife closer to the seat of learning.

Substantial health benefits can accrue from appropriate usage of school grounds, both for physical health[13] and mental well-being[14]. In addition, school grounds can be used to develop health education agendas for primary school pupils[15], and improvements in food behaviour and knowledge are associated with school gardening[16].

The wider community is often prevented from accessing local school grounds because of concerns over safety and maintenance costs. However, opening up grounds can integrate schools within their locality and encourage community participation in school life, including grounds maintenance. There is evidence that (even primary school) children can play a significant role in the environmental education of parents and other adults[17, 18] and this may be improved by expeditious use of school grounds, particularly where other green space is limited.

From years of experience of supporting school grounds management (through undergraduates carrying out vocational units on Environmental Management degrees at Metropolitan Manchester University), it is clear that there are substantial synergies between environmental enhancement and the school curriculum. Indeed, enhancing grounds for biodiversity has a greater impact on primary age children (6-9) than for older ones (10-13)[19]. The integration of use, potential for extending this to the wider community, and enhancement for benefits such as biodiversity are often undersold.

ST MICHAEL'S PRIMARY SCHOOL, TRAFFORD

St Michael's has been developing its grounds for biodiversity since 2000, when a year 6 class wanted to create a meaningful legacy for other children. They conceived the idea of a wildlife garden, designed it (following many hours of research), and raised the funds and workforce to build it. The timescale from concept to completion was 10 weeks; an achievement in itself. The project was not part of the curriculum (being implemented after the SATs examinations), and taught the children project management, practical mathematics (calculating path areas, pond volumes, weights of aggregate, costings, etc.), letter and persuasive writing (which proved so effective that HRH Prince Charles sent his head gardener from Highgrove House to help), presentation skills, drawing plans to scale, identification of plants, horticultural techniques and landscape design.

The garden has been used regularly not only to teach about habitats, adaptation, interdependence, and invertebrate ecology within the science curriculum but also as a resource for several popular lunchtime groups. Horticultural skills have been supported for a gardening group, as have identification and habitat-creation skills for a wildlife group. A cooking club was formed, inspired by the availability of school-grown food, and the school joined the Food for Life initiative. As the garden developed beyond its initial boundaries, the school applied to become a Breathing Space and (with National Lottery funding) developed a wildflower meadow, native hedgerows and a coppice. This led to the creation of a community gardening club for wildlife and weekly gardening and wildlife monitoring sessions in the evenings or at weekends. Pupils worked with the local parks' department to sow wildflower meadows in the neighbouring park and children were invited to help the gardener in the formal gardens and to celebrate National Tree Week by planting an oak tree and decorating an ancient tree with bird feeders.

The school community widened as environmental education was delivered outside the curriculum and outside agencies made links with the school. Gardening and wildlife club members were invited to plant native fruit and nut trees in a near-by allotment and to learn about bee-keeping and honey-making. Pupils were given access to the allotment and allowed to harvest whenever they liked. As children and their families engaged in wildlife gardening they developed a greater interest in human impacts on local and global environments, encouraging improved sustainable living to become the norm. The school hosted a 'Wildlife on your Doorstep' evening where local wildlife groups showed the community what to look for in their locality. The school also teamed up with a grassroots charity (Action for Sustainable Living), to commit to reducing energy consumption, use water more carefully, and source food locally. Their work contributed to The Snowy Project, culminating in a day lobbying councillors at the town hall to commit enhancing sustainable living in Trafford. This enabled children to see how local government operated, giving a better understanding of democracy and people power, all part of the Citizenship curriculum.

The wildlife garden has enabled St. Michael's to fulfil many criteria of the Sustainable Schools, Healthy Schools and Eco-Schools agendas and significantly contributed to the school's outstanding status. The synergistic effect of environmental education here, and elsewhere in Trafford, led to greater networking between schools on the Sustainable School, Eco-School and Healthy School

"Giving pupils responsibility, personally and through environmental champions, can highlight the importance of individual and community responsibility"

journey. Good practice is shared through support groups involving staff delivering environmental education in their schools. This does not appear to have happened with any other subject. Teaching children about the environment and how to make healthy sustainable choices is crucial if non-curricular agenda are to be met. This is however difficult for schools like St Michael's without supporting funding, staffing, or cohesive communities. Teachers need assistance when taking children out of school, but additional helpers currently require Criminal Records Bureau checks. Coach trips to habitats like coasts or rivers can be so expensive that schools run relatively few per year. However, by exploiting school grounds, children can experience seasonal changes, and be encouraged to think critically every week at school about food choices, habitat-creation, conservation, climate change, water conservation, life cycles, to name but a few. Even small urban schools with little green space can watch birds nesting, via web-cams from nest-boxes (such as blue tits at St Monica's R.C. Primary, Trafford). However, funding such work is not within annual budgets and seeking this through grants, competitions or corporate social funds requires additional time and expertise. Schools without access to such funds find it difficult to develop their grounds beyond vegetable patches and bird boxes. Even some large schools (e.g. Wellacre Technology College, Trafford, who secured funding for an Eco-Centre in their grounds) can struggle to complete projects through matched funding and as governments change their strategies for education spending.

The creation of the wildlife garden at St Michael's has therefore had many benefits that would have been difficult, if not impossible, to achieve in other ways, and almost certainly not through a single other initiative. The most crucial elements for environmental awareness and education have been the engagement of pupils themselves with the development[20], the enhancement of the local environment providing a resource for future cohorts of pupils, the interaction of many different elements associated with the school's environment[9], and the engagement of the wider community for support and mutual environmental education. This is in addition to potential health benefits for pupils and other stakeholders[13] and the wider promotion of the school through the achievement of various awards and OFSTED approval[21].

COMMUNITY-WIDE BENEFITS

Effective environmental education in schools not only enthuses children but also creates synergies between interdisciplinary subjects and benefits whole communities. Schools benefit in turn by community involvement in the life of the school. Successful initiatives include making best use of resources such as school grounds. Examples include linking with community groups (e.g. Scouts/Guides), and enabling community food growing by local people with little other space to grow food, to enhance community cohesion and provide volunteers for grounds maintenance. Schools can also share grounds' staff. Hosting courses from agencies such as the BTCV (e.g. Green Gyms) may also help to maintain grounds as students learn hedge-laying, coppicing, pond-building, bee-keeping, and horticultural skills. Other community-based courses, including basket/willow weaving, and jam-making, could provide an income source and help to manage specific habitats and species. It seems that schools that value their grounds for biodiversity and food growth have a richer curriculum and this in itself promotes community support.

Imaginative implementation of environmental education in primary schools can provide direct educational and health benefits for pupils, and enhance the wider locality. Regular contact with nature and physical activity such as gardening can improve mental health and well-being. Health promotion and facilitating life-long learning for environmental education is especially important in areas of high deprivation where access to green space for children (and the wider community) is often lowest[12]. We suggest that schools use their grounds within environmental education frameworks to work with children, local communities and organisation (e.g. local wildlife trusts, Groundwork, BTCV) to produce multi-purpose environments that are robust, high-quality places, requiring low-cost maintenance. For such initiatives to be successful in the long-term, they should be part of a broader change rather than simply individual projects[22]. Unfortunately at present such wider frameworks appear rather remote. **ES**

C. Philip Wheater is Professor of Environmental and Geographical Sciences and Head of the School of Science and the Environment at Manchester Metropolitan University. **Joanne Leach** is PSHE and Science Coordinator at St. Michael's Primary School, Trafford. **Penny A. Cook** is Reader in Public Health Epidemiology at the Centre for Public Health, Liverpool John Moores University.

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CASE STUDY

Engaging the educators

Janice Griffiths and **Marcus Grace** describe an innovative project which brings together a range of partners to engage secondary science teachers with an aspect of environmental education through oceanography.

The secondary curriculum in England offers a range of opportunities for teaching content related to environmental science. At key stage 3 (KS3), the curriculum states that students should learn about the chemical and physical processes resulting in geological activity, and that human activity and natural processes can lead to changes in the environment. At key stage 4 (KS4), this is progressed to learning about how the effects of human activity on the environment can be assessed using living and non-living indicators, and how the surface and the atmosphere of the Earth have changed since the Earth's origin and are changing at present. At both key stages 3 and 4, students are required to consider the applications and implications of science including:

- The use of contemporary scientific and technological developments and their benefits, drawbacks and risks;
- How and why decisions about science and technology are made, including those that raise ethical issues, and about the social, economic and environmental effects of such decisions; and
- How uncertainties in scientific knowledge and scientific ideas change over time and about the role of the scientific community in validating these changes.

The environment-related part of the curriculum is largely interpreted by the examination boards in terms of human effects on the environment and sustainability. For example, Oxford Cambridge and RSA Examinations(OCR) 21st Century Science includes modules on Air Quality and Sustainable Energy and also references to the safe and sustainable use of chemicals and evidence for global warming.

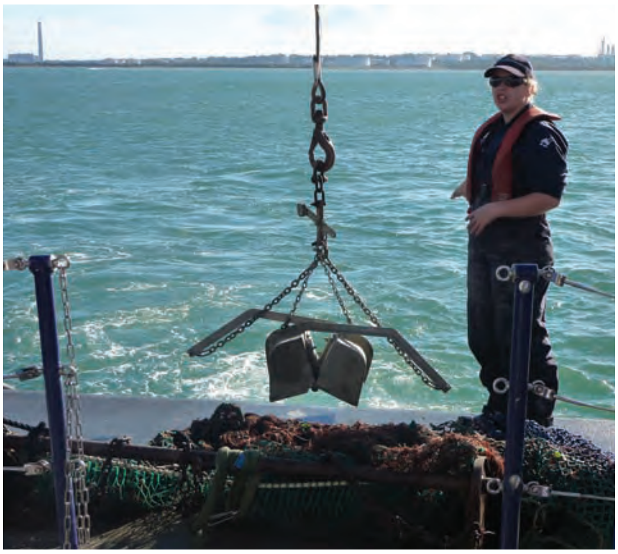
RATIONALE FOR THE OCEANOGRAPHY PROJECT

Six teachers in Oxfordshire are currently undertaking a project identifying opportunities for teaching environmental content linked to oceanography, funded by AstraZeneca Science Teaching Trust.

Drawing on oceanography in science teaching provides the opportunity to identify major environmental issues such as climate change and sustainable development, which cannot be studied adequately without considering the role of the oceans. Students are already aware of television programmes and news reports on oil spills, shipwrecks and ocean races, and so are already familiar with some aspects of the oceans and how they relate to the environment.

Oceanography, therefore, addresses some of the key global issues society faces and is a rich source of material

Left: Measuring the salinity and temperature of water in the Solent



"Oceanography – is a relatively young science, but draws on the traditional sciences of biology, chemistry, physics and geology – it is the archetypal interdisciplinary field. Although not a curriculum subject itself, oceanography can provide wonderful examples for teaching concepts in school sciences and good reasons for learning science, maths and technology"[1]

BOX 1 : AIMS AND OUTCOMES

To develop and pilot a package of creative resources to support delivery of content and skills at KS3 through the context of oceanography.

To increase pupils' engagement and enjoyment of science at Key Stage 3 in the context of the new curriculum, and therefore attainment.

To enable schools and colleges which do not have easy access to the ocean to use oceanography as a context to teach content and skills at KS3.

To enable teachers, including non-specialists, to identify a range of opportunities in the KS3 curriculum for teaching all three sciences in a context-based approach, including identification of opportunities to teach functional skills including How Science Works.

To develop a programme of professional development for teachers to support delivery of the package that can be disseminated in a wide range of fora including a dissemination event.

to address key concepts and is thus a useful subject to stimulate interest in the environment. Preliminary research shows that of 100 year 6 pupils questioned, 71 knew that approximately 70% of the earth is covered by water; 70 and 33 mentioned the oceans as a resource for food and water, respectively; 10 mentioned the oceans as a habitat for animals (but only 4 for plants) and 3 mentioned natural resources. This response indicates that pupils begin studying with some firm knowledge, but also some misconceptions about the importance of the oceans to their everyday lives.

THE OCEANOGRAPHY PROJECT

This project uses the focus of oceanography as a context to deliver content and skills from the science curriculum. Evidence suggests that context-based approaches motivate pupils in their science lessons and foster positive attitudes to science[2]. It takes into account the lack of access of many regions of the country to the oceans – the project is being run in Oxfordshire; as part of the project, teachers are developing a package of resources, professional development and events to bring oceanography "inland" and make explicit the relevance to students. Contributors include teachers, the National Oceanography Centre, Southampton (NOCS), the Science Learning Centre South East (SLCSE), Oxfordshire Local Authority, Oxford Museums, Science Oxford and STEM and Student Ambassadors, drawing on a broad range of expertise in curriculum development, professional development, subject knowledge, school and public engagement and pedagogy. The project also builds upon the partnership of SLCSE with NOCS in running professional development for secondary and post-16 teachers and lecturers.

STRUCTURE OF THE PROJECT

Autumn term 2010: initiation

One teacher from each of six schools from Oxfordshire was recruited for the project; teachers were self-selecting. The group met for a two-day residential event in Southampton at NOCS in mid-October; the group included the six teachers, Dr Simon Boxall from the National Oceanography Centre, staff from the SLCSE and Oxfordshire Local Authority advisers. On the first day, the group explored the study of oceanography, its importance to environmental issues and relevance to school science. This was followed by a study trip on the Solent in the research vessel, Callista. The group participated in a variety of activities including using Secchi disks to assess water clarity, using advanced equipment to measure salinity and exploring the flora and fauna from mud sampled in the estuary. Teachers were shown how to interpret data collected and how to access the wide range of online data available world-wide to use in the classroom. On the second day, teachers worked with NOCS students to identify a focus for their teaching ideas and explored a range of resources available. During the remainder of the autumn term, the teachers worked on the production of teaching resources in collaboration with a student from NOCS, designed to bring together subject and pedagogical expertise and practical experience of teaching at KS3.

Spring term 2011: piloting of materials

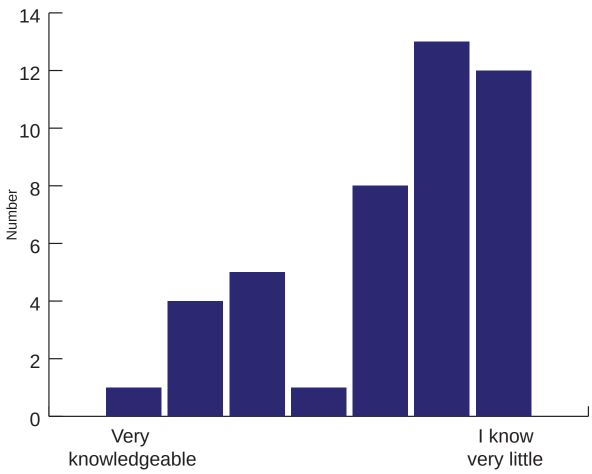
Teachers are currently piloting the resources they have developed with KS3 classes and will be evaluating the resources and materials. A professional development episode is to be designed and delivered by the SLCSE, Science Oxford and Oxfordshire Local Authority. The professional development will take place with the whole science department in each of the six participating schools and will address the initial work achieved on linking oceanography to the KS3 curriculum and the resources and materials developed.

EVALUATION OF THE PROJECT

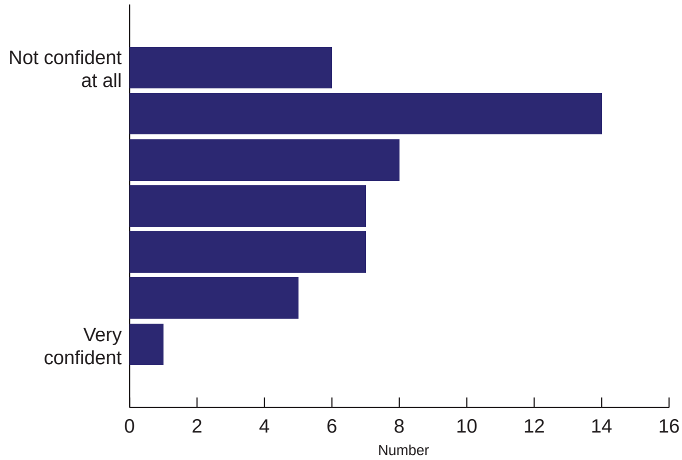
An online questionnaire (i-survey, University of Southampton) of participating teachers' knowledge of and attitudes to science (focusing on oceanography-linked aspects) and use of resources has been developed; this has been carried out prior to the commencement of the project and will be repeated at the end of the project for participating teachers.

A second questionnaire exploring pupils' knowledge and attitudes to and enjoyment of science (oceanography-linked aspects) and science resources

▼ **Figure 1: Frequency distribution of teachers' perceived knowledge of oceanography (N=44)**



▼ **Figure 2: Frequency distribution of teachers' perceived confidence in integrating oceanography to teaching of science at KS3 (N=48)**



has been developed using i-survey; this will be administered to pupils whose teachers have participated in the project and a control group whose teachers have not been involved. Focus group interviews in the summer term 2011 will also be held with teachers participating in the project and feedback sought from departmental colleagues.

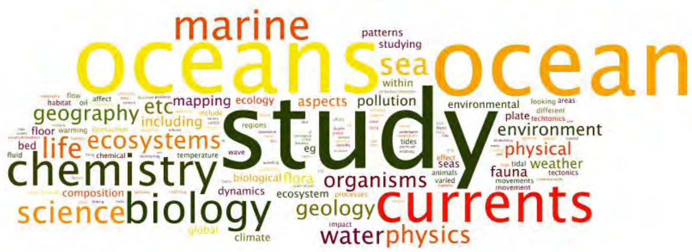
Initial survey data

Some 53 teachers from Oxfordshire responded to the initial survey. The majority knew little about oceanography as a subject (**Figure 1**). Only 15% thought they had linked their teaching at KS3 with aspects of the subject, and the majority were not confident in linking their teaching to oceanography (**Figure 2**). When asked what they thought was involved in the study of oceanography, the most common associations were with oceans, currents, chemistry, biology, geology (less so physics), ecosystems and environment (see **Figure 3**). Weather and climate were also mentioned.

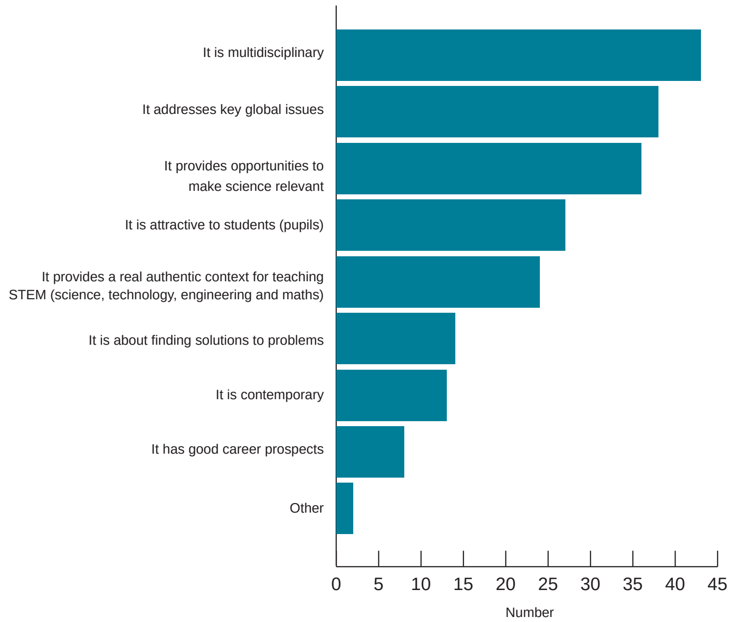
Teachers were also asked which features of oceanography were attractive (**Figure 4**). The multidisciplinary nature of the subject, relevance, ability to address global issues and providing an authentic context were all considered important. Perhaps not surprisingly, potential for a future career was not considered as an attractive attribute and this reflects a deficit in knowledge and experience of careers in science by teachers and in school science generally[3].

All teachers participating in the project to date have reported an increased understanding of oceanography as a subject and increased enthusiasm for the subject area. All teachers have planned, and are currently teaching, sequences of lessons based on oceanography, which have been planned in collaboration with their

▼ **Figure 3: Words most commonly associated with oceanography by teachers** Source: www.wordle.net



▼ **Figure 4: Frequency distribution teachers' views of the attractive features of oceanography as a subject**



partner NOCS students. This collaboration has been found to be particularly successful, as the partnership brings together subject knowledge and knowledge of resources, understanding of the KS3 curriculum and pedagogy (see **Box 2**).

NEXT STEPS

During the summer term, 2011, the teaching resources and approaches will be evaluated informally by teachers participating in the project. Episodes of professional development will then be carried out with departmental colleagues in each school to disseminate the work to date; further dissemination across Oxfordshire is planned for the summer/autumn term 2011. Resources will also be collated into a booklet that will be made available across Oxfordshire.

The remaining surveys (teacher and pupil-surveys) will be carried out during the summer term 2011. The project findings will be disseminated on the AstraZeneca Science Teaching trust website[4] and autumn conference, and at suitable education conferences. The outcomes will also be published formally.

Feedback to date strongly suggests that this is an extremely effective model of professional development which engages teachers with a particular subject area and offers a fresh approach which integrates input from teachers, oceanography students, and organisations involved in professional development (SLCSE, Oxfordshire Local Authority, Science Oxford and Oxford Museums). ES

Janice Griffiths is Director, Science Learning Centre South East at the University of Southampton, and **Marcus Grace** is Deputy Head (academic) of the School of Education at the University of Southampton.

"Potential for a future career was not considered as an attractive attribute and this reflects a deficit in knowledge and experience of careers in science by teachers"

BOX 2: TEACHER FEEDBACK ON THE PROJECT

The project elicited different approaches to the task, as shown by the feedback from two teachers. The first was investigating a specific issue (sea level rise), whereas the second was exploring oceanography as an interdisciplinary subject area, with students being grouped into project and subject-specific groups.

Marcel Van den Heuvel, Cheney School

"I have started a project with a year 9 group. The class has divided itself into smaller groups (2-4 students) and each group has chosen a location in the world where a rise in sea level might be a problem (I have a world map on the wall where they have posted a note). In one lesson a fortnight, I have them work on the project. After choosing the location, they all have written a short report on the current state of the sea level and why a rise might be a problem and for whom. They have started scanning changes of sea level in real time as well as backwards in time, looking at various techniques that have been used in the past and looking at modern techniques, including ARGO floats. They will continue with this until Easter time. At that point they will need to prepare a report that also includes some predictions for the future. They will then try to find a school in their chosen location and make contact. The report will then be send to that school to share ideas. I am also planning to organise a trip to NOCS and run a study day on the Solent."

Kat Lygate, The Cherwell School

"Lesson plan, Oceanography Project, Y8 Assessing Pupil Progress task, assessment focus 3 (AF3): This is a sequence of three lessons designed to allow assessment of pupils on AF3 within the context of finding out about the study of oceanography. The students will work in two types of groupings: (project groups: biologist/ chemist/ physicist/ geologist and subject specialist groups - (4-5 per subject, e.g. 5 biologists, 5 chemists, etc.).

- Lesson 1 - What is oceanography; how do scientists work collaboratively; setting the problem and what questions do we need to ask (in project groups)?
- Lesson 2 - Demonstrations of key principles and research.
- Lesson 3 - Collate the information from subject specialist groups and present findings (in project groups).

Assessment of AF3:

- Teachers to assess based on pupil conversations during the progress of the activity using an assessment tick grid.
- Evidence from posters (peer assessment).
- Success criteria to be shared with students."

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Young influences

Mark C. Mifsud examines the factors influencing Maltese youth, what they know about the environment, and what is important to them.

The major environmental issues in Malta are related to its small size and high population density, which is augmented by an influx of visitors each year. Not much is known about the environmental knowledge of young people in the Maltese islands, or of the main actors that are responsible for the acquisition and development of environmental knowledge amongst young Maltese. Research was undertaken during 2007 and 2008 to address this gap, comprising a class administered questionnaire survey completed by 447 students in the post secondary age range. Stratified sampling was used within the studied colleges and schools to ensure that youth studying languages, sciences, business, and humanities were represented according to the actual percentages at the school level.

AT A GLANCE: MALTA

A small archipelago, situated in the Mediterranean between Sicily and Libya, comprising of three inhabited islands and a number of uninhabited smaller islands.

Area: 316 km^2
Population density: ›1300 km^{-2}
Tourism: 1.2 million visitors per year[1]

Main environmental issues[2]:
- waste production and management
- reliance on fossil fuels for energy production
- high private motor usage
- freshwater production requiring a high energy input

KNOWLEDGE

Students were asked about their knowledge of four major environmental areas: global environmental issues; local environmental issues; knowledge of important concepts; and knowledge of local solutions. For each area, there were six multiple choice questions; each correct answer was given a score of one. The scores were summed together to give the four separate knowledge score, and overall scores across all four areas were also calculated.

The students' knowledge on local environmental issues was at a lower level than that of global environmental issues (see **Table 1**). One reason for this may be the total absence of Maltese textbooks in the sciences. Malta still heavily relies on imported textbooks from America or the United Kingdom for the sciences. The opinion of young people on the general population with regard to the environment might be summed up in the following statement:

"It is very bad. People are still not aware enough of the importance of nature. They still litter the environment and harm animals. They do not care because of egoism and ignorance. They are close minded and believe the environment belongs to them" **(16 year old female)**

▼ **Table 1: Maltese students' scores regarding their knowledge of environmental issues, concepts and solutions to problems. Scores for each of the knowledge areas are out of 6. The overall knowledge score is out of 24.**

	Knowledge of global issues	Knowledge of local issues	Knowledge of important concepts	Knowledge of local solutions	Overall knowledge
Mean score ± variance	3.4 ± 1.8	2.9 ± 1.8	3.2 ± 1.6	2.7 ± 1.3	12.1 ± 10.6

IMPORTANCE OF LOCAL ISSUES

Overpopulation was identified as the most important national environmental issue and was mentioned by 50% of the student respondents (see **Table 2**). The perceived importance of overpopulation as a main national environmental issue may align with the very high population density on the islands, and the boom the building industry was passing through at the time of the surveys: traditional, large townhouses were being demolished to make way for apartments to accommodate the increasing population. Other important national issues identified included air pollution, traffic congestion and solid waste (**Table 2**), all of which are all directly related to overpopulation.

The importance of these local environmental issues was exemplified by one student's response:

"My opinion is that we are more interested in digging up the only beautiful environment that's left and building a block of flats for the good of the people. We are an overpopulated island owning more than one car. The air we breathe is exhaust." (17 year old female)

Other environmental issues were identified by fewer respondents, including, for example, hunting and trapping (which occurs exclusively for birds in Malta). Hunting and trapping issues are main environmental issues as represented in the local media, and this issue can be inflated by political parties in opposition to gain political advantage. Students see this as an important issue, but also recognise the political context and emphasis. The following student recognises the inflated importance awarded to hunting by politicians:

▶ **Table 2: Ranking of importance of local environmental issues by Maltese students.**

Rank	Environmental issue	Students identifying issue (%)
1	Overpopulation	50
2	Air Pollution	43
3	Traffic Congestion	41
4	Solid Waste	26
5	Hunting and Trapping	16
6	Water Pollution	15
7	Global Warming	12
8	Aquifer Depletion	11
9	Habitat Destruction	11
10	Quarrying and Related Impacts	8.5
11	Ozone Layer Depletion	6.5
12	Liquid Waste	4.5
13	Soil Erosion	4.4
14	Sound Pollution	4.3
16	Biodiversity Depletion	3.8
17	Acid Rain	3.1
18	Production of Particulates from Building Industry	3.6
19	Forest Destruction	1.6

"Not such a good state, but could be worse. Lots of effort on banning hunting when the major worries should be air and sea pollution." (17 year old female)

IMPORTANCE OF GLOBAL ISSUES

Global warming was identified as the most important global environmental issue, and was mentioned by 55% of student respondents (see **Table 3**). This was closely followed by ozone layer depletion (mentioned by 48% of students). Other global environmental issues were less frequently highlighted, although air pollution and forest destruction were concerns for many respondents. Overpopulation was again noted as a concern, but at a global scale.

Rank	Environmental issue	Students identifying issue (%)
1	Global Warming	55
2	Ozone Layer Depletion	48
3	Air Pollution	35
4	Forest Destruction	32
5	Overpopulation	18
6	Biodiversity Depletion	15
7	Water Pollution	14
8	Acid Rain	13
9	Habitat Destruction	10
10	Traffic Congestion	8.7
11	Solid Waste	3.4
12	Aquifer Depletion	2.2
13	Soil Erosion	2.2
14	Production of Particulates from Building Industry	1.8
16	Liquid Waste	1.8
15	Hunting and Trapping	1.6
17	Sound Pollution	1.6
18	Quarrying and Related Impacts	0.2

▲ **Table 3: Ranking of importance of global environmental issues by Maltese students**

SOURCES OF INFORMATION

The majority of students received some information from all the listed sources (see **Table 4**). Results showed that students receive most information from school (65%), television (48%) and the internet (44%). Conversely, fewer students obtain information from government agencies (10%), radio (10%) and billboards (4.3%). Many students stated that there is a lack of environmental awareness of the local general public, with some suggesting that whilst awareness is still low it is increasing.

Rank	Environmental issue	Students identifying issue (%)
1	School	65
2	Television	48
3	Internet	44
4	Books	36
5	Family	33
6	Magazines	17
7	National campaigns	15
8	Friends	12
9	Non-governmental organisation (NGOs)	12
10	Government agencies	10
11	Radio	10
12	Billboards	4.3

▲ **Table 4: Sources of environmental information used by Maltese students.**

RELIABILITY OF INFORMATION

Young people were asked to identify the reliability of the listed sources of environmental information (see **Table 5**). Young people perceived the most reliable sources to be school (56%), books (47%) and the internet (38%). In contrast, radio, billboards and friends were thought to provide less reliable environmental information.

IMPROVING EDUCATION

This research sheds light on the effectiveness, or otherwise, of current formal and informal environmental education providers. The importance of schooling as a provider of good and reliable

▶ **Table 5: Reliability of environmental information as perceived by Maltese students.**

Rank	Information source	Rated 1st for reliable environmental information (% of respondents)
1	School	56
2	Books	47
3	Internet	38
4	Television	37
5	NGOs	34
6	National campaigns	30
7	Magazines	17
8	Family	17
9	Government agencies	14
10	Radio	14
11	Billboards	13
12	Friends	7.6

environmental information has been highlighted in this study. Schools are currently playing a central role in imparting environmental knowledge which is considered to be very reliable by the students themselves. However, more consistency across schools is required and outdoor education needs to be higher on the agenda. Simple activities, such as field visits, appear to be of utmost importance to increase the number of students who study environmental science at higher academic levels, as they expose students to the reality of the environment and the work of environmental scientists. Television has been afforded a high score for provision of information but it has a lower rating with regards to reliability. Political interference seems to be the major obstacle. Vetting by an independent board would perhaps reduce this interference, but gaining trust in such boards in the Maltese islands may be best achieved by employing non-Maltese residents as a means to avoid the risk of perceived political bias. This perception appears to be less negative when the appointee is not of Maltese nationality.

It is clear that students are more knowledgeable about the global environment than about the local environment. This situation has possibly been brought about by a number of factors, but the main concern is the lack of textbooks on the Maltese environment. Rather than let authors try to make ends meet (Malta is a very limited market) and publish the books themselves (as the situation stands now), the government should actively commission authors to publish such books to fill in these lacunae.

NGOs, local policy makers and local educators have to take these findings very seriously when devising new environmental education programmes to ensure that such programmes do not just lead to an accumulation of knowledge, but also to improved pro-environmental behaviour. Researchers should start studying the effectiveness or otherwise of such programmes to influence behaviour, so that maximum benefit is derived from the limited financial and human resources available. **ES**

Mark Mifsud lectures at the Department of Environmental Science, University of Malta, and acts as a consultant to the Malta Environment and Planning Authority.

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Inspiring post-16 students

Jane Banks examines the reasons why students choose to study environmental studies and the factors that enthuse them to study this area of science at university.

Despite the confusion caused by the name change from 'environmental science' to 'environmental studies' in 2009, the subject is still widely accepted as a science course alongside the traditional sciences. The name change was caused by the move from six units to four, with the replacement of centre-assessed coursework by the embodiment of assessed practical skills within the written exams. The subject continues to meet all other criteria for sciences[1].

The observations and suggestions in this case study reflect the experiences of students and teaching staff in Peter Symonds Sixth Form College (PSC), in Hampshire, which has the largest environmental studies A Level department, averaging a total of 200 students across both AS and A2 every year.

MAKING INFORMED CHOICES

Although it is possible to study GCSE Environmental Science, this subject is not widely offered and of the 16 feeder schools and approximately 145 additional schools from which students are recruited to this particular college[2], only a very small minority of these schools has environmental science on the GCSE curriculum. Potential students, and indeed their parents, therefore begin to consider A Level choices generally unaware this subject offers a firm foundation in both the physical and living components of the environment in their first (AS Level) year, and develops these concepts into more technologically and scientifically demanding studies of environmental problems, and solutions, in their second (A2) year.

In the majority of cases, potential students and parents first encounter this possibility when they visit the college during one of several Open Evenings during the year. The environmental studies display and information are situated along with the other science subjects, so those students visiting chemistry and biology, for example, are encouraged to visit the environmental studies display because of the complementarity of these subjects. By far the commonest question is "How is environmental studies different to geography?"; the staff spend much of their time explaining that environmental studies focuses predominantly on the science behind human impacts on the environment, and the solutions that can be enforced to combat them. Geography at A level, on the other hand, is concerned with the impacts on human populations, although there are some topics that are 'common' to both subjects; there are, indeed, also topic areas that are common with biology, physics and probably more so with chemistry. In addition, environmental studies has a more holistic approach than geography, in the development of higher cognitive skills, especially identification and selection of data, evaluation of their significance and the formulation of new theories. These are set in a context of contemporary, relevant topics that affect the lives of everyone.

"How is environmental studies different to geography?"

VIEW FROM THE CLASSROOM: ELLE PASSINGHAM

Ellie came to PSC in September 2006, unaware of the subject, but with a natural love of the outdoors, propagated mainly by family holidays in the UK and her parents' interest in the natural environment, particularly her mother's in ornithology. Lacking the opportunity to study environmental science at GCSE, Ellie was inspired by the Open Evening displays and talks to embark on this route of A Level study.

She was one of the participants on the Belize 2007 reef and rainforest trip, which was a pivotal time for her, highly influencing her long-term career plans. When studying the reef component of the trip, Ellie became very aware that the island she was staying on, less than one metre above sea level, was inevitably threatened by the impacts of global climate change, so she resolved to do what she could to prevent this happening. Ellie became very involved in the 'Eco Schools' project in college, which she described as hugely beneficial in providing awareness of the bureaucratic issues involved in recycling and energy conservation. As testament to her hard work and commitment to the subject, she received the 2008 PSC Environmental Science Student Award.

Despite not studying any other 'conventional' science subject (she achieved excellent grades in philosophy, and psychology as well as environmental science), she successfully attained a place on the Wildlife Conservation degree programme at the University of Kent. She always felt that her lack of A Level biology (not chosen because she did not enjoy the GCSE course) would disadvantage her, but her enthusiasm and commitment has shown otherwise. When describing how environmental studies at A Level helped with her degree studies, Ellie is emphatic in her belief that the scientific and technological concepts in the course have given her a clear advantage in her undergraduate studies.

Ellie is now about to complete her degree, having written her dissertation on the factors affecting leaf cutter ant behaviour (studied during a two month research trip to Peru in 2010). She gained invaluable work experience through a local ecological consultancy firm, and assisting in educating both teachers of this subjects and students, and has decided to focus on agro-environments in the next year or two, working on a variety of projects within UK universities.

"The passion and enthusiasm of the Environmental Science staff at Peter Symonds College gave me the confidence to believe that I could make a difference...The course is inspiring, and importantly provided me with the tools and skills (analytical, understanding of the role of statistics, communication and so on) that have given me such an advantage at University."
Ellie Passingham, April 2011

The next challenge then is to reassure parents that:

- This course is accepted by universities, especially the Russell Group (albeit with one exception) as a Science subject;
- There are ample opportunities to pursue a degree programmes in environmental science or closely related subjects (over 600 such degree programmes are available in the UK); and
- The career possibilities are varied and plentiful.

The displays used cover a range of topics from renewable energies (solar ovens, wind turbine, solar charged batteries), to recycling (a selection of everyday items made from recycled materials) and the equipment used in teaching fieldwork skills and practical conservation techniques. The environmental studies department has always worked hard to provide varied, stimulating and informative field trips, and the image boards used in the Open Evening sessions, really do convince students that this is a course that they may well want to study.

THE STUDENT EXPERIENCE

If a student chooses to study this course (possibly as a first choice A level, sometimes as a 'last resort' choice) they suddenly find themselves immersed in a dynamic, engaging subject. With three teachers who teach only this subject, the students receive up-to-date information on global environmental issues and the opportunity to develop practical skills, giving them a significant advantage when applying for university, and future employment. This situation contrasts markedly with other centres in the country where only around 25% of environmental studies teachers teach only this subject[3], and a similar percentage have a degree in environmental science. PSC students gain the advantage therefore of teachers who can share resources, expertise and support, without having their time divided between many subjects.

Teaching methods range from slideshows illustrating environmental issues and their solutions, through to internet research (where they develop the skills of analysis and synthesis). However, one of the key

"Over 40% of PSC students who complete the environmental studies A Level every year go on to study environmental science or a closely related subject at University"

Top left: Birdwatching in Belize, 2007
Top right: Comparing herself to a jabiru stork, Belize Zoo, 2007
Bottom: Opening the new recycling point in the main college refectory, 2008

components is field trips. These have been developed to cover a vast range of topics and opportunities for the development of skills, which may be subject-specific or transferable to all areas of education.

Day field trips have included visits to a sewage treatment plant and incinerator (which are integral part of the Waste Management component of the second year course), ecological techniques in freshwater, woodland and heathland ecosystems, marine sampling in the Solent (through the National Oceanographic Centre, Southampton) and visits to power stations (hydroelectric, coal and oil fired). The 'Practical Wildlife Conservation' course which is run as an extension activity has provided students with invaluable skills in the use of tools and techniques in woodland management. Residential trips of four to seven days have focussed on environmental issues in Malta, renewable energies (Centre for Alternative Technology, Wales) and more recently, energy generation and practical conservation (Flatholm Island in the Severn Estuary).

Annual overseas field trips have been established over several years, offering students to be involved in community projects and wildlife conservation in Kenya, and to learn about sustainability in rainforest and coral reef ecosystems in Belize. These trips, in particular, are highly influential in forming students' career pathways.

The students are further supported by an environmental studies intranet site, workshops and other activities that may be relevant in a college, or wider, context. Some students have been instrumental in pushing forward the college recycling policy, or petitioning for an additional local Park and Ride service. In the 2011 AS year, 90% of the 135 students have chosen to study this subject for a second year[4], compared with less than 75% in other subjects.

BEYOND A LEVELS

Over 40% of PSC students who complete the environmental studies A Level every year go on to study environmental science or a closely related subject at university[5]. A significant number go straight into paid employment in this field or undertake volunteer placements, with the objective of going into higher education.

THE FUTURE FOR THE A LEVEL

Environmental studies/science became new A level subjects in the 1970s. In the UK, there is no shortage of passionate, enthusiastic teachers of A Level Environmental Studies, but many of them are teaching in a vacuum, isolated from the ability to share resources, experience and knowledge. Combined with this is a general lack of knowledge amongst parents, students and other teaching staff, about the opportunities that this subject offers. The immediate challenge for all teachers of Environmental Studies in the Post Compulsory Education sector, but also for those teachers in Secondary and indeed Primary Education, must be to demonstrate that this is a science worth studying, so worth studying in fact, that for many people, it can only be 'the' science of the 21st Century. **ES**

Jane Banks is Head of Environmental Studies at Peter Symonds College, Winchester, Hants and an Open University tutor in Environmental Science.

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Evolving higher education

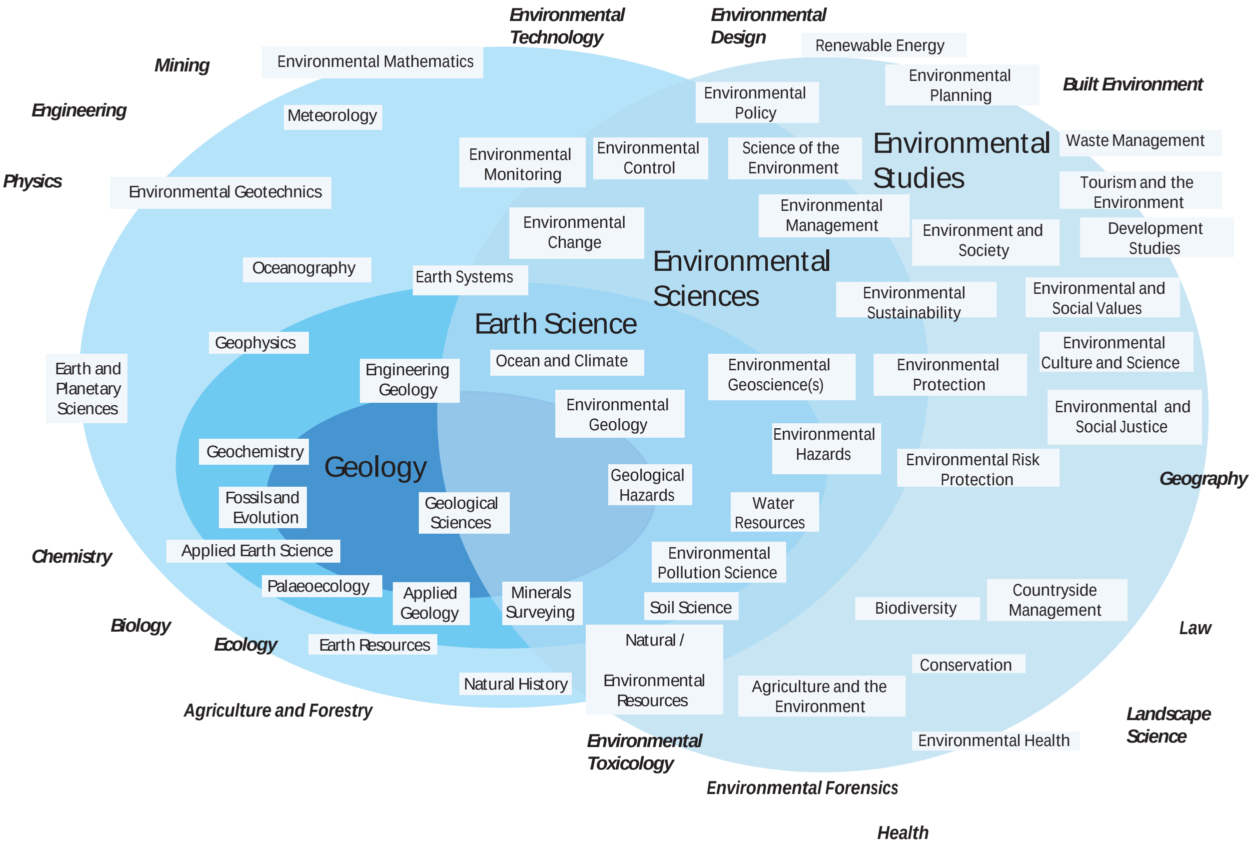
Roger Smith reflects on the histories and changing fortunes of environmental sciences in the higher education sector.

Environmental science as an undergraduate discipline was first established in UK universities in the 1960s. The discipline arose from the developing environmental concerns of the first wave of environmentalism in Europe and North America that was spurred on by fears relating to rapid population growth and the resource demands, and accompanying pollutants, of the post-war booming consumer society. There was a developing perception at the time that the more narrowly focused academic subject departments such as geography and biology, present in UK universities since Victorian times, did not have the breadth of expertise to address environmental concerns. As the Quality Assurance Agency for Higher Education (QAA) reported, the origins of the School of Environmental Sciences at the University of East Anglia derive from 'a proposal that an interdisciplinary school embracing those aspects of the biological and physical sciences which are relevant to the environment should be established'[1]. The social sciences were then added before the first intake of students.

It was, of course, easiest to assemble novel groupings of expertise in the newly created universities and polytechnics of the 1960s and a number of degree programmes, such as those at East Anglia, Hertfordshire, Lancaster, Plymouth and Stirling, date from that time. The resurgence of environmental concern in the 1980s, driven by problems such as acid rain and the Chernobyl explosion, saw another burst of programme creation, although a number of providers from that period have failed to stay the course. In recent years the growth of modularisation has resulted in an increase in the number of named awards in universities. Along with the recent movement towards larger academic units in universities, this contributed to a trend to amalgamate traditional geography, earth and environmental science academic units in order to deliver economies of scale on the one hand and a focus upon sustainability on the other.

This variation in the evolutionary histories of environmental sciences in UK universities has resulted in a wide variety of arrangements for the delivery of undergraduate programmes. These range from provision delivered by large and dedicated 'Schools of Environmental Sciences' to often smaller programmes organised across internal institutional boundaries and driven forward by a programme leader or small team. This diversity is recognised in the constitution of the Committee of Heads of Environmental Sciences (CHES) that accords equal status to representatives from a broad range of universities with a variety of delivery mechanisms. Also, as a result of different evolutionary histories, programmes may have different emphases; some perhaps having grown from collaboration between biological and social sciences, whilst others may focus more on earth sciences or environmental chemistry. Within larger departments students often have considerable opportunity for specialisation across a variety of the 'subjects' of environmental sciences and a consequence of this range of opportunity is

"Employer understanding of the capabilities of ES graduates is less well developed than for traditional academic disciplines although the need for their capabilities is perhaps now better appreciated"



▲ **Figure 1: Venn representation placing environmental sciences within areas covered by the subject benchmark statement for ES[3].** Based on source: QAA 2007[2]

considerable diversity in the knowledge, understanding and skills of graduates. In one sense this reflects the great diversity of professional job opportunities open to and taken up by graduates from these programmes and this can be seen as a strength. The downside, perhaps, is an uncertainty in employers' minds about the characteristics of environmental sciences graduates. Despite it being almost 50 years since the first environmental science departments were established in UK universities, employer understanding of the capabilities of environmental science graduates is less well developed than for traditional academic disciplines, although the need for their capabilities is perhaps now better appreciated as a result of the sustainability movement and the recent 'greening of society'.

The diversity of environmental sciences and related programme is captured effectively in **Figure 1**, which accompanies the published benchmark statement for the disciplines Environmental Sciences, Environmental Studies and Earth Sciences (ES3)[2] and instructively shows the relationships of those subjects allied to environmental sciences. Despite the range of academic activity depicted, both the QAA, through the benchmark statement (an academic definition and descriptor of the subject) and Higher Education Funding Council for England (HEFCE), through its Research Assessment Exercise, have recognised the coherence of national academic groupings in this area.

DEMAND FOR ENVIRONMENTAL SCIENCE

Undergraduate environmental sciences programmes have experienced varying fortunes over the last 20 years. As outlined above there was a surge of interest in and recruitment to environment programmes around 1990 related probably to two things, a resurgence of public interest in the environment and a period of rapid expansion nationally of undergraduate student provision. The remainder of the 1990s saw a falling away in student demand leading to some programme closures. As recorded in the *Mapping the Environmental Landscape* report[3] the new millennium has witnessed a modest increase in student applications but also a tendency towards the closure of smaller programmes with a group of larger providers drawing students into their programmes.

STRUCTURES FOR DELIVERY

Some 86% of the universities responding to the survey had experienced restructuring during five years from 2003 to 2008, revealing a multiplicity of locations for environmental sciences within university structure.

Left: University field trip

An interesting feature of undergraduate student recruitment in the last decade is that the tremendous surge of interest in environment programmes that resulted from the growth of public interest in environmental problems in the late 1980s has not been duplicated in the period between 2005 and 2010 when the focus on climate change again brought the environment to the public's attention. There has been some growth in demand but not as much as might have been anticipated from previous experience of environmental boom times, and some have suggested that this relates to employment prospects and a perception that jobs in environmental sciences are hard to get and relatively poorly paid. It will be interesting to see how this perception plays out in relation to the new fees regime to be implemented from 2011. In particular, environmental science has often been popular with mature students (those older than 21) and it will be intriguing to see how their career choices are influenced by the substantially increased financial obligation of the new loan scheme; over the last few years postgraduate taught provision (where students often meet the full financial costs) has risen, with nearly 5000 students in 2005[3].

Environmental science is to be found associated with groupings of science, health, business, humanities and social sciences and engineering. The 10 to 15 year trend in universities to create larger academic structures has undoubtedly had an influence upon environmental sciences. Multi or inter-disciplinary subjects perhaps fare best in smaller academic units where linkages can be fostered. The creation of larger groupings can produce tensions and conflicts of interest. Staff experiences of restructuring are varied; some noted the loss of influence and prestige whilst for others new linkages and opportunities were presented[3]. Overall, the net effect of recent change has probably been to lower the profile and influence of the subject within universities at a time of increasing public interest in and concern for the environment. This may, however, overstate the case. Some would contend that university restructuring in reality makes little difference to strong academic subjects that are enduring. It is likely that department restructuring has had a negligible effect on the undergraduate student experience in most universities. Most undergraduate education is strongly focused upon the programme experience.

SUSTAINABILITY AND EMPLOYABILITY

The sustainability agenda has swept across higher education over the last five years or so driven by a combination of local concern for the human impact on the environment and a broader HEFCE initiative that sees universities as leaders of sustainability in society. Ten to fifteen years or so ago there were discussions in CHES in relation to the positioning of environmental science departments and education in respect of the green agenda. Some held a strong view that a separation should be maintained between the science activities of departments and those more general environmental concerns that inevitably involve broader political considerations. The 'greening' of society and of the major UK political parties has, perhaps, resolved this discussion but there is now in higher education a requirement to expose all students to sustainability debates and topics that go beyond the traditional boundaries of even the largest 'Environmental Science' departments.

In some universities this obligation to provide a broader sustainability curriculum has been picked up by environmental staff but a legitimate distinction does remain between the narrower objective of understanding and managing the environment through

"The net effect of recent change has probably been to lower the profile and influence of the subject within universities at a time of increasing public interest"

environmental science, and that of sustainability education with its broader and sometimes diffuse objectives. Historically in the UK, periods of enhanced environmental concern have coincided with episodes of national prosperity: will the recent political enthusiasm for sustainability, with its attendant costs, be sustained as we move into a period of, perhaps prolonged, financial austerity? During the last few years of the Labour government, environmental issues achieved a high priority at government level but more recent developments such as the abolition of the Sustainable Development Commission and the Royal Commission on Environmental Pollution may point towards changing (or at least the downgrading of) priorities.

The *Mapping the Landscape* project also looked at employment and the skills of graduates of environmental science programmes as they join the employment market. Industry respondents suggested that there was a shortage of graduates but an adequate supply of postgraduates. Employers thought, too, that there was a shortage of practical skills with a suggestion that graduates knowledge was "too broad with not enough focus on industrial or professional skills including report writing, negotiation and business skills"[3]. One difficulty here is that undergraduate environmental sciences programmes are often, and necessarily so, broad, and have also over the last 20 years or so seen an increase in the incorporation of social and economic (defined broadly) aspects of environmental studies. According to a 2006 report on initial training requirements for environmental sciences[4], the sustainable development initiative requires environmental professionals to understand the sustainable development context of their work and to have an understanding of economic, social, cultural and political factors. These factors do not appear to be included in a comprehensive way in most undergraduate programmes, suggesting they will need to include new areas of skills and knowledge if graduates are to become leaders in finding sustainable solutions to environmental problems[4].

This may indicate that there is conflict between the demands of an industry that seems to be asking for focused technical skills and those of sustainable development educators who seem to have a view of the need for graduate environmental polymaths. Such tensions are inevitable and are frequently encountered in the design of environmental undergraduate programmes where a path has to be found between, on the one hand, the provision of focused scientific knowledge and skills and on the other the contextualisation of the application of those skills and knowledge in addressing the broader environmental concerns of society. They are often addressed in larger programmes by the provision of an 'environmental science' foundation that is common to all followed by the opportunity to specialise in the sub-disciplines. It seems likely that the multi-disciplinary concerns of sustainable development will be addressed by multi-disciplinary teams (in the same way that environmental impact assessment requires an input from a range of specialists) but many environmental science educators would argue that the effectiveness of environmental scientists in such a context requires a broader rather than narrower approach at undergraduate level.

From the standpoint of undergraduate educators, graduates depart from their programmes to a surprisingly wide range of environmental careers and many will undertake post-graduate study with the aim of either focusing further on an area of undergraduate specialisation or seeking a broader theme based qualification in environmental assessment or management. Environmental science as a subject has evolved rapidly over the last 40 years from its roots in traditional sciences and one of its central characteristics and claims to distinctiveness comes from its ability to enable graduates to take the holistic view that is necessary both to identify and to attempt to address the environmental concerns of society. **ES**

Roger Smith is Deputy Head of the School of Environment and Technology at the University of Brighton.

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OPINION

Coming of age

Diane Purchase considers the motivations behind students studying for a postgraduate qualification, the barriers they may confront and how academics can best support their students to continue the journey

Consider the following scenarios:

- A gleaming certificate bearing your name, the title of your first degree and your alma mater's insignia, is staring back at you in your hands; you wonder: "Where do I go from here?"
- A company payslip with depressingly few zeros in the correct places, silently returning your gaze; you ask: "How can I improve my prospects?"
- Images of cute polar bear cubs balancing precariously on the retreating ice sheets and/or helpless seabirds languishing in a sea of crude oil peering out from your television/MP3 player/PC, the narrator warning us about the perils facing our environment; you speculate: "What can I do to make a difference?"

Do they sound familiar? Could it happen to you?

DEMAND FOR PROGRAMMES

For most of us, gaining an undergraduate qualification is a significant milestone in our journey of education and it may represent a natural exit-point. However, an increasing number of graduates choose to continue their journeys by undertaking postgraduate studies. Over the past 12 years, postgraduate education in the UK has grown 36% faster than undergraduate education and almost 25% of students in UK higher education are postgraduates[1]. More specifically, a survey by the Higher Education Careers Services Unit revealed that approximately 23.6% of environmental-related graduates enter further study, compared to the average of 15.4% of all first-degree graduates[2]. So what inspires a budding Environmental Scientist to pursue a postgraduate degree?

Many graduates consider postgraduate study as an investment that boosts their long-term career prospects and give them an edge in this competitive job-hunting environment. It appears that the typical environmental professional is highly qualified. A 2009 poll of more than 2,000 environmental professionals indicated about 90% of those surveyed are educated to at least degree level, nearly half have a masters degree and 5% have a PhD degree[3]. A recent survey by the Institution of Environmental Science (IES) which canvassed the views of its Fellows, Full and Associate members[4] also found that degree qualifications, in particularly a postgraduate award, lead to higher pay and more seniority within an organisation. It is evident that in such a highly qualified and competitive job market, a postgraduate degree is decidedly desirable. Let us not forget the tough economic situation the UK is facing in 2011. The enormous budget deficit impacted both the public and private sectors and greatly reduced the availability of graduate appointments; many graduates may opt for a postgraduate qualification to avoid the

"Approximately 23.6% of environmental-related graduates enter further study, compared to the average of 15.4% of all first-degree graduates"

challenging employment situation while improving their job prospects.

Employability may not be the only driving force behind postgraduate study. Continuing Profession Development (CPD) is essential to catch up with the changing levels and types of professional skills. In most professions employees are required to keep abreast of the knowledge and development in their area of expertise. Others seek to improve or upgrade their current skill base to better advance their career or improve their career prospects. These students are driven and focused, and also have very defined goals (see Shaw & Kemp, this volume).

Being passionate about the environment is another strong motivator to embark on postgraduate study. Students wish to develop a deeper understanding of the environment and many are enthused by the pursuit of specialised knowledge which enables them to 'make a difference'. A number of students on my own MSc programme cited this as one of the main reasons to engage in postgraduate study. Our students came from diverse backgrounds all over the world, but they are all passionate about their chosen subject and believe in using their skill and knowledge to help the environment (see **Box 1**). This strong sense of commitment to the environment is also reflected in the 2009 survey: four in five of the environmental professionals surveyed have a sense of "being able to make an environmental difference within their organisation" and 86% feel they can "make an environmental difference to society"[3]. Many MSc postgraduates went on to pursue their PhD degrees (this accounts for approximately 6-7% of our own MSc programme). A postgraduate degree not only provides the knowledge they seek, it also prepares students to take on further challenges to make a real impact in a specific research area.

It is apparent that most postgraduate students have a firm idea why they chose to undertake postgraduate study. Most are 'savvy' about environmental issues, passionate about making a difference and focused on improving their career opportunities. Funding, however, remains one of the major obstacles. In contrast to undergraduate degrees, there is less funding available for postgraduate study; many students will need to find sponsorship, fund themselves by working part-time or by getting a loan. With the implementation of the university tuition fee in 2012, students would accumulate an even more substantial debt if they choose to continue with postgraduate study. In an article in the Times Higher Education, Sir Adam Roberts asks: "if the fees reform puts graduates off postgraduate study, where will academia find its new blood?"[5].

Many universities will turn to overseas students as a means to fill this gap. The UK is not part of the signatory of the Bologna Declaration; universities in the UK are in a fairly unique position in Europe to be able to offer one-year master taught programmes. This is often seen as an advantage for overseas graduates who seek to complete a postgraduate degree.

THE BOLOGNA DECLARATION: AT A GLANCE

The Bologna Declaration on the European space for higher education is the main guiding document of the Bologna Process for creating the European Higher Education Area. It was adopted in 1999 by 29 European countries, pledging to reform their education systems to create a convergent European standard. Making academic standards more comparable would enable students and graduates to move between countries, using prior qualifications as acceptable entry requirements for study.

STUDENTS FROM OVERSEAS

Overseas postgraduate students may provide a valuable income stream to universities, but they also bring along their own set of challenges, from problems in gaining student visas to homesickness. Overseas students also have very different expectations, which could be exacerbated by their unfamiliarity with our academic requirements. Many students tell me the MSc programme is very intensive, much more so than they anticipated, and that there is not enough time to acclimatise. Many are puzzled by our exasperation when they lift and quote chapter and verse from internet sources onto their assignments. Some students shrink back from our attempts to encourage them to challenge and to critique. When asked for the reasons behind their reticence and reluctance to participate, they admit that they find the concept of challenging one's teachers both alien and uncomfortable. Expectation management is crucial to engage our overseas postgraduate students. If we are to preserve our current advantage in postgraduate provision, universities need to have additional resources in place (such as help in academic writing).

IMPROVING PROVISION IN THE UK

Postgraduate education in the UK has been identified as a great asset; the Smith report listed 24 recommendations to improve our postgraduate provisions[1]. Higher Education Institutions are asked to:

- take a lead on providing more opportunities to students to develop core competencies and transferable skills;
- embed transferable skills training in all postgraduate research programmes;
- provide flexible postgraduate provision e.g. work-base learning and multi-institutional delivery; and
- establish employer needs for postgraduate skills.

BOX 1: VOICE FROM THE LECTURE THEATRE

Personal statements from some students citing the main reasons for choosing to study the MSc Environmental Pollution Control programme at the University of Middlesex:

"I am really fond of environmental chemistry. It offers plenty of scientific theories to control and deal with environmental problems."
Yue, a student from China

"I have enjoyed an interdisciplinary approach in my environmental studies ... I made a decision to further study and gain professionalism in this area."
Neela, a student from Nepal

"Activities such as mining, oil exploration and gas flaring has begun to affect the environment, deteriorating living conditions and threatening the very world we lived in... It becomes imperative, therefore, to have more skilled environmental pollution experts and hence my interests."
Mobolaji, a student from Nigeria

"I intend to use the knowledge and expertise gained from this programme to become an advocate for the ecosystem, safeguarding the environment and human health."
Waleola, a UK student

"I have found particular interest in environmental microbiology; using microbes to clean up the environmental pollution... In future, I would like to specialise in some aspects of pollution control and management of the environment for pollution."
Aneta, a Polish student residing in the UK

"For the past few years my main objectives were concentrating with developments on problem solving skills in the global south [sic] and I am desperately in need of help, knowledge and skills in the environmental control to ensure that everybody is safe and plays by the law."
Basil, a French student residing in the UK

"If the fees reform puts graduates off postgraduate study, where will academia find its new blood?"

We need, therefore, to support our postgraduates, not just by equipping them with specialised knowledge, but also fostering skills that enable them to thrive in a competitive job market. Critical thinking, research techniques, time management, oral and written presentation skills are all crucial to their success and can be easily embedded in the design of the curriculum. Their learning experience can be enhanced by involving group work, presentation, project management, inventive formative assessment and case study analyses, which inject a strong dose of realism into the study. To introduce more flexibility in our mode of delivery, we could consider strategies such as day and/or block release, work-base learning and blended learning (using a combination of distance learning and traditional didactic teaching) all will provide greater flexibility for self-funded students who require to work part-time or working students who wish to improve their skills.

Establishing employer requirements for postgraduate skills is also essential. The Natural Environmental Research Council (NERC) issued a report on the skills required at postgraduate and professional level in their publication, *Most wanted: skills needs in the environmental sector*[6]. The review identified 224 postgraduate and professional skills or knowledge areas that are needed as well as 15 critical skills gaps (see **Box 2**). The needs of employers are also featured in the *Mapping the Environmental Science Landscape* report, which highlighted a number of employer issues and the willingness for employers to become engaged in the design of the Environmental Science curriculum[7]. Results from these reports helped to improve our provision, and target areas that are valued by employers, which enable our postgraduates to be employed in the environmental sector.

The IES has carried out a follow up survey for students who have graduated from their accredited programmes which will be published in September. The aim of this survey is to collect data on:

- levels of unemployment for recent graduates in the sector and how many went on to further study;
- attitudes towards internships; and
- attitudes towards professional bodies and the services they provide

It is hoped that this new survey will continue to enhance our curriculum design and better target the needs of our graduates.

Of course, we should continue to impart our own enthusiasm and love of our subject to our students. Site visits, seminars and lectures by guest speakers from renowned research institutions or the profession, engaging students in research, all help to inform and inspire.

BOX 2: MOST WANTED

The 15 Critical Skills Gaps identified by NERC (modified from their report[6])

Modelling –for innovation through exchange of knowledge and experience
Multi-disciplinarily –to work across academic boundaries
Data management – to provide understanding of data across the section both at the specialist level and at a cultural level
Numeracy – strong quantitative skills to apply to a range of situations
Translating Research – to work with policy makers, business and society; to improve public understanding and conversion of research into end products
Fieldwork – underpins environmental research and practice
Risk and Uncertainty – to quantify and interpret risks and to help decision making
Taxonomy and Systematic – to monitor and understand the functionality of the environments
Soil Science – for understanding issues across the environmental sectors such as food and energy security

Environmental Epidemiology – to relate public health and environmental conditions and hazards
Sustainability Science and Planning – to ensure sustainable use of natural resources
Microbiology – to understand the changes in ecosystem and the application in renewable energy and waste management
Food Supply – to manage and protect existing food supply and soil resources
Energy Supply – to develop and manage energy resources in relation to the environment
Freshwater – for efficient and sustainable use of water resources

TRANSFORMATION

Postgraduate study has come of age. It is no longer the ugly duckling of higher education, caught between the once well-funded undergraduate programmes and the much revered research degrees. As Harriet Swain from the Guardian puts it: "postgraduates have been expected to be not only brilliant researchers but team players, communicators, and above all employable"[8].

The substantial increase in the postgraduate number over undergraduate study is a clear indication that students recognise the values of a postgraduate degree. To turn it into a worthwhile investment, universities need to be proactive in shaping our provision, not only in enhancing the student's knowledge and skill base, but also in providing opportunities and support through flexible delivery for these students, engaging employers and other stakeholders in the design of the curriculum, so that our students can continue their journey in education towards a promising future. ES

Diane Purchase is a Senior Lecturer in Environmental Health/Biology at Middlesex University and the Programme Leader of MSc Environmental Pollution Control. Diane is the Honorary Secretary of the Committee of Heads of Environmental Sciences.

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Covering the distance

Distance need not be a barrier to learning. **Sarah Davies** explores some innovative and exciting ways that technology can be used to connect us to environmental learning.

Distance learning can sound like a lonely and isolating experience, but the contemporary reality is remarkably different; the learner is connected and supported in a myriad of ways. In the past, the long distance learner was viewed as an individual, learning alone. They could be in a small bedroom, in a shed at the bottom of the garden or in a hut at the end of a runway in an isolated posting, and the books they were reading were their only connection with the world of learning. Today, however, the distance learning student is at the centre of a web of connections, linked to a range of resources and people. The role of authors of environmental science courses and materials is to weave those connections together; combining written text with multimedia and enabling a variety of communications between tutors and students. The student experience has definitely been enhanced by different ways of learning and connecting with others.

WHO ARE THE DISTANCE LEARNERS?

Learning no longer stops on leaving school or university and many people are finding that location need not be a barrier to study. Environmental professionals need to keep skills and knowledge updated and this can often be done through distance learning. One of the benefits of learning while working is the opportunity to immediately implement new knowledge and understanding in the workplace. Charles Handy, the leading management thinker, argues that 'you can't learn management in a classroom'[1]. He believes that to learn management skills it is necessary to practice them in a real world setting and that studying whilst working enables this. Increasingly, young students are considering that learning whilst working, or studying whilst living at home, are viable options, especially as pressures on the fee system for university study in the UK have started to build. Distance learning is also useful for adults looking to change careers or return to work and learning after a career break and for people with caring or other commitments who often find they need a more flexible way of learning.

ENHANCING DISTANCE LEARNING

Studying by distance learning does not mean studying alone. New technologies are taking the distance out of distance learning by keeping learners in contact with tutors and other students across the world. Best practice is to provide ongoing support to students. Tutors and students can meet face to face in tutorials, but more consistent support is achieved by talking online, either through an online forum, video- or audio-conferencing or instant messaging. Technology is also changing the ways that students receive learning materials, allowing

> "The distance learning student is at the centre of a web of connections, linked to a range of resources and people"

greater access to resources than ever before. Teaching material can be supplied over the internet, allowing creative use of audio and video, newsfeed links or online datasets. Students can interact, sharing their own data and images and collaborating or commenting each other's work in online blogs. Tutorials can take place synchronously (where everyone can work together online at the same time) or asynchronously (with students logging on at times convenient to them). Students can also obtain e-books and other electronic resources from online libraries.

Distance learning is traditionally thought of as part-time and campus courses as full-time, but it is more of a mixed economy than is often realised. Distance learning students can study full-time and campus-based students will encounter elements of technology-enhanced distance learning. Campus-based students very often have access to a course website or virtual learning environment and although the campus library will, of course, stock physical books, it will also have e-books. A number of universities and colleges are extending the use of internet technologies (such as blogs and facebook) to connect with their students before they come to university, as a means to smooth the transition into higher education.

OPENING UP LEARNING

The possibilities for environmental science education at a distance are not simply for formal learning, but include opportunities for sharing resources and learning from each other. Sometimes called 'open learning', this process can involve finding and sharing information online, connecting to groups of people with common interests, or using open educational resources. There are increasing calls for open access to information and learning resources. Funding organisations are providing grants for the development of open educational resources, or stipulating in their research funding that information from projects should be made freely available. Examples of open educational resources include iTunesU, the Open University's OpenLearn and MIT's OpenCourseWare. iTunesU is a website where universities are posting video and audio materials for their own students and others to use. From high profile universities such as Yale and MIT in the United States and Oxford and Cambridge in the UK to small community colleges, a whole range of institutions are actively using this site and there have been millions of downloads of free material.

Such approaches are sympathetic to Tim Berners-Lee's concept of the World Wide Web as a tool for participation and connection as opposed to a broadcast medium. The web's facilities for connecting people and sharing information mean that distance can be used as a benefit to environmental learning. Firstly, as people connect to others in different countries, environments and social situations, there is an opportunity to learn from and be inspired by others. Secondly, data and information can be shared and mapped across the world giving a wider picture than can be produced by individuals working alone.

Two examples highlight the possibilities for open, participatory environmental learning at a distance – diary making and citizen science. These involve people, from children to adults, from different countries and cultures, in learning about the environment and becoming involved in ways that interest them.

1. INSPIRATION: SHARING STORIES

Many attempts to engage people with environmental issues have not been entirely successful. A key mantra for governments, researchers or non-governmental organisations has tended to be, "tell them it's a fact, tell them it is scary, tell them again". There is now evidence that this kind of message only carries things so far and, in the process, creates problems such as 'green fatigue'. Engaging and involving people in key environmental issues for the long term requires a subtle balance to educating and informing that avoids preaching or 'bullying' if resistance to attitudinal and behavioural change is to be overcome. The Creative Climate project is aiming for a different approach to environmental education for the longer term, with

▲ **Figure 1: Sharing knowledge and action.**
Source: Creative Climate 2011[3].

BOX 1: THE ENVIRONMENTAL IMPACTS OF STUDYING

Does learning at a distance have a lower environmental impact than attending a 'traditional' or campus-based institution? One study indicates that it may well do so. When travel, paper consumption, computing, accommodation and campus site activities were considered, distance learning programmes in higher education were shown to have dramatically lower energy use (87% lower) and CO2 emissions (85% lower) than full-time campus-based courses[2]. Part-time campus courses also reduced energy use and CO2 emissions (by 65% and 61% respectively). The lower impacts of part-time and distance compared to full-time campus courses were mainly due to reductions in student travel and the elimination of much of the energy consumption of students' housing, plus economies in campus site utilisation.

As with many impact assessments though, the picture is not quite that simple. It is generally expected that the move to 'online' will lead to greater environmental benefits through 'dematerialisation'. However a number of issues complicate this picture, including energy use of computers and 'rebound effects'. A rebound effect occurs when increased environmental performance in one area has unintended consequences on individual behaviour that mitigates this benefit. Online distance learning offered only small energy and CO^2 emissions reductions (20% and 12% respectively) compared to print-based distance learning courses2. These reductions are smaller than might be expected because online learning requires more energy for computing and because of various 'rebound' effects, such as students printing out more of their course materials than anticipated and increasing use of computers in one area can lead to increased in other areas of people's everyday lives.

a blend of inspiration and aspiration for developing and sustaining environmental champions. This is a diary project recording how people understand and respond to environmental change. One of its central assumptions is that human creativity is one of the keys to meeting the challenges of biodiversity loss, climate change, resource depletion and sustainable living. The aim is to build a huge living archive of experiences and ideas that respond to these issues.

A diverse mix of individuals and institutions write or record an online diary that gives an account of how they understand and are acting on issues of environmental change. It is not an overly onerous task – people update their diaries twice a year in the run up to the shortest and longest days. The website collects thoughts and stories from doorstep to workplace, from laboratory to garden; from international conference to community meeting. Many people will start a story as an individual, but others may want to post as a group. Some may want to submit on behalf of some thing or some place: a street, a glacier, an insect. Others may want to gather stories from other people, acting as independent researchers of changing understanding and action.

Curated by the Open University working in collaboration with the BBC, the project was started in 2009 and now has hundreds of diary entries. Some of the diarists have been specially selected and asked to contribute, but the site is open for anyone to set up their own diary and take part.

These diaries can be used in formal learning or as informal personal development. In a classroom setting, teachers can build an activity around diary writing, getting students to think and write about environmental issues that affect them and their community. Teachers might prompt students to choose a diary on the site that particularly inspires or interests them, and to post a response online. For personal development, the diaries

Climate Change diarists from the tropics to the poles are sharing their diaries.
Source: Marije de Haas, Cape Farewell (left), Mark Brandon (right image).

Source: Creative Climate 2011[3]

"There are increasing calls for open access to information and learning resources"

on the website hold an exciting potential. Those who start their own diary can find inspiration amongst their fellow diarists as well as a means of reflecting on their own progress as their diary builds up over time.

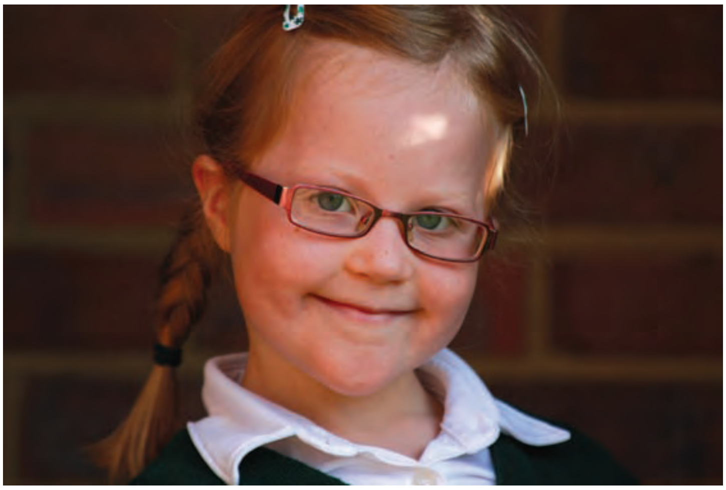
The diaries provide individual stories of people's experiences and responses to issues of environmental change, and it is connections to these that provide inspiration and a wider awareness of environmental impacts and responses.

2. INVOLVEMENT: CITIZEN SCIENCE

'Citizen science' enables individuals or groups to get involved in programmes of scientific work on a voluntary basis by carrying out observational, measurement or computing related tasks and to become part of a science project. This idea actually builds on a long history of volunteer monitoring of the natural environment, but has been given impetus through the internet and social media. The environmental area is particularly well represented in citizen science, with

Top: With iSpot you can identify animals and plants using your mobile phone. Source: Mike Dodd

Above: The common frog Rana temporaria; one of many species observed by citizen scientists and recorded on iSpot. Source: © Mike Dodd



Above: Katie Dobbins with the Euonymous Leaf Notcher moth – the first recorded in Britain, identified through the iSpot website.

BOX 2: EXPLORE THE DIARIES

A sample of the diaries currently available on the Creative Climate website.

Sustainable lifestyles
Trina Hahnemann, Danish chef and writer, talks about Dirt Café, and her passion for cooking, organic food and sustainable lifestyles.

China diaries
Gao Daya is seven years old and yet she understands that 'we should save electricity, save water, recycle more and drive less' if we want to live in a safe, clean environment.

An urban oasis
An Environmental Science student, Rebecca Davies, shares her view of the urban environment and how she is working with a New York City community to develop urban agriculture.

Taking change into their own hands
Totnes is a small town in South Devon with a population of 15,000 people. They have pledged to become oil-free by 2030 making them the first Transition Town in the UK.

Getting back to basics
We shouldn't worry about the future of the environment but trust in the present, Venerable Amaranatho of the www.amaravati.org/abmnew/index. Amaravati Buddhist Monastery shares his beliefs from the London Faith and Climate Change Conference.

Source: Creative Climate 2011[3]

nature recording being a typical project. However, citizen science projects take place in many different subject areas – ranging from classifying galaxies in the astronomy project GalaxyZoo, to mapping individuals' happiness in the social science project Mappiness.

The aim of many environmental citizen science projects is simply to foster greater environmental awareness. Others are looking, in addition, to help people develop skills and to collect valuable scientific data. One example that covers all three of these is OPAL (the Open Air Laboratories network). This project encourages people from all backgrounds to get back in touch with nature and covers five topics: soil, water, air, climate and biodiversity. For biodiversity, the iSpot website aims to help anyone identify anything in nature by linking experts (including amateur experts) with beginners through a sophisticated reputation system that encourages users to help and learn from each other[4]. Beginners can post up an observation of an organism, suggest what it is or see if someone else can identify it. As individuals' knowledge grows, they can help others by adding an identification of their observation. Individuals' reputations grow as others agree with their identifications. The system is supported by a range of biological recording schemes and societies who are interested in helping people learn about biodiversity and who benefit from the new observations. All the time records are added to the site, a database of biological observations builds up.

iSpot has been used to help teachers improve their biological identification skills. This is vital as learning to recognise different animals and plants is often cited as one of the most frequently encountered problems when teaching outside, and can inhibit teachers from involving pupils in outdoor learning about wildlife. In less than two years of operation, iSpot has helped 10,000 users to identify 43,000 sightings of some 4,500 taxa, from lichens to birds. One exciting observation was made by six-year old Katie Dobbins who found a furry moth on her windowsill. Her father uploaded a photo to the site and experts identified it as the Euonymous Leaf Notcher (Pryeria sinica). A native of Asia, this is the first ever sighting of it in Britain.

One of the issues for citizen science is the level of skill of untrained volunteers. Different projects tackle this skills need in different ways. Some projects, such as iSpot, use expert help systems, others include various levels of online or hands-on training. Research shows that well planned projects with appropriate training schemes can produce accurate and valuable scientific data[5].

Weather and climate are popular citizen science topics. The Community Collaborative Rain, Hail and Snow network is a US project where volunteers measure the amount and type of precipitation that falls in their own locality and report it to a national database. This project increases the density of precipitation data collected, heightens awareness about weather and provides data that is used as an open resource. Projects can also involve computer-based work on the past and predicted future environment. One example is Old Weather, a UK project that is helping scientists recover worldwide weather observations made by Royal Navy ships around the time of World War I. This information is then used for climate modelling and to improve a database of weather extremes.

At a rather more complex level, there is Climateprediction.net; a distributed computing project which produces and tests predictions of the Earth's climate up to 2100[6]. People can get involved by giving time on their computers – time when they have their computers switched on, but are not using them to their full capacity. Participants can also learn about climate modelling and prediction.

One of the aims of awareness-raising is to link learning with behaviour change. Once people find out about, and become interested in, their environment they are more minded to protect it and change their own lifestyles and actions. Providing learning, access to knowledge and scientific skills can help with this process and empower individuals and communities. In an example of citizen science aimed directly at helping a community protect its environment, researchers from University College London are enabling Baka pygmies in Cameroon to collect data about their trees[7]. The community forests of the Baka people are under threat from illegal logging, but now they can map trees in their territory using GPS and upload the information to an international database. This means they can then prove which trees are on their lands and hold loggers and officials to account if these trees are removed without their permission. Environmental monitoring and recording has long been a topic of interest for the public, and it is heartening to see the upsurge in interest in citizen science over recent years. There are many drivers for this, but two of the most powerful must be the enhanced accessibility of data collection and sharing technologies and the increasing push for public engagement in science and the environment.

"Providing learning, access to knowledge and scientific skills can help... empower individuals and communities"

CONNECTING WITH ENVIRONMENTAL LEARNING

Location need not be a problem for environmental learning. The connected nature of the modern world gives us unprecedented opportunities to solve the problems of distance and, even to turn distance into a benefit by making use of widely dispersed people in different environments and different cultures. Creative use of new technologies, whether through formal courses or open learning, can link people across the world to share stories, collaborate in data collection and improve their skills. ES

Sarah Davies is a Lecturer in Environmental Science at the Open University and Qualifications Director for the OU's Environmental Science degree.

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Maturing with the sector

Peter Shaw and **Simon Kemp** consider professional body requirements for continuing professional development and its context and role for environmental scientists.

'CPD is the means by which professionals maintain, improve and broaden their knowledge and skills and develop the personal qualities required in their working lives'

The Science Council

In contrast to other opportunities for education in an environmental context, those who engage in continuing professional development (CPD) as practising environmental scientists have usually reached a stage at which awareness, inspiration and aspiration have combined and led to them performing a "specific occupational role" or "becoming a specialist"[1]. The focus on CPD for many professional environmental scientists is thus biased towards skills, knowledge and understanding, in other words opportunities to personally develop to meet their needs to remain employable and effective in their role.

In this context, the very nature of environmental science creates a need for CPD. The continually and often rapidly changing landscape of environmental science acts as an extrinsic factor that incurs a need for frequent enhancement of skills, knowledge and understanding. Given the dynamic and fluid nature of legislation, economy, and political imperatives, for example, an effective environmental scientist can rarely meet emerging needs without adopting a pro-active approach to training, practice, and learning. CPD can provide a means of keeping abreast of "hot topics"[2] and meeting the demands of new and emerging developments, technologies, and legislation[3].

Justifiably, professional bodies in the environment sector stress the need for and role of CPD. Although professional status has not yet become a 'licence to practice' across the environment sector, membership of professional bodies is broadly considered to provide evidence of professionalism, with a corresponding expectation of quality standards. There are perceived benefits of professional status to the individual, employers, clients, the sector, and to society, and CPD is central to the aims and principles of professional bodies. Membership of professional bodies and associated CPD activities should confer and demonstrate alignment of an individual with professional standards and expectations; as noted by the Institution of Environmental Science (IES), "participation in CPD …. acts as a mark of quality assurance"[3].

There are formal requirements for CPD across the environment sector, commonly aligned with the needs for recognition of professional status. Holders of the award of Chartered Environmentalist (CEnv), for example, "…are expected to undertake appropriate CPD" as part of a commitment to maintaining competence[4]. Keeping up-to-date with new developments and issues is a key benefit of CPD that aligns with competence across professional bodies in the environment sector. There are considered to be other, wider-ranging benefits of CPD (see **Box 1**).

In addition to the broad expectation in the environmental science sector that professionals engage in CPD, there may also be strong personal motives for an individual to develop their professional competence through CPD. Many environmental scientists are characterised by a desire to make a positive difference through their work. Enhancing the effectiveness of their work through training, learning and experience leads to an intrinsic satisfaction that should not be underestimated; when combined with the potential for CPD to lead to and underpin career progression, these are powerful motives for environmental scientists to engage with the CPD agenda.

BOX 1: PERSONAL MOTIVATION

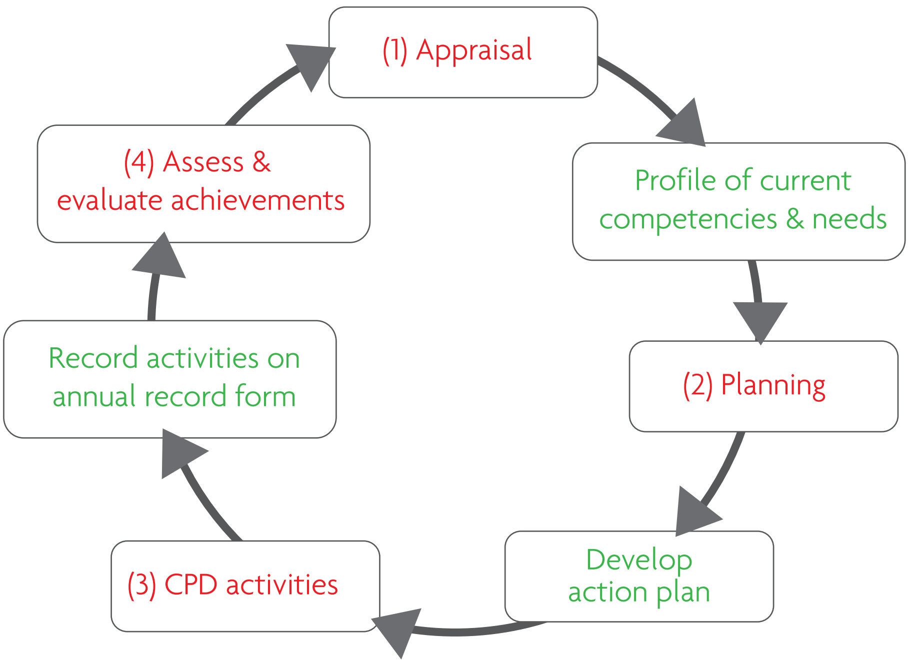
Potential direct benefits from CPD activities include:

- Furthering an individual's own knowledge of their discipline[3]
- Enhancement of an individual's career prospects and salary[3]
- Demonstrating "credibility to peers, clients, colleagues, and employers"[5]
- Demonstration of professional achievements[3]
- Gaining a competitive edge over others[6]
- Ensuring work is conducted safely and legally[7]
- Increased job satisfaction[3]
- Gaining higher personal confidence[6]

CPD PROVISION IN THE SECTOR

Whereas professional bodies take a broadly similar view of the role and benefits of CPD, their frameworks, structures, and purpose differ. Approaches may

Figure 1: The cyclical (annual) approach to CPD as outlined by the IES. Text boxes show **Actions** and **Documents**. Source: IES 2011[8].



orientate around individuals, involving self-appraisal and reflection, and leading to planned CPD activities. This model is employed, for example, by the IES[3] as a guiding structure for an annual cycle of CPD needs, activities and evaluation (see **Figure 1**). Within this framework, the IES expects that CPD will be undertaken within three thematic areas vis-à-vis subject-specific skills, practical/technical skills, and personal/interpersonal skills, and that CPD across all three themes should be balanced according to the needs of the individual[3].

By contrast, requirements for professional recognition elsewhere are more formally specified. For example, the Society for the Environment (SocEnv), which is responsible for awarding CEnv, prescribes five key areas of competence (see **Box 2**), each of which comprises a set of descriptors alluding to how each competence might be demonstrated. Although this approach superficially contrasts with that adopted by the IES, each of the five key areas specified by SocEnv can be readily placed within the framework of subject-specific skills, practical/technical skills, and personal/interpersonal skills as employed by the IES[3]. The SocEnv and IES specifications differ but their role and purpose are complementary. Indeed, SocEnv guidance on the CEnv award implies that the CPD requirements of their licensed bodies (including the IES) should be met; the 5 competencies specified by the SocEnv do not comprise CPD requirements per se, but guide initial assessment of applications for CEnv status.

The Chartered Institute of Wastes Management (CIWM) also allows a wide range of qualifying activities for member CPD, and members are obliged to undertake CPD to ensure appropriate standards.

BOX 2 : KEY COMPETENCIES

The 5 key compentencies required for granting or maintenance of professional status according to SocEnv[4]

A. Use knowledge and understanding of the environment to further the aims of sustainable development.

B. Analyse and evaluate problems from an environmental perspective, and develop practical sustainable solutions.

C. Demonstrate leadership in sustainable management of the environment.

D. Demonstrate effective interpersonal skills.

E. Demonstrate a personal commitment to professional standards, recognising obligations to society, the profession and the environment.

Due to the nature of risk associated with working in this industry, Health and Safety must be incorporated into CPD activities[9]. The qualifying activities are not restricted to CIWM courses and events. Academic courses, research, and publication are also included, along with other evidence of professional practice. Likewise, the Chartered Institution of Water and Environmental Management (CIWEM) also specifies a need for members to demonstrate fourteen "mandatory competencies" for membership. Learning outcomes of CPD units provided through the CIWEM are aligned with these mandatory competencies such that the experience gained through CPD contributes directly towards professional status[7]. Detailed guidance is also provided regarding what is required specifically for demonstration of competencies, including supporting evidence. These mandatory competencies[10] include, predictably, knowledge and understanding, and units, for example, in water and waste water treatment are available. It is notable that the CIWEM's mandatory competencies allude firstly to factors that create the need for CPD (ability to develop a strategy "to address legislative, economic or technological changes affecting the sector in which you work"), and secondly to "commitment to continued learning and professional development in both personal skills and professional knowledge"[7].

With respect to the mode of delivery of CPD, it is likely that engagement and uptake are entirely reliant on individuals being able to participate in a manner that is sympathetic to their situation. Pragmatically, this issue comes down to a question of time and money, and decisions are most likely to be made the basis of costs and benefits. With this in mind, CPD training could be considered optimal if it was effective in terms of achieving its purpose and delivering benefits, whilst being affordable and demanding manageable allocation of time.

Review of existing provision in CPD reveals various approaches to optimising CPD through flexibility. Two approaches are apparent: flexibility can take the form of choice concerning what is done and/or how it is done. The CPD requirements for the IES, for example, emphasise self-appraisal (for which a guide is provided) combined with a structured cyclical approach (see **Figure 1**). Within this framework, guidance is provided as to which activities CPD is considered to comprise. These activities include not only formal, timetabled events (e.g. lectures, courses, workshops etc.), but also work that takes place over long periods (e.g. research projects and articles) and informal learning (e.g. private study)[3]. There is an important facet here in that this approach recognises formally that there are activities undertaken within the routine work of a professional environmental scientist constitute activities that constitute and contribute to CPD.

▼ **Table 1: Potential influences of CPD on environmental science professionals.**

AWARENESS	Does CPD bring new challenges in environmental science (e.g. new technologies, legislation, and procedures) to individual's attention?
INSPIRATION	Does CPD make individuals want to engage in unfamiliar or emerging fields?
ASPIRATION	Does CPD alert individuals to opportunities to meet new challenges and progress in terms of competencies and career?
SKILLS, KNOWLEDGE, AND UNDERSTANDING	Does CPD provide individuals with opportunities to acquire and develop what is needed to become better environmental scientists?

By contrast, it is arguable that more content-led CPD aligned with specific requirements of a professional body (such as CIWEM[7, 10]) lends itself less well to informal learning. In such cases the provision of CPD may be made flexible by avoiding set timetables and circumventing the need for individuals to attend sessions at set times and locations. In this regard, distance learning has much to offer. A web-based format (for example CIWEM[10]) offers opportunities for learning that are not constrained by the abilities of individuals to attend sessions or workshops, but offer a means by which learning can be fitted around other demands, with due recognition of other workloads, tasks and priorities. If learning can take place over an extended period (up to 15 weeks in the case of CIWEM online CPD units), there is an additional benefit in that week-on-week effort can amount to a relatively 'light touch', whilst allowing flexibility for other tasks to take precedence if and when required.

In a broader context, it is illuminating to consider the role of CPD in the context of 'journeys' in environmental science. Earlier and formal education can be thought of as contributing to individual's awareness of the environment, perhaps leading through inspiration to aspiration and eventually a career (see Shaw, this volume). Although CPD in the environmental science sector applies generally to those who have already embarked on a sector-specific career, CPD may thus be considered to generate awareness, inspiration and aspiration within environmental science, and provide opportunities for learning that renew, enhance, and extend competencies (see **Table 1**). The key difference is that an individual's experiences in formal education might influence direction towards a career, whilst education in the form of CPD might influence direction within a career. Opportunities to recognise needs for acquisition of new knowledge, understanding and skills are imperative for an environmental scientist to maintain the necessary competencies in a dynamic sector.

In an education context, it is notable that the language of CPD consistently uses educational terminology. "Learning outcomes", "reflective practice", "feedback" are familiar terms to those in the education sector, but the links go deeper. The cyclical approach to CPD (see **Figure 1**), for example, echoes the principles of Kolb's experiential learning cycle (i.e. planning, having, reflecting on, and learning from an experience)[11] and follows the pattern of "plan, do, review" that is embedded in education from an early stage, and then adapted in the Deming Cycle as "plan, do check, act" for professional practice in environmental management. This is perhaps a key but forgotten strength of CPD; its philosophy and methods are familiar and known, and engagement in the CPD agenda does not require realignment of an individual with processes that differ greatly from prior experience. Indeed, reflective self analysis in the context of CPD differs little to the concept and methods widely applied in undergraduate degree programmes[12].

FUTURE OPPORTUNITIES

There is little doubt that CPD in the environmental science sector is mature in terms of its recognised role and importance. The variation in approaches across the environment sector reflects its complexity; the increasing movement towards inclusion of sustainable development within professional practice[13] has implications for a diverse range of professions[14] extending beyond but related to environmental science.

Notwithstanding differences across the environmental sciences sector, requirements for CPD are expressed

"An effective environmental scientist can rarely meet emerging needs without adopting a pro-active approach to training, practice, and learning"

clearly through relevant professional bodies, and systems are in place to ensure that they can be met and competencies demonstrated. If this system should be diminished in any way and the commitment to CPD reduced, there is a risk that the effectiveness of environmental science professionals may be impacted. As already noted, undertaking CPD brings not only benefits but also costs, potentially for both individuals and employers. Who, though is, responsible for ensuring that appropriate CPD engagement and activities take place? Attitudes to the balance between costs and benefits – for individuals and employers – are highly varied, and no doubt influenced by the broad status of the economy. Means may thus have to be found through which individuals might continue to meet CPD needs by recognising and responding to changing circumstances.

In times of austerity, for example, there may be a need to turn towards those methods of delivering CPD that incur lower costs. Online, distance learning methods could be attractive, for example. Although costs are incurred, there are two key advantages:

- CPD through distance learning does not incur needs for attendance and associated travel and accommodation costs; and
- The time needed has relatively little impact on an individual's workload on a week-to-week basis[10].

The disadvantage, of course, is that it is difficult if not impossible to replace or recreate the benefits that may be gleaned through approaches to CPD which bring together individuals and permit direct interactions and networking.

By the same token, less precisely prescribed requirements for CPD may be advantageous. Formal recognition of activities and tasks that might be undertaken within the workplace as CPD reduces reliance on externally-provided CPD opportunities. By adopting a suitably reflective and focused framework, there is a strong case for workplace-specific activities to contribute to CPD, albeit with limitations. CPD orientated around personal and interpersonal skills, for example, might easily be carried out within the workplace, whilst CPD focusing more on knowledge and understanding might be better delivered through means involving specific training through external agents. An optimal approach might well blend purpose with opportunity to yield substantial benefits. ES

Peter Shaw is a Senior Lecturer in the Centre for Environmental Sciences at the University of Southampton and Chair of the Committee of Heads of Environmental Sciences. **Simon Kemp** also lectures in the Centre for Environmental Science at the University of Southampton, and is Director of Employability and Employer Engagement in the Faculty of Engineering and the Environment.

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Which way forward?

Ros Howell looks at how the future need for environmental experts can mesh with the increased impetus for wider understanding of environmental and sustainability issues.

It is evident that, increasingly, professionals in all sorts of roles have to deal with complex social, environmental and economic issues. Employers are seeking new kinds of competencies in ethics, human ecology, conflict resolution and environmental management; increasingly there is a need for people with interdisciplinary problem solving capacity as well as scientific or technical competence. This is especially so for the environmental professions. The key challenge seems to be this: how will the environmental professions meet the need for people with specialist skills and knowledge, and at the same time the pressing need for more interdisciplinary skills? How can the greater breadth of understanding implied by inter-disciplinarity be achieved whilst ensuring adequate depth of subject provision? This situation essentially points to the need for more education and training for the environmental professions. Environmental professionals, in dealing with increasingly complex problems needing interdisciplinary perspectives, will have to be more able and confident to enter into dialogue with a wide range of stakeholders. The situation is well summarised by the following:

"Is it not unrealistic to envision a generation of sustainable development 'specialists' whose perspective simultaneously encompasses the entire field? What research for sustainable development demands is, if anything, increasingly specialised work by experts in such field as energy, food and water; however, they must also be capable of collaborating in the overall effort to solve global environmental problems. What is important here is that the specialists in these diverse fields expand their perspective beyond their particular area of expertise enough to create a co-operative framework for combating these global environmental problems together."[1]

Ultimately, environmental specialists have to have a broader perspective to enable them to contribute to solving global environmental problems. Equally, there is a need for increasing levels of sustainability literacy amongst people in all walks of life, including a generally increased awareness and understanding of the workings of environmental systems by all those who want to engage with sustainable development. New directions for environmental education are emerging through the implementation of broad Education for Sustainable Development (ESD) initiatives, the significance of inter-disciplinarity in this context, and the development of new paradigms, which are increasingly referred to as 'sustainability science'.

ENVIRONMENTAL SCIENCE AND ESD

The development of greater understanding of sustainability must depend on a highly significant contribution from environmental science and related subject areas, even though sustainability is a considerably broader concept. Environmental science along with geography and other environment-related disciplines are seen as the discipline areas that most obviously underpin sustainability education, due both to the subject matter, and the potential for working across academic boundaries. These subjects are already inherently interdisciplinary, focusing often on the built, technological, social, cultural, political and economic as well as the natural environment, albeit to different extents[2].

One key aspect of ESD is that it seeks to promote more systemic thinking, encouraging understanding of connectivity rather than reductionism in understanding and managing situations marked by complexity – basically more integrative, adaptive and 'joined-up' thinking[3]. Key knowledge and skills outcomes associated with ESD have been identified (see **Box 1**). As long ago as 1987, the Bründtland Report of the World Commission on Environment and Development (WCED) said that education had the task of providing "comprehensive knowledge, encompassing and cutting across the social and natural sciences and the humanities, thus providing insights on the interaction between natural and human resources, between environment and development"[4].

It is now half way through the Decade of Education for Sustainable Development. The Bonn declaration of 2009 confirmed the role of universities, especially, to strengthen global and local knowledge of ESD through their teaching, research and community functions[5].

What then is the relationship between sustainability and environmental science? There is a dynamic tension between established environmental science and increased promotion of ESD. ESD is often seen as 'soft' in comparison to the 'hard' sciences, which includes environmental science as well as the more traditional physics, chemistry and biology disciplines that underpin it. The challenge is for the established environmental sciences to 'talk to' the wider aspects of sustainability, which includes economic, social and cultural dimensions, and especially issues of social justice. Equally, those who are not environmental 'experts' need to engage with scientific thinking about the environment. Furthermore, 'sustainability literacy' is not a million miles away from the need for broader 'scientific literacy', currently promoted by initiatives to promote Science, Technology, Engineering and Mathematics (STEM) subjects.

"The challenge is for the established environmental sciences to 'talk to' the wider aspects of sustainability, which includes economic, social and cultural dimensions, and especially issues of social justice."

Here, it is again useful to look back at the seminal WCED report of 1987, which envisaged a positive relationship between scientific knowledge and environmental education: "our technology and science gives us at least the potential to look deeper into and better understand natural systems"[4]. Indeed, it has been suggested that current interest and concern amongst young people in the environment and sustainability should be used more as a 'doorway' into engagement with STEM subjects[6,7]. It is also notable that in a recent report from the Higher Education Academy, 80% of first year undergraduate students thought that sustainability skills would help them get a job in the future[9]. There are certainly issues around sustainability that can be used to enthuse and interest young people more in scientific issues.

THE NECESSARY SKILLS

It is pertinent when thinking about the future of environmental education to look at the relevant research horizons which are influencing the skills and knowledge needed by environmental professionals. The UK Living with Environmental Change (LWEC) Programme identifies the need to develop a low carbon economy, ensure secure and sustainable supplies of food and water, and increase the resilience and capacity of people, places and infrastructure to respond to environmental change.

In a horizon scanning report the most important dimensions of uncertainty for the environment that could impact on the UK's interests over the next twenty years were identified as:

- Cities and the environment;
- Economic growth within environmental limits;
- Costs and benefits of renewable energy;
- Food production;
- Sustainability of the water supply;
- Changing behaviours;
- Changing ecosystems;
- Reducing uncertainty around climate change impacts;
- Transport and mobility;
- Consequences of population movement; and
- Deploying technology.

In trying to characterise these dimensions of uncertainty, the report states that:

- Research in the future must anticipate what will happen, rather than describe what has happened;

- The environment cannot be looked at in isolation from social end economic trends; and
- Policy makers need new tools and approaches to understand complexity and uncertainty surrounding environmental issues[9].

The report Most Wanted: Skill Needs in the Environment Sector summarises work led by the Natural Environment Research Council (NERC) to examine skills that postgraduates and professionals need to equip them for work in the environmental sector. It is an output of the Skills Needs Review, originally commissioned by the Environment Research Funders Forum (which merged with LWEC in June 2010). A range of 'hard' and 'soft' skills were identified as being in short supply. A widely recurring theme was the lack of inter- and multi-disciplinary skills, between environmental sciences and, for example, engineering, business, social sciences, maths, statistics and computing. Especially identified was the need for interdisciplinary working spanning not only the physical sciences but also the social sciences, economics, and communications[10].

BOX 1: KEY OUTCOMES FOR ESD

- An appreciation of the importance of environmental, social, political and economic contexts of their discipline.
- A broad and balanced foundation knowledge of sustainable development, its key principles and the main debate within them, including its contested and expanding boundaries.
- Problem solving skills in a non-reductionist manner for highly complex real life problems.
- Ability to think creatively and holistically and to make critical judgements.
- Ability to develop high level of self-reflection (both personal and professional).
- Ability to identify, understand and evaluate and adopt values conducive to sustainability.
- Ability to bridge the gap between theory and practice, in SD only transformational action counts.
- Ability to participate creatively in interdisciplinary teams.
- Ability to manage change.

"Critical theory, unlike problem solving, stands apart from the prevailing world order and asks how it came about."

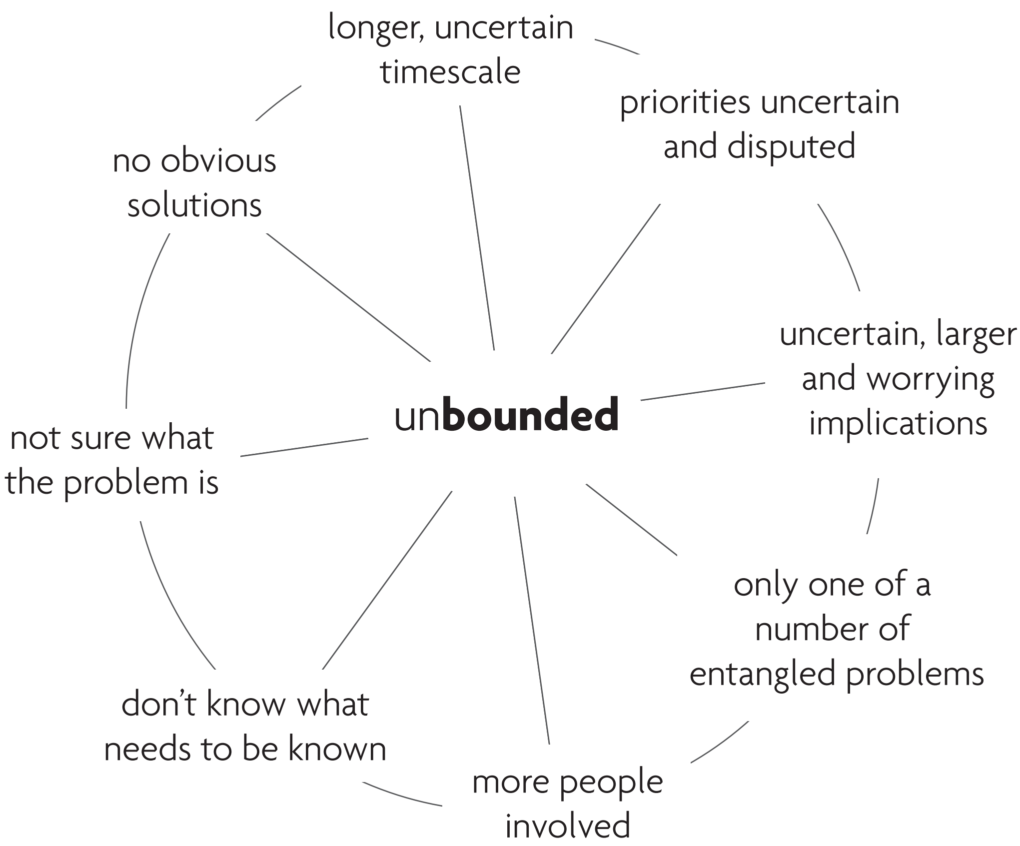
Altogether, fifteen skills were identified as being in critically short supply, including hard edged skills such as numeracy, computer modelling and conducting field research, and softer skills, for example to enable better communication of science. Such skills are badly needed, for example, to allow the UK to develop and apply new technologies, respond to the impacts of climate change and extreme weather, and enable better knowledge and understanding of environmental issues. Also key are skills dealing with complexity, as a new area in risk and uncertainty modelling; training is needed to quantify uncertainty in climate change models and observations, and also critical is communication of this uncertainty. The report also identifies a need to develop postgraduate skills in the new discipline of sustainability science.

SUSTAINABILITY SCIENCE

Sustainability science is a developing discipline area that seeks to deepen understanding of the linkages between global systems (the planetary base) and social systems (political, economic and other human devised structures) and also human systems. In effect, sustainability science means treating sustainable development from a scientific perspective. According to some, it is not a science by any usual definition but a plethora of ideas and perspectives, sometimes conflicting, by which it is hoped to achieve a viable future for mankind[11].

It is therefore normative in essence, and is more consistent with critical research approaches than traditional problem solving; it does not shy away from value and beliefs[12]. Critical theory, unlike problem solving, stands apart from the prevailing world order and asks how it came about. It calls into question contemporary institutions and power relations and allows for normative choice in favour of alternative social and political solutions. In this sense sustainability science is not so much an applied science as an enterprise centred on 'use-inspired basic research', and it is not yet an autonomous discipline but a vibrant area bringing together scholarship and practice, global and local perspectives and various disciplines.

▼ **Figure 1: Wicked or unbounded problems.** Source: PP4SD 2010[14]



"Environmental science, whilst enabling the development of a much needed professional sector... now points to a less certain and more questionable science."

SOLVING 'WICKED' PROBLEMS

Over the past fifty years environmental science had elucidated society's understanding of earth processes, and the impact of humans on these processes. This developing understanding of various branches of environmental science (ecology, pollution science, ecotoxicology, for example) has developed the ability to limit impacts through risk assessment and risk management, for example by increasing regulation of emissions to land, water, air, and increasingly more holistic management of ecosystems. The EU officially adopted the precautionary principle in of the Lisbon Treaty (Paragraph 2, article 191). This was in response to the growing recognition of uncertainty in scientific knowledge; it means action should be taken to prevent environmental damage, even if risks are uncertain. This principle now informs much of European environmental policy. So environmental science, whilst enabling the development of a much needed professional sector that barely existed until forty years ago, now points to a less certain and more questionable science. It would seem that the era of a completely 'objective' and value free science is over, and the new scientific approach is called 'post normal' science. One key argument is that current emphasis on disciplinarity, in spite of the obvious associated strengths, is that it can restrict what is perceived to be relevant and draw boundaries too narrowly. The current emphasis on disciplines is not much more than 100 years old and that seeking interdisciplinary links, for example linking science and humanities for purposes of integration and synthesis is nothing new[13].

The need to deal with uncertain complex problems that characterise un-sustainability points in the direction of a new kind of approach to problem solving; an approach based on dialogue and multiple inputs, in effect an extended peer community. Many problems of un-sustainability are increasingly being described as wicked problems. Wicked problems (see **Figure 1**) are unbounded, they have no clear beginning or end, and priorities are uncertain or disputed. Wicked problems include, for example, climate change, food supply and energy supply; these are complex, multi dimensional problems, where stakes are high and uncertainty is high. In this respect, such problems cannot be 'solved' by the traditional application of scientific knowledge - the whole problem solving approach needs to be revised.

These approaches have been characterised as post normal science, or precautionary science, and lie at the difficult interface between science and policy[15]. Post normal science again emphasises more interdisciplinary thinking and more dialogue to make progress on problems of un-sustainability. These new approaches cannot replace the need for more traditional forms of science, but are needed to complement traditionally recognised science for dealing with new types of issues.

LOOKING TO THE FUTURE

In 2011, when considering 'Which way forward?' there are some key questions being considered:

Does everyone need to be an environmental expert? No, but everyone does need to have sufficient understanding of basic environmental systems and processes if they are to engage meaningfully with sustainable development, and this is embraced by the general recognition of the importance of ESD at all levels of education. All graduates are now expected to be 'sustainability literate' (and, this goes hand in hand with the need for scientific literacy and increased reach of STEM disciplines).

Does everyone need to have a better understanding of environmental systems and processes? The answer here, then, is yes.

Do environmental professionals need to be experts in everything? No, this is impossible. However environmental professionals must be able to collaborate in the effort to solve global problems – they must have a broad enough perspective to contribute to a co-operative framework. A 'sustainable development' specialist may have broad expertise but will need to consult with those with more in-depth knowledge (which might be of a disciplinary area, or a geographically local area).

Do environmental professionals then need to be better prepared to engage in wider dialogue? The answer here, then, is yes.

There is a need for more specialists in many areas of environmental science. These specialists may be developed at undergraduate or postgraduate level but they will all have to be more able to engage in dialogue with non-specialists, who will have to have at least a basic level of understanding of environmental processes and the part of humans in them. In this way the necessary range of viewpoints and inputs into decision making and dealing with wicked problems that characterise the road to sustainability can be brought into play. ES

Ros Howell is Senior Lecturer in Geography and Environmental Management at Manchester Metropolitan University.

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IES: New members and re-grades

Name	Occupation	Grade
Ebrahim Abuhusain	Environmental Specialist	M
Tukhanh Agapakis	Geo-environmental Consultant	M
Philip Bailey	Environmental Manager	A
Nora Bartowme	Student	Af
Miriam Bello	Student	A
Richard Booth	Community Recycling Officer	M
Lauren Boydell	Senior Consultant	M
Heather Broad	Geo-environmental Consultant	M
Keung Chan	Assistant Environmental Consultant	M
Theodore Chatzipanagiotis	Junior Consultant	A
Andy Cole	Environmental Protection Technical Officer	M
Matthew Collins	Graduate	Af
Peter Collins	Environmental Consultant	M
Beth Conlan	Knowledge Leader	M
Warren Corns	Research & Development Manager	F
Matthew Derbyshire	Environmental Consultant	M
Daniel Evans	Senior Consultant	M
Michelle Fallone	Senior Geo-Environmental Scientist	M
Sian Ferguson	Interim Chief Executive	M
Joan Gillespie	Senior Environmental Scientist	M
Jennie Godwin	Senior Consultant	M
Daniel Helm	Regulatory Officer	A
John Hodgson	Air Quality Consultant	M
Mark Hughes	Carer	A
Jonathan Hutchinson	Geoenvironmental Engineer	M
Joseph Jackson	Director	M
Alice Jupp	Christian Environmental Consultant	A
Tsun Kam	Assistant Consultant	M
Maria-Eleni Karyampa	Student	Af
Alison Kenny	Environmental Scientist	M
John Laverty	Senior Environmental Scientist	M
Megan Le Mare	Environmental Consultant	A

IES: New members and re-grades

Name	Occupation	Grade
Sheryl Lee	Area Conditions Officer	M
Wai Li	Lecturer	M
Karla McBride	Senior Planning Inspector	M
Emma McCudden-Woodcock	Senior Development Officer	M
Maxine McMimm	Event Assistant	A
Maria Metallo	Scientific Coordinator	M
Richard Navin	Student	Af
Vieri Nucci	Graduate	A
Luc Porter	Graduate Air Quality Scientist	A
Rachel Powis	MSc Student	Af
Jillian Price	Environmental Officer	M
Jonathan Pullen	Operational Director	M
Paul Quimby	Principal Environmental Consultant	M
Christopher Rice	Senior Consultant	M
Benjamin Richardson	Graduate	A
Susie Robinson	Principal Consultant	M
Nadia Schweimler	Student	Af
Tim Sellors	Principal Environmental Consultant	M
Catherine Shields	Principal Ecological Consultant	M
Venan Sondo	Environmental Scientist	M
Angela Spinks	Assistant Air Quality Consultant	M
Srinivas Srimath Tirumala Gudimella	Principal Environmental Consultant	M
Paul Taylor	Head of Technology, Air Quality Expert	M
Jacobus Van Rooyen	Geospatial Analyst	M
Daniel Walker	Scientific Officer	A
Christopher Warren	Environmental Scientist	M
Christabel Watts	Intern	A
John Whitton	Project Champion: Energy and Sustainable Technologies	M
Megan Williams	Environmental Protection Officer	A
Neil Young	Environmental Scientist	M

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