The Environmental Curriculum

Opportunities for Environmental Education across the Secondary Curriculum

Key Stages 3 & 4

NAEE
NATIONAL ASSOCIATION FOR ENVIRONMENTAL EDUCATION (UK)

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National Association for Environmental Education (UK)

NAEE (UK) is a Charitable Incorporated Organisation: 1166502

The National Association for Environmental Education (UK) is an independent charitable organisation that supports and promotes teaching and learning about the environment in the formal education sector.

The object of NAEE is to provide a public benefit by advancing environmental education within early years settings, primary and secondary schools, and institutions responsible for teacher education within the UK and elsewhere, in particular but without limitation by:

- facilitating curriculum development through the provision of resources, information and ideas for teachers
- providing financial support for pupils to visit outdoor education centres
- collaborating with organisations that have related objectives

NAEE is a membership organisation, with members receiving 3 journals per year.

For more information about NAEE, or to become a member, visit our website.

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About the author

This handbook has been compiled by Juliette Green, a writer, teacher and freelance environmental educator. Juliette has written books and resources about outdoor learning, science and English. She is a member of NAEE's Executive.

Cover image: Students at Ringwood School using a thermal imaging camera to identify heat loss from the school buildings due to cracks or poor insulation. Photo credit: Gill Hickman.

Unless otherwise stated, photographs are taken from articles in NAEE's journal *Environmental Education,* or from schools who took part in NAEE's Hugh Kenrick Days — a bursary for schools to visit environmental education centres.

NAEE has also produced an early years and primary curriculum document. This can be downloaded from the NAEE website.

Foreword

Writing some two years on from the publication of NAEE's Early Years and Primary Curriculum Handbook in 2015, I was briefly tempted to write the same Foreword as I did then – after all, the problems we face are much the same, other than being a little bit more urgent, with those responsible for education policy in England remaining studiously indifferent to the issues. That said, there have been significant changes in the wider world. The Paris Agreement was signed in December 2015 and the UN has demanded that countries work to realise the 17 Sustainable Development Goals (SDGs). Taken together, and if successful, these programmes will transform the lives of billions of people across the planet – including lives in the UK. The Paris Agreement and the SDGs not only embody the hope of a better world – socially, economically and environmentally – they also represent a race against time. In a narrow sense, this is a race faced by people who dice on a daily basis with preventable destitution, social exclusion, discrimination, malnutrition, illness and an early death. In a broader one, it's a race faced by us all, as we work to limit climate change and global warming before lasting damage is done to planetary systems. There are positive signs out there, and negative ones as well.

Closer to home, in the first week of January 2018 the UK government launched its much anticipated 25 year plan to improve the environment. Although this sees a positive role for schools and for other community-based education providers, which will generate opportunities for environmental educators, it looks rather limited. As NAEE President, Justin Dillon noted in an NAEE blog:

> *"The 25-year plan seems to miss a fundamental point. ... Schools and their leaders have a key role in influencing public attitudes and empowering students to support the reverse decades of environmental degradation in both urban and rural areas, but this plan, for all its merits, only plays lip-service to a challenge that must be at the heart of social change in England and, indeed, all of the UK."*

A focus on such issues has been at the heart of environmental education for many years, and 2017 sees the 40th anniversary of the United Nations' Tbilisi Declaration which set out the importance of environmental education to the future of the planet, its people and biosphere. NAEE's 1976 statement of aims was a key part of the UK documentation presented at Tblisi, and there was then a widely-shared feeling that, as the Earth's problems became more acute, environmental education would be increasingly seen as more and more necessary. However, in those 40 years, it's not really been like that. For example, the blossoming of curriculum interest in the 15 years that began in the mid-1970s, which led to a range of A-level, GCE and CSE courses in environmental science and environmental studies, was brought to a shuddering halt by the conformity and centralization of the national curriculum. Although environmental education was granted cross-curriculum theme status, that didn't mean much in the end, especially in secondary schools where a subject curriculum and specialist, expert subject teachers tend to combine to militate against cross-curricular work.

That said, there are excellent examples of secondary schools exploring ways of subject departments working together to address such issues, and also of adopting whole-school approaches to them, as this valuable document illustrates. The current secondary school curriculum, for all its faults, does provide numerous opportunities for schools, teachers and students to explore a wide range of the world's most pressing issues. The power of this handbook lies not just in its careful analysis of what the curriculum says, but also in its excellent exemplification of how teachers are seizing opportunities to explore these issues with their students. The case studies of practice are particularly useful in helping us see what's possible in today's schools. There is something here for everyone: for experienced practitioners there will be insights from other people's work; and for those just starting out, a wide range of teaching and learning opportunities are carefully set out for scrutiny, evaluation and adaptation.

It is clear that environmental education has a key role in helping us address the challenge we all now face: how can we all live well, without compromising the planet's continuing ability to enable us all to live well? We do not yet know enough about how to do this, and so we must learn our way into it. I welcome this handbook as a contribution to this great task.

Professor William Scott Chair of Trustees, National Association of Environmental Education (UK)

Contents

Introduction

Environmental education helps to foster caring, responsible attitudes and inspires young people to take action in order to live more sustainably. It can also develop a sense of identity and pride in their local environment and community. It not only covers the natural world and 'green' issues, but also the built environment, and the ways in which humans relate to the places where they live.

Environmental education within schools is now more important than ever: children and young people spend less of their free time outdoors, because of safety concerns and the increasing use of technology, and budget cuts have led to the closure of outdoor learning centres across the country. This handbook highlights the opportunities for environmental education that can be found in the 2014 Secondary National Curriculum in England.

What is environmental education?

There are three interrelated components of environmental education:

- **Education ABOUT the environment**
  Developing knowledge and understanding about the environment, both local and global. This is taught mainly through the subjects of the sciences, geography, history and design & technology.
- **Education IN the environment**
  This can be thought of as the 'hands-on' element, i.e. using students' immediate surroundings and the wider world as a learning resource which helps to develop a range of (cross-curricular) skills. For example: communication skills (via spoken and written language, drama, art, music etc.), mathematical skills, study skills, problem-solving, personal and social skills, and information technology skills.
- **Education FOR the environment**
  The development of positive attitudes and behaviours towards the environment. This aspect can only really be effective if the other two elements are in place, as students need to be able to understand, recognise and value the environment in order to want to safeguard it for the future.

These components are explained in more detail in *The Handbook for Environmental Education* (published by Routledge, ISBN 978-0415093149) written in 1994 – but still very relevant today – by former NAEE Secretary Philip Neal and Joy Palmer, a former NAEE Chair and current Vice-President.

A brief history of environmental education in schools (England and Wales)

Environmental education in schools stemmed from ideas and initiatives such as environmental studies (involving a mix of history, geography and nature studies, mainly in the school locality), field studies (work carried out further afield), wildlife gardening, Earth Education (using direct experiences with nature to engage children's feelings and senses), a greater focus on the ecology of urban areas, and the development of city farms.

Between 1990 and 1994, environmental education gained greater recognition and prominence as a 'cross-curricular theme', encompassing both the built and natural environment through the following seven topics: Climate; Water; Energy; Plants and animals; Soil, rocks and minerals; Buildings; Industrialisation and waste; and People and communities. However, this was the last explicit reference to environmental education in the national curriculum.

From 2000 onwards, the curricular focus shifted towards Education for Sustainable Development (ESD), with the Government's *Sustainable Schools Strategy* running between 2006 and 2010, and the inclusion of the 'cross-curricular dimension' *Global dimension and Sustainable Development* in the 2008 secondary national curriculum. Sustainable development is based around the concept that development should be able to meet the need of present generations without compromising the ability of future generations to meet their own needs. Environmental education is definitely a key component of ESD, as students need to understand how our activities impact on the local and global environment in order to live sustainably.

In recent years, Outdoor Education (OE) – particularly the forest school movement – has become increasingly popular in schools. In 2006, the Government launched the *Learning Outside the Classroom Manifesto*, which advocated the use of outdoor learning — from the school grounds and local area, to visits further afield and residential trips — as an essential aspect of education. The manifesto highlighted the values of hands-on, experiential learning as a way of enhancing and supporting work back in the classroom. However, NAEE strongly believes that any education that takes place *in* the environment should also be education *about* and *for* the environment; in other words, not merely using the outdoors as a resource but taking the opportunities to understand and appreciate the natural (and built) environment to lead to positive action.

Environmental education in the current national curriculum

The days of environmental education (or education for sustainable development) being a specified cross-curricular theme/dimension appear to have gone, but there are many opportunities for education *in, about* and *for* the environment that **can** be found in the KS3 & 4 curriculum.

In the introductory pages of the 2014 Secondary National Curriculum, reference is made to the fact that a *"balanced and broadly based"* curriculum should promote *"the spiritual, moral, cultural, mental and physical development of pupils at the school and of society"* and prepare students for *"the opportunities, responsibilities and experiences of later life".* This definitely has strong links with environmental education, as our future generations need to be equipped with the skills and knowledge to make decisions that will impact on their local environment and the planet as a whole.

It is stressed that the national curriculum should just be one element of children's education and that teachers should use it to develop a range of *"exciting and stimulating lessons to promote the development of pupils' knowledge, understanding and skills".* What better way to make lessons exciting, stimulating and relevant to children than using their local (and wider) environment as a place of learning?

The three main curriculum subjects that have the most obvious opportunities for environmental education are geography, science and design & technology, but there are also links to English, maths, history, citizenship, PE, creative subjects and even languages and computing.

Some useful websites have been included within the sections of the document; but there is also an extensive website list on pages 44-46.

Environmental education engages the **heart**, **hands** and **mind**.
Photo credit: Heatha Gregory

Environmental Education through Geography

Written with **Henricus Peters** Editor, *Environmental Education* e-journal, NAEE

Geography has close links to environmental education, as it should be about "*inspir[ing] in pupils a curiosity and fascination about the world and its people"* and equipping them with *"knowledge about diverse places, people, resources and natural and human environments, together with a deep understanding of the Earth's key human and physical processes"* (KS3 curriculum).

The GCSE curriculum is more explicit about the environment, by giving students the opportunity to *"understand more about the world, the challenges it faces and their place within it"* and stating that *"geography enables young people to become globally aware and environmentally informed and thoughtful, enquiring citizens."*

The Geographical Association's manifesto 'A Different View' (2009) describes geography as "*one of humanity's big ideas"* and makes a compelling case for its place in the curriculum. It shows the value of thinking geographically, provides an introduction to *"living geography"* and reflects on the changing role of fieldwork, demonstrating the practical importance of 'real-world' geography.

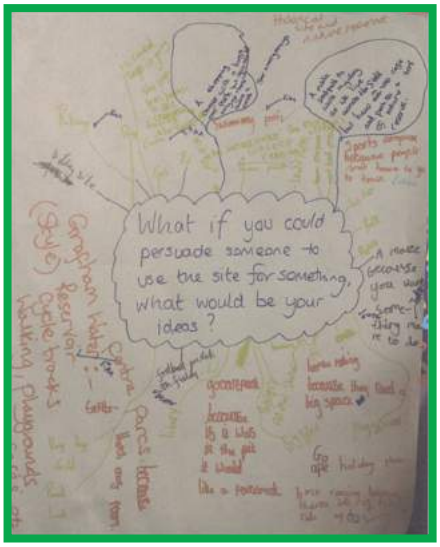
Through fieldwork and other geographical skills, students can learn about the quality and vulnerability of different environments and the possibilities for positive environmental management. They can discover how we, as humans, have shaped the world, which in turn should help them to develop decision-making skills and gain a sense of personal responsibility.

Human geography

- Human geography links to the impacts humans have had — or may have in the future — on the local and global environment, for example settlement and land use, economic activity and the distribution of natural resources. Students can investigate the impacts (both positive and negative) of human activities on the environment, for example energy production and usage, water security, waste, buildings and industrialisation. They can learn about the finite nature of many resources, the impact of mineral extraction and energy production, and the fact that not everyone in the world has access to clean water.
- **Development and urbanisation:** Geographers use social, economic and political indicators to measure development in countries throughout the world. One of the key questions that students can research is: 'What is the standard of living of the people who live in a country?' There are many different ways to measure the quality of life or level of development of a place: economic indicators such as GDP, jobs, wealth; social indicators like health, education and equality; and demographics — how many people and where they live.

  Students can find out how an economically-developing country might create a more negative impact through its (primary or extractive) industrial activities on its natural environment, compared to another country which has appropriate systems in place.

  At a local level, you could set students a challenge of carrying out an environmental impact assessment (EIA) for a real or hypothetical new development. For example, give them a letter from the local council (or your school's academy sponsor) stating that they wish to build two new classrooms and would like the students' advice about where best to site them so that there is the least impact on the environment. Provide them with the measurements of the classrooms and three potential locations. Students can carry out studies in groups to establish the plants, animals and habitats that might be affected, considering whether habitats could be re-established elsewhere. They could also take into account considerations such as which location would provide



Students' ideas about repurposing a local brownfield site.
Photo credit: Bruce Huett

the most sunlight, which could impact on electricity and heating bills. The activity would be summarized by each group preparing a formal response to the proposals and sharing these at a meeting involving the whole class and the 'developers'.

- **Interdependence:** Students can study, at both a local and global scale, the ways in which human lives, livelihoods and communities are dependent on the environment. For example, they could look at the use of plants for food, medicine (including the potential to cure diseases such as cancer and HIV), toiletries and other products, by investigating the origins of products they use in a day.

  The KS3 geography curriculum refers to understanding how *"human activity relies on effective functioning of natural systems",* so a study of a threatened ecosystem such as tropical rainforests would reveal the importance of conserving such an ecosystem with reference to the impacts on human lives (including those of indigenous people).

  Students can also explore the environmental interdependence of individuals, groups, communities and nations, for example how power station emissions from Britain can affect air quality in Scandinavia, or how emissions from Germany can affect air quality in neighbouring countries because of their burning of brown coal (lignite).

A 'backpack challenge' at a botanical garden to find out about the uses of tropical plants. Credit: Heatha Gregory

- **Globalisation:** Students can study issues around globalisation, which has made the world seem a smaller, more connected place, through the rise of multinational corporations, increased global trading and internet access. The resulting impacts – economically and ethically – provide opportunities for research and social action.
- **Migration:** World population growth and how to manage it, within the boundaries of the planet's capacity, is one of humankind's greatest challenges. Environmental and economic factors affect population density, distribution and structure. Students can explore the positive (e.g. jobs and better lifestyle) and negative effects (e.g. over-crowding, war, famine) of migration.
- **Tourism:** Tourism is one of the fastest growing industries in the world and it generates jobs. The money spent by tourists adds to the wealth of countries (economic growth). Secondary students will be tourists, either with their families or when undertaking foreign field trips, and can investigate sustainable or eco-tourism.
- **Settlement geography:** Settlements can range from small hamlets to very large, mega-cities. They can be identified by their pattern or the functions they offer. Many settlements have things in common and so they can be grouped in order to study them. Students can look at the ways that settlement sites were chosen in the past, i.e. close to features that would make life easier. These features included: flat land, to make building easier and safer; local raw materials, for example wood and stone, to build homes; a local water supply for drinking, washing, cooking and transport; dry land that would not flood easily; fertile soils to grow crops; shelter; possible transport links, such as a ford or low crossing point of a river; and a defendable site like a hilltop. They could also study modern settlements such as Brasìlia, where a new capital city for Brazil was built that had a more central location than the former capital Rio de Janeiro. They could locate, plan and design their own settlements, looking at how environmental and human needs could be balanced.
- **Energy and resources:** Our need for energy is growing as our world becomes more advanced. Developing renewable energy sources – wind, water, solar, geothermal, biomass – will be crucial as finite fossil fuels cannot meet demand and are depleted. Nuclear has many pros and cons. The cutting down of rainforests, for wood as well as palm plantations, has consequences and should be studied and debated by our students.

- **Sustainability:** Introduce your students to the UN's 17 Sustainable Development Goals (ow.ly/hBAX30fqrGc) and ask them to put together an action plan of practical, personal goals to help them live more sustainably at home, school and elsewhere. (*The Lazy Person's Guide to Saving the World* has a suggested list of actions: 'Level 1 Sofa Superstar', 'Level 2 Household Hero', 'Level 3 Neighbourhood Nice Guy'.) There are several websites with teaching ideas based around the Global Development Goals, including Oxfam, UNICEF, CAFOD, the British Council and 'The World's Largest Lesson' (worldslargestlesson.globalgoals.org).

  Students can study indigenous peoples who still aim to live in harmony with their natural environment, alongside their development-focused neighbour regions and countries. Examples of these, such as Mongolian horse herders, Amazonian tribes and indigenous people of Northern Canada, are good case studies for sustainability.

- **Ecological footprints:** Students can calculate their own 'ecological footprint' (a good calculator can be found at: footprint.wwf.org.uk), in terms of the water, food, energy etc. that they use and the waste they produce. They can then explore creative solutions to reduce the size of their footprint (in hectares). They can also compare their footprints to those of similarly-aged students in other countries around the world.

- **Ecological handprints:** A significant problem with the idea of the ecological or carbon footprint is that there's a strong focus on reduction — a footprint records things we should be doing less of, or, perhaps, not doing at all. But some people argue that the psychology here is all wrong and that we need to focus on positives rather than negatives in order to create more enthusiastic responses. One such alternative is the 'environmental handprint'. This is a measure of what we are doing right; for example taking exercise, cycling to places, consuming local food, using renewable energy. This involves positive psychology as we'd be trying to increase the handprint. Its supporters say this could encourage communities to be more enthusiastic about sustainability.

- **Purchasing:** Ask students to investigate the implications of their purchases of items such as mobile phones and clothes — on both the people who produce them and the environment — and issues around their disposal. Issues can include working conditions, trade, habitat destruction, deforestation, transport and pollution (e.g. water, air, noise) produced by factories. These issues can be explored using ideas such as the Sustainable Development Goals, eco-footprint/handprint (both mentioned above); or the sustainability compass (see page 11).

- **Labelling:** Students can investigate 'eco labelling', such as Fairtrade, Rainforest Alliance, Green Palm (the logo of the Roundtable on Sustainable Palm Oil — RPSO), FSC (Forestry Stewardship Council, for sustainable wood-based products), Soil Association logo (to certify organically-grown products). They can look for the logos on products in local shops or supermarkets and research the benefits (as well as possible flaws or conflicts) of these certifications.

- **Waste and pollution:** Students can investigate the ways that rivers are used in this country and around the world, how this can lead to pollution and how this is (or is not) dealt with. For example, the River Irwell in Lancashire has gone through many changes in the past 200 years: prior to the development of Manchester as a hub of industry, the waters of the Irwell were clean, providing drinking water for local people and supporting good populations of fish, including salmon. However, as industry increased, mills and factories such as bleach works, tanneries, cotton mills, paper mills and gas works, as well as houses, were built alongside the river, all using its waters and causing it to become severely polluted and almost completely devoid of fish and plant life. In the 20th century, as industry was reduced or operated more sensitively, water quality improved and the Irwell now supports a variety of fish and plant life once more. (Information taken from irwellriverstrust.com.)

  Comparison could be made with the River Ganges in Asia, one of the world's biggest rivers (seven times the length of the river Severn), which is sacred to Hindus and provides a lifeline to local people who use it for irrigation of crops, washing and travel. However, it is heavily polluted, which is now affecting populations of the blind river dolphin that live in it, as well as those who bathe in its waters, which are considered to be pure. (For more, see BBC Bitesize video clip: ow.ly/yf2630fqrL2.)

Physical geography

- **Climate change:** Climate change is having a huge effect on how and where people live and the 'climate debate' can still be controversial, with political views challenging scientific evidence. The KS3 programme of study refers to *"weather and climate, including the change in climate from the Ice Age to the present"* and the GCSE curriculum specifically mentions *"evidence for different causes [of climate change], including human activity".* This links to study of climate change in the science curriculum (see the Chemistry section of this document).
- **Weather:** Students could set up their own weather station, by making measuring equipment (e.g. rain gauge, anemometer, barometer, weather vane, cloud key — see the Design & Technology section of this document for more details) to measure local weather conditions and patterns.

  Students can research local and global weather events and explore whether human activities have influenced these, for example building on flood plains, damming rivers.
- **Landscapes:** Students can investigate the impacts of human activities on various landscapes (local and/or global). Examples might be erosion caused by buildings encroaching on coastal habitats; or glacial landscapes as indicators of the impact of climate change on global habitats, e.g. reduction of glaciers.
- **Natural disasters:** Students can explore the environmental impacts (and in some cases, human causes) of natural disasters such as earthquakes, floods, tsunamis, tropical storms, forest fires etc., including those in the UK (most notably flooding due to changes to rivers and catchments). Students might examine the claims of those who say that 're-wilding' is needed if we are to reduce such problems. They can also look at the consequences for people and their property.

Studying the landscape of the Peak District. Photo credit: Lynn Reeve

Geographical skills and fieldwork

- Fieldwork is an essential aspect of geography, which helps to develop an understanding of physical and human processes on a variety of scales — local, national and global — through hands-on, sensory experiences.
- Fieldwork carried out in the school grounds can help students to gain more of an insight into their local environment, but can also help to hone skills that can be used in fieldwork further afield. For example, students can interpret, annotate and create maps of their school grounds and practise sampling techniques.
- Ask the students to carry out an environmental survey — in different parts of the school grounds, a local park or nature reserve, the town centre, or a more distant area visited during a field trip — identifying plants and animals using keys, taking measurements such as light or noise levels and soil pH; and recording their findings through photographs, sketches, scale drawings, map annotations, tables and field notes. They could also devise their own set of criteria against which to measure the 'environmental quality' of an area (e.g. plant diversity, cleanliness, litter). This could then lead to work on how the environment could be improved, perhaps just in one specific area of the school grounds, chosen by the students as a result of their survey work, with the students taking the main responsibility for developing this area.

Carrying out a survey in a local shopping area. Photo credit: Beth Christie

The students can devise questionnaires and carry out interviews, for example asking local residents about their buying habits (linking back to eco-labelling), waste management or the quality of the environment.

- It is important to point out to students that environmental issues are often not as clear-cut as they seem: they must learn about the conflicts that can arise between, for example, nature conservation and human development. A good way of exploring these issues is by using the 'Sustainability Compass' (or 'Development Compass Rose'). Here, the points of a compass are replaced with the following 'lenses' (or 'domains'): **N**ature, **E**conomy, **S**ociety, **W**ellbeing (or in the Development Compass Rose, W stands for **W**ho decides). Split the students into groups for each lens and ask them to explore that aspect of the issue or situation – either through first-hand evidence such as questionnaires in a local area or on a field trip, or using secondary information sources for a more distant or global issue. Each group can then give presentations to show that they have seen or learnt from their compass point perspective. This should enable them to make connections between the compass points and may affect their overall ideas or thoughts in either a positive or negative way, so creating a greater understanding of the complexities of the issue and potentially coming up with solutions. To make the process more concrete, they can connect to aspects of each other's findings using strips of coloured paper.

An example of students using the sustainability compass. Photo credit: Lynda Rolph

The Royal Geographical Society have produced a range of curriculum-linked KS3 resources, which were developed as part of the Rediscovering London's Geography project, funded by the GLA (Greater London Authority) through the London Schools Excellence Fund, but are not specific to London. There are also some excellent subject-knowledge animations for teachers, including an overview of El Niño and its impacts on development and an overview of the sustainable development goals. These can all be found on their website: rgs.org ('Our Work' — Schools and Education — Teaching Resources).

People and environment (KS4)

- **Global ecosystems and biodiversity:** Students are required to look at two different ecosystems, which could include a threatened ecosystem such as lowland heathland in the UK (which could be studied through fieldwork) or tropical rainforests (which could be investigated by visiting a botanical garden). The GCSE curriculum states that students should *"draw out the interdependence of climate, soil, water, plants, animals and humans; the processes and interactions that operate within them at different scales; and issues related to biodiversity and to their sustainable use and management".* Students can find out about the designations that are given to protected sites — such as Special Protection Areas (SPAs) for birds, Special Areas of Conservation (SACs), Ramsar wetlands, Sites of Special Scientific Interest (SSSIs) and Marine Nature Reserves (MNRs) — and look at how these are managed and monitored.
- **Resources and their management:** The GCSE curriculum requires students to be given an overview of *"how humans use, modify and change ecosystems and environments in order to obtain food, energy and water resources"*, so they can look at the environmental impacts of current and historical usage of resources.

Case Studies: Environmental Education through Geography

Aylesbury High School, Buckinghamshire

The Geography Quality Mark, operated and awarded by the Geographical Association, encourages and enables school focused, long-term, portfolio-based Continuing Professional Development (CPD). At the beginning of the Quality Mark process, the school geography department audits its strengths and areas for development, and then develops an action plan. The following two school terms are spent completing the Quality Mark framework, which is closely linked to Ofsted subject criteria, and providing a portfolio of evidence.

As Head of Geography at Aylesbury High School, I found this incredibly powerful, as my geography department improvement plan was informed by the Quality Mark, and vice versa. It also enabled the whole department to be involved in and take ownership of improvement, which allowed us to move forward more effectively in developing teaching and learning.

The awarding of Quality Mark raises the profile of the geography department within the school and the local area. There were discussions with the Senior Leadership Team before, during and after submission, and celebration with staff and students following the award. The geography department used the Centre of Excellence logo on all of its teaching materials, which gave a strong identity and demonstrated pride in the quality geographical experience which had been created.

A specific aspect developed over the course of the three awards was renewed focus on fieldwork at key stage 3. In 2008, when Aylesbury High School first achieved the award, there was fieldwork built into all year groups, moving from a local to a national focus. Year 7 visited Aylesbury town centre to investigate shopping patterns; Year 8 visited Coombe Hill, which is managed by the National Trust; and Year 9 visited the London Docklands, to discover how the area had changed over time. By 2011, the focus of these field trips had become more cross-curricular whilst keeping geography at the heart. For example, at Coombe Hill, workshops were introduced on environmental poetry and species sampling which were run by the school's English and biology departments respectively. The school's most recent submission, in 2014, developed fieldwork so as to give the students more independence. Year 7 were designing their own fieldwork, around the school site; Year 8 students were still engaged in cross-curricular workshops but they were more innovative and included missions from *Mission:Explore* [produced by the Geography Collective, since renamed 'Explorer HQ']. It was the Year 9 field trip to London Docklands which had developed most, as the girls were given completely free rein to plan their own field trip; a risky scenario but one which was incredibly successful.

The Secondary Geography Quality Mark has certainly had a massive impact on me as a teacher and head of department — on teaching and learning in the school and beyond — then as moderator and co-ordinator at the Geographical Association.

(geography.org.uk/cpdevents/qualitymarks)

Rebecca Kitchen Secondary Curriculum Leader, The Geographical Association

The contribution of fieldwork to geography education

In geography, fieldwork is regarded by the Government, most parents and the overwhelming majority of subject teachers as an essential element of the learning experience for young people. Indeed, the commitment to fieldwork by teachers of geography can often feel evangelical – something we equate with our subject identity or a large part of the reason we became geography teachers in the first place. We associate fieldwork with a sense of freedom, of breaking out from the constraints of the regular classroom environment and offering the opportunity to recover something of the spirit of exploration that helped to create the discipline itself.

In 2016, the Geographical Association (GA) surveyed secondary teachers to find out how much and what kinds of fieldwork they did, and whether this was changing. As part of this survey, it asked teachers about obstacles to fieldwork, revealing a depressingly familiar list of factors, especially cost and lack of support from head teachers.

Given the challenges to undertaking fieldwork, it's important that the benefits are increasingly well articulated and researched. The positive impacts on social and personal skills, disposition to learning and on attitudes, values and character traits such as resilience are well documented elsewhere, so I won't address these here. However, in my view, there is a need to better articulate the role and impact of fieldwork on academic achievement and on the acquisition of knowledge and understanding in school subjects like geography.

Over the last year or two, I have been writing about fieldwork in geography as 'the application of knowledge and understanding to the particular circumstances of a real-world location' .I see this as a very important attempt to counterbalance the way many people and organisations characterise fieldwork as being 'only about skills' – a position I fundamentally disagree with.

Rather, I suggest that fieldwork involves and develops the act of observing and asking questions of, and in, the real world and that this provides a unique and essential learning experience for young people. It develops investigative skills, careful observation and primary (first-hand) data collection in distinctive and important ways. But this experience isn't simply a skill, or a technical procedure. Fieldwork investigation gives young people experience of the complexity of a real world location and invites them to both appreciate and begin to make sense of its complexity, or 'messiness'. Doing so helps them to appreciate that the 'theoretical' world of the textbook and their own investigative research is partial and limited. This seems to me to be a critical insight into the nature of geography, of geographical knowledge and the process of becoming a geographer: we do geography fieldwork because direct observation is an essential, rewarding but challenging part of creating valid knowledge about the world. I am drawing on a very long tradition of thinking here: in the 13th Century the English philosopher Roger Bacon asserted that both 'Experimentum' and 'Argumentum' were necessary ingredients to understanding phenomena fully; the 18th Century writer Goethe concluded that understanding also affects observation ('we only see what we know') and more recently, Alex Standish of the UCL Institute of Education has suggested that fieldwork helps pupils to understand that their agency is involved in gaining knowledge – that it doesn't just 'drop out of a textbook'.

In an era of fake news, perhaps we should be a little more upfront about the contribution of fieldwork to ways of acquiring and testing knowledge and to understanding our own, very human, limitations in doing so.

Alan Kinder Chief Executive of The Geographical Association (from a guest blog on naee.org.uk/blog)

Environmental Education through Science

Science is the logical place to start when looking at environmental education; after all, sciences are all about helping us to make sense of our world. The introduction to the science curriculum states that *"a high quality science education provides the foundations for understanding the world"* and that *"pupils should be encouraged to recognise the power of rational explanation and develop a sense of excitement and curiosity about natural phenomena".* Two of the aims are:

> *"To develop understanding of the nature, processes and methods of science through different types of science enquiries that help them to answer scientific questions about the world around them."*
>
> *"To ensure that all pupils are equipped with the scientific knowledge required to understand the uses and implications of science, today and for the future."*

The KS3 curriculum states that *"teachers should feel free to choose examples that serve a variety of purposes, from showing how scientific ideas have developed historically to reflecting modern developments in science"* and for KS4, this is extended to include *"informing students of the role of science in understanding the causes of and solutions to some of the challenges facing society".*

So, there are plenty of opportunities for education IN the environment (practical work in and out of the classroom/laboratory), ABOUT the environment (understanding processes that affect us and the planet) and FOR the environment (using scientific knowledge to think about how we might solve current and future environmental problems).

Working scientifically

- In KS3, students are encouraged to *"ask questions and develop a line of enquiry based on observations of the real world, alongside prior knowledge and experience"*. In other words, they should build on the hands-on science work carried out at primary school, through a wider range of sampling techniques (e.g. during fieldwork), and use this as a foundation for studying more abstract concepts.
- In KS4, students are expected to think more deeply about science by *"appreciating the power and limitations of science and considering ethical issues which may arise"* (e.g. experiments involving animals, conflicts between nature conservation and local employment).
- Students in both key stages learn more about how scientific theories can explain phenomena in the world around them, and how these theories have been – and continue to be – modified over time as new ideas, methods and evidence come along. They are also taught about the importance of peer review and how results are communicated to a range of audiences, for example explaining complex scientific ideas – such as those involved in climate change research – to non-scientists.

Biology

- **Cell biology (KS3 & KS4):** Students can collect materials from outside, such as parts of plants (bark, leaves, stems, petals) and animal hair. They can observe the cellular structure of each through a microscope and identify the features of different types of cells (e.g. only plant cells having a cell wall, chloroplasts and a vacuole; palisade cells having extra chloroplasts to help with photosynthesis; root hair cells having a specific shape and structure; different types of meristems in plant stems, roots and leaves). Students can also soak plant roots in coloured water, then look through a microscope to observe the root hair cells taking up the water by osmosis.
- **Transport systems (KS4):** Students can dissect plant stems to identify the xylem and phloem, make models to show how these transport systems work and investigate the effects of any damage to plants due to disease or environmental factors.
- **Biomechanics (KS3):** Students can make observations of animals during fieldwork and look at how the skeletal and muscular systems work and interact. Animal skulls or skeletons can be purchased for closer inspection, although consideration should be given to whether these are ethically sourced (e.g. animals that have died through natural causes or by-products of the meat industry). They can look at the ways in which the environment shapes an animal's capacity to move, for example a lizard on hot sand or a slug moving across leaves.

- **Nutrition and digestion — humans (KS3):** When studying the content of a healthy human diet and the consequences of imbalances in the diet, students can explore environmental issues linked to food production around the world, for example: deforestation to make way for livestock; production of methane by cattle; droughts leading to crop failures and starvation/famines; pesticides causing declines in populations of bees and other important pollinators; and organic farming leading to improvements in conditions for wildlife. Also potential solutions to food shortages – such as eating insects, or drinking plant-based milk alternatives – and the importance of ensuring that these solutions enable humans to maintain a healthy, balanced diet. Links can be made to the food miles of different foods that we eat and the environmental benefits of eating locally-grown produce.
- **Nutrition and digestion — plants (KS3):** Students can make observations of plants and how they carry out photosynthesis under different conditions, for example by measuring light levels in different areas and comparing the structure of the plants (leaf size/colour, height etc.) and looking for adaptations (e.g. some shade-loving plants have coloured leaves).

  Students can investigate how plant roots obtain nutrients and water from the soil (by observing roots and root hairs through a microscope) and how we can provide plants (such as garden plants or food crops) with additional nutrition in an environmentally positive (i.e. composting food waste) or negative way (e.g. fertilisers leaching into water courses and causing algal blooms/eutrophication; ancient peat bogs being dug up). It is important to clarify to students that fertilisers are not 'plant food' (as often described when sold in garden centres), as they do not store energy that is released in a plant; however, they are a source of material essential for plant growth, and this can be examined through comparative plantings out in your school grounds or local area, using fertilisers the students make themselves in the classroom/laboratory (e.g. magnesium sulphate, ammonium sulphate, Epsom salts, coffee grounds, crushed egg shells, wilted comfrey leaves or nettle leaves soaked in water). [N.B. 'home-made' fertilisers should be tested on a small area first and should never be applied on hot, sunny days as this can lead to scorching of the plant.]

Identifying & studying plants. Credit: K Bunting

- **Gas exchange systems — plants (KS3):** Students can use microscopes to examine first-hand the stomata on the undersides of leaves and make comparisons between different plant species and under different conditions (e.g. dark or light, wet or dry).
- **Reproduction — plants (KS3):** Students can investigate the effects of acid rain on seed germination by germinating mustard or cress seeds in Petri dishes standing upright in solutions of varying pH (plastic bottles can be cut to use as reservoirs for the solutions). Flowers from the school grounds can be collected and dissected to identify the constituent parts, but it is important not to take too many of these, as they are essential for bees and other insects. Students can observe insects pollinating different coloured flowers and record which colours bees visit the most. They can also observe the different shapes, colours and other features of flowers that are visited by different pollinators, such as butterflies, moths, wasps, bats or flies. They can use microscopes to look closely at pollen grains (noting the different shapes/sizes for different species), the growth of pollen tubes, and spores produced by non-flowering plants (e.g. ferns).
- **Plant reproduction — seed dispersal (KS3):** Students can collect different types of seeds from the school grounds or local area and investigate the different methods of dispersal used (recapping and extending work from KS2). Methods of seed dispersal can be linked to forces (see the Physics section of this document). They can compare wing length and flight times of winged fruits, which have been found to generate lift to enable them to travel further from the parent plant, and this can be linked to data handling in maths. They could also design and make their own seeds and explore how they would be dispersed. Understanding seed dispersal in wild plants is important when looking at how damaged ecosystems can be restored. Students can also look at the controversy of invasive/alien plants dispersed by humans travelling around the world.

- **Photosynthesis (KS3 & KS4):** Students can observe photosynthesis in action and identify how leaves (in the school grounds, as well as distant biomes such as the tropical rainforest) have adapted to maximise the take-up of light for photosynthesis (e.g. large leaves, holes, darker colours). They can use light meters to measure levels and use this information to find suitable plants to grow in those areas of the school grounds.

  Having an understanding of photosynthesis can greatly help students to understand about the environmental impacts of deforestation – reduced oxygen production (tropical rainforests in particular are responsible for producing between 20 and 30 per cent of the Earth's oxygen), fewer plants to absorb the excess carbon dioxide produced by burning fossil fuels (cited as being one of the main causes of global warming). They can understand why parks and green spaces in urban areas are sometimes referred to as 'the lungs of a city' or rainforests as 'the lungs of the planet' even though, unlike our lungs, they are responsible for releasing oxygen into the atmosphere.

- **Respiration — plants (KS3):** Students can observe respiration (using plants or germinating seeds collected from outside in classroom/laboratory experiments) as the opposite process of photosynthesis, and address the misconception that it only occurs at night.

  Respiration can also be linked to composting, where aerobic and anaerobic decomposition take place. Students can examine an existing compost heap/pile (wearing gloves, in case of any sharp material) by looking for organisms (invertebrates, which can be easily seen, and using a microscope to look at microorganisms – bacteria, protozoa and fungi) working to decompose the plant waste and taking the temperature to show that heat is being produced by the working organisms. They could set up controlled experiments over time, for example creating two compost heaps – one that is turned frequently and kept well aerated and one that is left alone in a sealed container (this one should smell, as anaerobic respiration is taking place, which produces methane and hydrogen sulphide gases – the latter creating the 'rotten egg' smell).

- **Ecosystems (KS3 & KS4):** Students can recap work on habitats from KS2 and explore habitats and microhabitats in the school grounds, or during off-site fieldwork, to investigate ways in which the plants and animals depend on each other (food chains/webs, pollination, seed dispersal, provision of shelter etc.). Work on food chains/webs will link back to photosynthesis, with plants being the producers at the bottom of the food chain.

  Students can also observe first-hand (or via educational visits or secondary sources to look at more distant environments) the ways in which plants and animals have adapted to live in a particular habitat. They could also design their own animals and habitats.

  Students can experiment with 'companion planting' where mutually beneficial crops are planted together. A common combination is the 'three sisters': beans (which put nitrogen into the soil), sweetcorn (which provides structure for the bean plants to grow up) and squash (which shades the roots of the other two plants to deter weeds). Gardening or permaculture websites give details of the plants that benefit each other (as well as those that should not be grown together) and how this careful planting can reduce the amounts of chemicals required (pesticides, fertilisers etc.) by replicating natural systems.

Investigating tropical plant adaptations.
Photo credit: Heatha Gregory

  A visit to a local woodland (ideally at different times of year) could provide examples of interdependence and symbiosis within an ecosystem, for example flowers such as bluebells growing in early spring before leaves appear on the trees to block out the sunlight; lichens being made up of a fungus (which forms to the structure) and an alga (which provides energy through photosynthesis); fungi helping trees to extract water and nutrients from the soil and in return being provided with sugars via the tree's photosynthesis.

  Students should consider our interconnectedness with invertebrates (e.g. bees, worms) and the crucial role they play in maintaining all life on earth.

The KS3 curriculum states that students should be taught about *"the importance of plant reproduction through insect pollination in human food security"*. This provides opportunities for studying issues such as declining bee populations, organic gardening and encouraging natural predators rather than using insecticides. Students can explore the pros and cons of gardening organically, for example the amount of resources and space required versus pesticide and insecticide use.

At KS3, students are also required to learn about *"how organisms affect, and are affected by, their environment, including the accumulation of toxic materials"* and at KS4 about *"positive and negative human interactions with ecosystems".* Students can research and observe different types of pollution (oil spills in the sea, soil contamination, eutrophication of ponds and streams due to fertiliser drainage etc.) and the ways that organisms can be affected (e.g. build-up of contamination through a food chain resulting in the deaths of top predators). Conversely, they can also look at how human intervention has improved ecosystems, for example through habitat creation.

Invertebrate sampling can help to assess water quality. Photo credit: Steve Miles

Linking back to respiration at KS3, the KS4 curriculum refers to *"the role of microorganisms (decomposers) in the cycling of materials through an ecosystem"*. An extension of this is investigating how 'hydrocarbon chewing' microbes are used to clean up marine oil spills.

- **Health, disease and the development of medicines (KS4):** Students can observe and research diseases that affect plants such as 'ash dieback', which is caused by a fungus and with the potential to wipe out one of Britain's most abundant tree species. [Interestingly, environmental problems such as air pollution (providing more nitrogen) and climate change (warmer, frost-free springs) were actually thought to have benefitted ash trees.] Students can be 'Plant Disease Detectives' using an activity from Science and Plants for Schools (SAPS): ow.ly/N3bW30fqrzd.
- **Coordination and control — hormones (KS4):** The curriculum mentions *"hormones in human reproduction, hormonal and non-hormonal methods of contraception"* and this can be linked to some interesting research about the feminisation of male fish being caused by these hormones entering fresh water via the sewerage system — an example of changes caused by human actions.
- **Genetics and evolution (KS3 & KS4):** Students can recap work from KS2 by studying plants and animals in the school grounds (and further afield), looking at differences between species and variation between individuals of the same species (both continuous, e.g. body length; and discontinuous, e.g. seed shape). They can use keys to identify and classify organisms, and link to maths by taking measurements and creating graphs. They can also observe adaptations, particularly of plants, in the local environment, for example nettles have stinging hairs to deter herbivores.

  Students can research how changes in the environment have caused changes in species (e.g. peppered moths becoming darker during the Industrial Revolution for better camouflage from predators, bacteria becoming resistant to antibiotics) and in some cases led to extinction (e.g. golden toads are believed to have become extinct as a result of climate change).

  Students can research seed banks and find out about why we should conserve genetic resources, for example in the context of climate change. They could create their own seed banks using plants that currently grow in their school grounds or food crops that are linked to the heritage of ethnic groups living in the local area.

  Students can investigate selective breeding of plants and animals, and cloning — a good opportunity for debate about the pros (maximising yields) and cons (is it 'morally' right to 'mess' with nature?) of these.

This can be taken further in KS4, where students study *"the uses of modern biotechnology including gene technology; some of the practical and ethical considerations of modern biotechnology"* and investigate genetically modified (GM) crops. There are strong arguments on both sides of this debate that the students can explore — impacts on ecosystems and food chains; higher-yielding, disease-resistant crops that can alleviate hunger and malnutrition; out-competition of natural species; loss of traditional or heritage varieties; the potential to grow crops that can produce vaccines or detect chemicals in the air; the implications for pollinators; reduction in biodiversity. Also, this is an area of science that is developing rapidly, with scientists now being able to produce 'genetically edited' plants, where they alter the DNA of the genome rather than introducing DNA from a different organism.

Chemistry

- **The particulate nature of matter (KS3):** Students can link the requirements of plants for growth to states of matter — water (liquid), carbon dioxide (gas) and nutrients (solids, often soluble in water).
- **Pure and impure substances (KS3) / Chemical analysis (KS4):** Students can study some of the environmental applications of separation techniques, for example purification of drinking water, distillation of seawater, remediation of oil slicks.
- **Chemical reactions (KS3) / Chemical changes (KS4):** Students can learn about chemical reactions that take place in the cells of plants (within the cytoplasm), for example photosynthesis and respiration (linking back to biology). A classroom/laboratory experiment using plants (pondweed) and animals (small pond snails) collected from a local pond can be carried out to measure the rates of photosynthesis and respiration. Another chemical reaction related to plants is the breaking down of urea in wet soil that produces ammonia which is converted to nitrates for plants (illustrating why urea is used in fertilisers).

  Students can measure the pH of the soil in different parts of the school grounds and relate this to the plants and animals which live there. This can be linked to other ways of investigating soil, such as soil type, particle size and drainage. They could also measure the pH of rain water and research the causes and effects of acid rain.

Investigating soil samples

- **The periodic table (KS3 & KS4):** Students can research the use of compounds of 'essential' elements on plant growth. For example: nitrogen compounds are used to make amino acids which form proteins; phosphorous compounds help the development of roots, flowers, fruit and seeds; potassium compounds help to develop strong stems, increase water movement within plants and promote flower and fruit formation; magnesium ions are part of chlorophyll.

  They can then carry out experiments to show the use of these elements in reality, for example a plant that does not have enough nitrogen (within nitrate compounds) will have yellow leaves and poor growth. [The Science and Plants in Schools website has experiments for making and testing home-made fertilisers to show the effects on plant growth: ow.ly/N7Vw30fqrTb.]
- **Materials (KS3):** Students can investigate materials (both natural and human-made) that are used in the built environment, such as wood, types of rock, ceramics, polymers and composites, and their properties that make them suitable for these uses. They could also research new materials that are being developed, particularly those that replace oil-based plastics. For example, a 14-year -old Turkish girl called Elif Bilgin recently created a new type of plastic using banana peel (see elif-bilgin.com).

- **Chemical and allied industries (KS4):** This section of the KS4 curriculum includes many opportunities for exploring environmental issues – environmental impacts of making products *("life cycle assessment and recycling to assess environmental impacts associated with all stages of a product's life"),* recycling *("the viability of recycling certain materials")* and sustainability of resources *("carbon compounds, both as fuels and feedstock, and the competing demands for limited resources").*
- **Earth and atmospheric science (KS3 & KS4):** Students can identify different types of rock (igneous, sedimentary and metamorphic) in the local built and natural environment and look for signs of weathering and erosion (natural and due to human actions).

  Climate change and pollution are covered in the curricula at both key stages. At KS3, students should be taught about *"the production of carbon dioxide by human activity and the impact on climate"*. This is extended at KS4 to state that students should be taught about *"evidence, and uncertainties in evidence, for additional anthropogenic causes of climate change; potential effects of, and mitigation of, increased levels of carbon dioxide and methane on the Earth's climate; common atmospheric pollutants: sulphur dioxide, oxides of nitrogen, particulates and their sources".* However, teaching about environmental issues such as climate change requires careful planning to ensure that students feel empowered to want to take positive action towards these issues, rather than feeling depressed or alarmed. Explore with students the various actions that can be taken by individuals, schools, communities, organisations, countries and groups of nations. Encourage them to ask their own questions and research real data to begin to answer them. Students need to understand the science, not just behind the problems, but also the solutions.

  The KS4 curriculum also refers to *"the Earth's water resources and obtaining potable water",* which can again be taught in a way that is meaningful and inspires positive action, based on scientific knowledge.

  Students can calculate their own 'ecological footprint' (several examples of 'calculators' can be found online), in terms of their use of water, food, energy etc.; the amount of waste they produce and how they dispose of it. They can then explore creative solutions to reduce the size of their footprint (in hectares). They can also compare their footprints to those of similarly-aged students in other countries around the world. [A slightly different approach—the 'ecological handprint' is explained in the Geography section of this document.]

Students from Ringwood School, Hampshire, using role play to help explain to local primary school children about the carbon footprints of people with different lifestyles ("from the earth mother to the carbon guzzling rock star") . Photo credit: Gill Hickman

[Taken from an article in NAEE's 'Environmental Education' journal 106]

Physics

- **Matter (KS3):** Students can identify chemical and physical changes in plants, for example photosynthesis and respiration are chemical changes, while transpiration is a physical change. They can look at the conservation of matter in terms of carbon being released into the atmosphere from the burning of fossil fuels.
- **Energy (KS3 & KS4):** Students should learn about the environmental impacts of using non-renewable energy resources (fossil fuels), i.e. they took millions of years to be formed and cannot be replaced; harmful waste gases such as carbon dioxide, sulphur dioxide and nitrogen oxides are released into the atmosphere when they are burned. These waste gases cause acid rain and global warming, thereby enhancing the greenhouse effect. Understanding the science behind the extraction and use of these fuels will help students to understand why they should use them sparingly and why alternatives are being sought. This can also be linked to the idea of calculating and aiming to reduce their ecological footprint – often referred to as a 'carbon footprint' (or handprint — see the Geography section of this document).

  Students should learn about renewable energy resources (solar, wind, hydroelectric, geothermal, biofuels etc.) and debate the pros and cons of these, compared to each other and compared to using fossil fuels or nuclear power. It should be remembered that, although they do not create pollution, there can be other impacts on wildlife or ecosystems, such as birds and bats flying into wind turbines, habitat loss to build large-scale solar facilities, and flooding of bird feeding/nesting areas when using tidal power.

  Students could make their own solar (or wind) powered racing cars and pit them against each other. [For more details, see the first STEM case study in the D&T section of this document.]

  Students can research new developments in energy production, for example scientists are using their understanding of plant photosynthesis to develop cheap, emission-free energy using plant residue (straw and forest waste).

  They could also debate the pros and cons of energy-from-waste power stations, i.e. a way of disposing of waste that produces heat which can be harnessed for electricity production, but harmful gases are also produced.
- **Forces (KS3 & KS4):** Students can investigate the forces involved in different types of seed dispersal (linking back to biology) and describe them using diagrams with force arrows. For example: investigate whether the mass, shape or size makes a difference to the speed that seeds fall to the ground (using knowledge of gravity, air resistance and the particle model to explain their findings); create paper models to investigate whether the distance between the 'parachute' and the seed make a difference; compare different types of 'spinning' fruits.

  Relate water pressure to the effects on plants, i.e. water in the cells provides tension to help a plant to stand up and grow towards the sunlight. The students can use a microscope to look at healthy and wilted plants, by observing turgid and flaccid cells. This will help them to understand why plants need water in order to survive. There are links to osmosis (as an example of diffusion, referred to in biology, chemistry and physics), transpiration and cell structure.
- **Atomic structure (KS4):** Students can apply their learning about *"radioactive materials, half-life, irradiation, contamination and their associated hazardous effects, waste disposal"* to research the environmental issues related to nuclear power. They can also find out about the pros and cons of nuclear fission and nuclear fusion as alternatives to fossil fuels or renewable energy resources.
- **Space physics (KS3 & KS4):** Use the outdoor school environment to make large scale models of the solar system (using different sized balls and calculating the relative distances). Students could also look into the environmental impacts of space exploration/travel, such as rocket engine emissions (they emit reactive gases that cause stratospheric ozone molecules to break apart) and 'space rubbish' (debris like batteries, components and human waste — search nasa.gov for more information about orbital debris).

Case Studies: Environmental Education through Science

Key Stage 3

I have been teaching for many years, and have seen a large number of curriculum changes. Through the early days of the national curriculum, what could be termed 'environmental' education was taught in the same way as was the majority of the rest of the curriculum – as a discreet block. In many schools (or certainly those I taught in) this rendered anything to do with the environment as a series of tick boxes – often left late into the curriculum and rushed through.

I have often thought that this 'boxed' approach to environmental issues was largely missing the point – that everything is connected, and that the environment is a fundamental part of our existence – in the same way that, say, forces are. To place "eco stuff", as one former colleague called it, as an add-on devalues the subject, and surely defeats the object of science education: to encourage students to think in the widest sense of the word and to make informed choices.

Studying the local environment — as well as the global — can help students to live more sustainably in their own locality

I once worked in a school that had developed a 'thematic skills' curriculum in order to prepare its students to be effective citizens. Whilst this had may aspects that were valuable, noticeably absent was how to be an environmentally aware citizen. Learning about the rainforest is important, as I'm sure no-one would disagree, however it is just as important to understand how we can live in our own locality as sustainably as possible – and of course this means that it has to be individual and specific.

What is the solution? Recent revisions to the science curriculum have certainly increased the scope for creating learning journeys which include an environmental aspect – think about how much more impact there would be teaching the greenhouse effect at the same time as planetary science. I always feel that the key thing is to make students think and suggest, not just describe and explain; if a student goes home and makes a 'greener' choice or talks to their parents about the global impact of buying the latest smartphone, then we begin to take small steps towards a more sustainable future.

Ian Hall Science Teacher, Gloucestershire

Key Stage 4

Global warming is taught across all three sciences as part of the current GCSE curriculum. In biology it is taught in terms of the effect of an increasing human population and the effect on wildlife. In chemistry it is taught in the context of combustion and an evolving atmosphere. In physics, the absorption of infrared radiation by greenhouse gases is studied. The evidence for global warming, and the link between human-made CO_2 emissions and global temperatures is also considered.

In a scheme of work, all four components are studied in the same academic year and common SMSC (Spiritual, Moral, Social and Cultural) opportunities run through each. Students are encouraged to assess their own contribution to global warming by considering their carbon footprint compared with a similar student in an economically-developing country.

Students often report fatigue when studying global warming, as the same ideas come up time and time again in various curricula. They also report feeling guilty for the impact of their behaviours on the environment, and as a result are sometimes reluctant to engage with the topic. Positive strategies to avoid this can be employed, for example asking students to suggest creative solutions to global warming using their scientific knowledge or key pieces of information provided by their teacher. They can also be presented with interesting / thought-provoking solutions that have already been trialled (e.g. carbon sinks), and asked to suggest how they might work given their knowledge of the topic.

Amy Caswell Science Teacher, Birmingham

Environmental Education through Design and Technology

Design and technology looks at using *"creativity and imagination"* to *"design and make products that solve real and relevant problems…considering their own and others' needs, wants and values".* There are lots of ways that this could be applied to environmental issues, for example rainwater harvest and storage for watering plants; meeting the 'needs and wants' of animals by designing and making bird feeders, boxes and tables; or creating new habitats in the school grounds.

The GCSE curriculum states that students should look at the *"ecological and social footprint"* of materials and *"the impact of new and emerging technologies on… sustainability, people, culture, society and the environment".*

Students need to interact with the designed and made world to gain a better appreciation of the purpose for their design ideas and consider the potential users. A visit to a farm, supermarket, building site or play-park can provide a rich context. Structures such as bridges, bus shelters and buildings can also be useful stimuli. Particularly popular are the 'crossing a stream' or 'building a shelter' team challenges. These give hands-on experience of dealing with materials and different environments.

Another relevant aspect of the KS3 design and technology curriculum is the aim that students should *"understand and apply the principles of nutrition and learn how to cook".* Students can grow their own food crops and use them in healthy recipes, which in turn links to plant life cycles and plant parts/ functions in science.

Design, make, evaluate & technical knowledge

- **Applying traditional technologies:** Students should be taught to *"use research and exploration, such as the study of different cultures, to identify and understand user needs"*, so this could include studying the 'technology' used by indigenous people (e.g. rainforest tribes) which works in harmony with the environment. They could also look at traditional building techniques, such as cob (straw bales), wattle and daub, and sedum (grass) roofs.
- **Biomimicry:** Students could take inspiration from nature to try to find solutions to human problems ('biomimicry' or 'biomimetics'). They could research existing applications, such as 'cats' eyes' in the road and Velcro (based on how plant burrs stick to animal fur). Many more recent examples can be found online, including: synthetic shark skin to prevent barnacles from attaching to ships; a new type of e-reader screen based on the way butterfly wings gleam in bright light; a new adhesive inspired by geckos' feet that enable them to walk along walls and ceilings; a flexible tape that can be peeled off wounds without damaging the tissue underneath, based on spider silk; and a surgical needle inspired by the ovipositor of the female wood wasp, which she uses to bore into wood to lay her eggs. As inspiration, they could find out about Elif Bilgin, who created a new type of bio-plastic using banana peel at the age of 14 (see elif-bilgin.com).
- **Environmental technology:** Students can look at technologies that address environmental issues, such as dealing with pollution. For example: the Seabin, which collects floating marine litter and debris (seabinproject.com); a farm of 'smog-eating algae' that captures carbon dioxide from the air just after it is emitted by cars (greenforwardnews.com/algae-farm-eats-pollution); and desalination plants to provide drinking water from seawater.
- **Sustainable building design:** Students can research sustainable building designs from around the world, for example solar panels and water tanks on roofs, large windows on south-facing walls, sedum roofs, straw bale buildings. They could design their own 'eco-buildings' and make scale models. They could also 'pitch' to the school management and governors for energy saving measures in the school buildings.
- **Recycling and upcycling:** Provide opportunities for students to 'repurpose' waste materials, for example using plastic bottles to build a greenhouse, making recycled paper using natural dyes. They can also make recycling boxes and signs for classrooms and communal areas.

- **Careers in the built and natural environment:** Students could research jobs such as landscape architecture and sustainable building design.
- **Ethical and sustainable fashion:** Students can design and make jewellery and clothing from waste materials. They can also research where their clothes come from and devise ethical and environmental criteria to investigate and compare clothing companies (e.g. what are working conditions and pay like for the people who make the clothes?). They could even try growing their own fabric (see the second STEM case study on page 26).
- **Make a weather station:** Various pieces of equipment for measuring weather can be designed and made, using readily-available and pre-used objects. For example, students could make a rain gauge using a plastic bottle (cut off the top part and then insert it upside down as a funnel); a weather vane from items including a piece of card and a drinking straw; or a barometer out of a glass jar, a balloon and a needle or pin. (Ideas can all be found by searching online.) There will be links to maths when measuring and creating scales.
- **Evaluating the environmental impacts of technology:** The curriculum states that students should be taught to *"understand developments in design and technology, its impact on individuals, society and the environment, and the responsibilities of designers, engineers and technologists".* They can explore the environmental issues associated with development of new products, for example: the materials and energy used to make the product; the expected life-span of the product; and how it is likely to be disposed of when no longer useful. Questions that they could investigate might include: is it made using renewable or finite resources? How much energy or water is used during its production? Could it be produced in a more sustainable way, e.g. using less material, utilizing a more energy-efficient process? Does its manufacture create pollutants (affecting the air, water, soil etc.) or toxic substances? What will happen to the product at the end of its life, e.g. can it be re-used or recycled? Can it be repaired in order to extend its life? How much packaging is used and could this be reduced? Is the packaging biodegradable? How far does it travel between the raw materials and the consumer?
- **The Circular Economy model:** A circular economy (ow.ly/bPpP30gks4c) is one that sets out to minimise waste and to use whatever waste is created to produce new products. This is in sharp contrast to most of our current economy which can be characterised as a linear process: take → make → dispose. In all this, waste is the dominant feature. Raw materials are extracted from the earth, refined, and then fabricated into products for sale. When the consumer tires of the product, or wears it out, it then goes – sometimes after a bit of recycling – into landfill. At each of these stages, waste is generated, and usually also discarded, often polluting land and water. Recycling only really delays the inevitable. At each of the stages, energy is also used in the conversion process; sometimes significant amounts of it. This linear industrial process contrasts poorly with how biological systems operate. They are always circular with materials and energy flowing in loops. Waste is always consumed by another organism and the process can be characterised in this way: waste = food. At the heart of the idea of a circular economy is the design of systems and products so that waste is minimised and valuable materials can be recovered and reused. It's no surprise, therefore, that it's the design and technology curriculum in schools that has taken circular economy ideas most seriously. In this, it's possible to study the steps that engineering companies are taking to move us towards a more circular economy.

Cooking and nutrition

- The design and technology curriculum states that students should be taught to *"understand the source, seasonality and characteristics of a broad range of ingredients"*, so this links well with growing food crops in schools.
- Students can experiment to find innovative ways to cook food outdoors, and this could be linked with learning to forage for natural foods, provided you have an expert on hand to help them recognise edible — and poisonous — plants. [More details can be found in the Physical Education section of this document, which looks at outdoor and adventurous activities.]

Case Studies: Environmental Education through STEM (incorporating Science & DT)

Swinton School, Rotherham

"Make the fastest solar car you can!" This was the simple challenge posed to key stage 3 students at Swinton School, Rotherham, on a renewable energy project day.

Electricity is 'invisible' and can't be seen, or (hopefully) touched, meaning it is an abstract concept and one that is difficult to make relevant to students. However, electricity and themes related to its generation are major topics within the national curriculum at secondary school.

Sheffield Science Educator, David Garlovsky, has developed an approach to teaching these environmental themes in a fun way. He visits schools, introducing students to his self-designed solar-powered model racing cars, but instead of delivering these ready-made, they come in kit form, for students to assemble.*

Such cars allow teachers to tap into children's competitive spirits, and David starts every lesson by getting students into teams, with the challenge to design the best racing car possible and to race it against the other teams.

The 'Solar Active!' model car with a three-speed gearbox, powered by a single solar cell

STEM, the integration of science, technology, engineering and maths, in one single project, covers key parts of the national curriculum, with the design and technology syllabus requiring students to use a *"range of materials [and] components"* to solve their own design problems, and *"understand and use the properties of materials and the performance of structural elements"*. The solar racer integrates many of the topics of STEM while introducing an environmental theme.

A unique feature of the solar racing car is the number of features that can be manipulated to influence the functioning of the car. Wheel size, solar panel elevation, car design and wiring can all be altered, and no two cars are ever alike.

Special emphasis is put on the recycled nature of the parts used in the car. As much as possible, components of the kit are made from pre-used material. For example, the plastic wheel arches are made of reclaimed credit cards, and the boxes the cars are delivered in are made of recycled materials. In this way, students use material from existing products to make new things for new purposes. They mimic what happens in the actual car industry where new cars contain increasing amounts of recycled and refurbished materials. All this has the additional advantage that students learn to be creative. For example, although students at Swinton School were offered a number of different types of wheel, some came up with the idea of using old CDs instead. These proved beneficial because they caused no rolling resistance and were light, although they had trouble on uneven ground.

The whole process involves students thinking for themselves with teachers prompting them as much or as little as required. For example, when deciding on the type of wheel to use, prompts can be used to ask them to speculate as to the speed of the car when the wheels are large or small, and ask: how could you test them? If you changed the wheel size, what else must you do? How could you make it a fair test? And this is only one aspect open to experimentation.

** Of course, if you purchase the photovoltaic solar panels and motors, students could design and make their cars from scratch.*

An excellent example of how inquiry can be integrated into teaching with the solar racer is deciding on the best positioning for the angle of the solar panels. We prompt students with the question: does the height and angle at which the panels are placed influence the speed of the racer? And then ask: how could you investigate this?

When we asked: *"if you raise the panels what might happen?"*, one student, Liam, thought the car might *"collect more sun and go faster".* We then dismantled the panel and raised it so it was distinctly tilted, and Liam could see how this affected the performance of the car. Another student decided to put aluminium foil behind the racer to direct light onto the panel.

Such questions can be used to initiate a series of investigations, with students having to decide how to conduct the study. They have to realise that it is not enough simply to raise and lower the panel, but all other aspects of the racer must be kept the same when the panel is placed at different heights. Students can experiment by trying out different combinations, before deciding which angle of alignment is the most productive. After studying this problem, students can then relate their observations to how the strength of the sun varies at different times of the year because of the Earth's rotation and tilted axis.

Students race all the cars along a ramp, releasing them at the same time to make the conditions the same for each car (a fair test)

One student tests whether reflecting light onto the solar racer makes it go faster

Teachers' experiences have been very positive. Terry Dawson, a maths teacher comments: *"The energy of children when they pick up these kits and get started is fantastic. Initially we expect students to follow the instructions provided to them; they work in groups, and once this initial stage is over we give them additional material."* Steve Barnet, a teacher of design and technology, agrees: *"This is just throwing them in at the deep end really."*

What really impresses the teachers is the cross-curricular nature of the kits. *"We give the students the basic kits and the instructions and then leave it to them to build the prototypes,"* says Terry. *"We can integrate whatever we want into the lessons; maths, science, even English."* Chris Williams, a science teacher, adds: *"The students don't realise they are using engineering and maths skills, but when this is pointed out to them they realise the wide ranging implications of what they are doing."*

Even the teachers don't know where the work will go. Steve Barnet says: *"We give the students ownership, and put the onus on them to find things out. What we find is that when we ask the students to adapt the buggy, they come up with some weird and wonderful designs. They will re-design this, or adapt that. They then might think they have to reduce the weight, so they begin to take things off. Later they might think about friction and how to reduce that."*

Adapted from an article in *Environmental Education 112* (NAEE's journal) by **Mark Walker** Sheffield Hallam University and **David Garlovsky** Solar Active!

Queen Elizabeth II High School, Isle of Man

A group of students from Queen Elizabeth II High School, Isle of Man, spent a year growing fabrics from green tea, sugar and bacteria. The tragic deaths in a recent factory fire in Bangladesh had brought to the students' attention the problems of fast fashion. As fashion-conscious teenagers, they were aware that many of their peers had to have the latest styles and, since clothing was cheap, many saw it as disposable. A BBC News item on fashion designer Suzanne Lee, who grows her own clothes, was played at an eco-committee meeting. A group of girls were inspired and thought they would try it themselves and use it as a way to highlight their concerns about the throw-away fashion industry to their fellow students.

Using plastic under-bed storage boxes as containers, the girls experimented with different amounts of tea, sugar and vinegar. The material is created from Kombucha, which is a mixture of bacteria, yeast and other micro-organisms. The bacteria feed off the tea and sugar and start to spin cellulose. Eventually, after some weeks, a cellulose mat is formed. This can be dried to form a vegetable leather and then sewn conventionally or can be moulded whilst wet around objects, so no sewing is required. The girls made hats, waistcoats, a skirt, an apron and a bag. They conducted experiments on the material including use of dyes, flame tests, stretch tests and allergy tests. The tests were very positive. The girls discovered that they could re-use their tea solution. Only a small amount of tea and sugar needed to be added for another sheet to be grown in the same brew. This meant large quantities of water or raw materials were not wasted in the process of producing the material. The garments could also be composted after use.

The 'Grow your Own Clothes' project was broadcast on BBC North West Tonight and BBC Songs of Praise. The students' aim was for the clothes to have an impact and attract attention to their environmental concerns around 'fast fashion'.

The project gave the students the chance to be involved in independent real-life science by conducting their own experiments and research in a field that is relatively new. They had to develop problem solving, teamwork and presentation skills. They had to be resilient, learning that real-life experiments take a long time and the need to persevere when they come up against obstacles.

Peeling back the cellulose mat

Some of the students modelling their creations

The students won two awards: Ecover Young Green Champions at the Observer Ethical Awards, and the Biology Prize in the National Science and Engineering Competition.

Adapted from an article in *Environmental Education 106* (NAEE's journal) by **Lesley Sleight**, Head of Life Skills at Queen Elizabeth II High School

Environmental Education through English

Spoken language

- Students can research an environmental issue and then put together a formal presentation; speaking confidently and effectively, using evidence to back up what they are saying, explaining ideas and information clearly, and keeping to the point. They can also evaluate each other's presentations and ask questions to clarify their understanding.
- Different viewpoints about environmental issues can be explored through debate, with students being allocated particular sides of the argument (e.g. as environmentalists, developers, local residents, workers, politicians) or choosing a side based on their own personal point of view. Sufficient time should be given for research and planning, to ensure that the arguments are well-thought-out, backed up by evidence and persuasive. Students should be aware of the etiquette and conventions of debate, such as summarising what has been said by others and building on this or countering it, and challenging the opposing person/team courteously.
- Drama can be a useful way of exploring environmental issues. For example, a character might make a particular lifestyle choice and the implications of this choice (for people, animals, the planet etc.) are shown in the future, or in a distant place.
- Effective collaborative group work is required for all of the above and also when carrying out activities outside in the local (or wider) environment (e.g. during fieldwork or team-building activities). This includes students taking on different roles – and challenging themselves to try roles that don't come naturally to them; working together to achieve successful outcomes and meet deadlines; involving and listening to all members of the group; and utilizing everyone's strengths.
- There are many environmental issues that can be the basis for discussion, debate, presentations and drama. Here are just a few: renewable energy versus fossil fuels; pros and cons of nuclear power; ethics of animal testing (e.g. for medical research, cosmetics, cleaning products etc.); use of animals in sports (e.g. horse or greyhound racing) and entertainment (e.g. circuses); factory farming (animal welfare vs cheap meat/eggs/dairy); vegetarianism/veganism; is climate change real?; over-fishing; whaling; fossil fuel extraction in nature reserves (e.g. fracking in national parks) or environmentally-sensitive areas (e.g. oil-drilling in Antarctica); house-building on Green Belt land versus brown-field sites; re-introduction of top predators such as wolves or lynx; badger culling; fox hunting.

Reading

- As part of their research into environmental issues for the speaking and listening ideas outlined above, students can read/watch and evaluate different texts, websites and other media (e.g. television/radio programmes) to see whether the information being given, or the claims being made, are supported by evidence; also looking for any bias, misuse of evidence or omission of opposing evidence.
- Students could read influential texts about environmental issues, e.g. Rachel Carson's *Silent Spring* or *An Inconvenient Truth* by Al Gore; or even novels that portray a dystopian future, such as *The Hunger Games* by Suzanne Collins or *The Maze Runner* by James Dashner.

Writing

- Non-fiction texts that students could research, plan and write about environmental issues might include: information leaflets (e.g. all about recycling); persuasive arguments; formal letters (e.g. to persuade a company to stop using microbeads in their products); campaign material (e.g. to inform their peers about animal testing or climate change and what they can do about it); newspaper/ magazine/blog articles; promotional material for a school environment day (posters, flyers, presentation scripts etc.); and diary entries.

- Creative writing ideas: adventures of a plastic bottle / aluminium can; a story set in a dystopian future which resulted from people not looking after the environment today.
- Poetry ideas: environmental raps (e.g. look at the work of spoken-word artists or performance poets such as Benjamin Zephaniah); warning/message poems; poems appreciating the natural world (perhaps inspired by the work of some of the romantic poets); poems based on those from other cultures, such as Native Americans or Eskimos.
- Students could create their own environmental handbook, including a variety of different text types, to give ideas about what people (particularly children and teenagers) can do to live more sustainable lifestyles. They could be involved in every aspect, from research, to production, to marketing.

Environmental Education through Mathematics

Solving problems

- Students can use formal mathematical knowledge to interpret and solve problems, model situations and express results using real or hypothetical data related to environmental issues. For example: they could look at the school's energy bills, research energy-efficiency solutions (e.g. better insulation around windows and doors, thermostats in classrooms) and calculate how much money the school could save (and what they could spend it on); they could research costs of renewable energy, compared to coal-generated power, and see whether it would be cost-effective for the school to have a wind turbine or solar panels.

Number

- During fieldwork (through science or geography) in the school grounds, local or wider environment, students could calculate fractions and percentages, for example using aerial photographs to calculate percentage tree cover, taking metre quadrat samples as a fraction of a larger area and using these to estimate species density in the whole area.
- If students create their own weather stations (see the Geography and DT sections of this document), they will need to be able to make accurate scales for the equipment (e.g. rain gauge), which will involve using standard units of various measurements, including decimal quantities.

Algebra

- There are links to science, with students using scientific formulae, for example calculating the flow speed of a stream by measuring the time taken for a ball to travel a particular distance (then inserting the numbers into the formula v=d/t), or calculating rates of photosynthesis.
- Students can use coordinates to plot positions on maps and set challenges for their peers.
- Fibonacci sequences in nature can be investigated, for example the numbers of petals on flowers (e.g. daisies), the arrangements of leaves on stems, spirals on pinecones, seeds in sunflowers, sections in cross-sections of fruit, chambers in some snail shells, arms on starfish, the golden ratio between the human forearm and the hand.

Ratio, proportion and rates of change

- Students will use scales on maps during geographical fieldwork; they can scale up or down to make models, design outdoor artwork or plan new areas in the school grounds (e.g. a vegetable plot, a wildlife pond).
- The KS4 curriculum mentions that students should *"set up, solve and interpret the answers in growth and decay problems",* so this could be applied to calculate the half-life of toxic chemicals such as pesticides, in order to work out how long they might persist in the soil, a water-course or a food chain.

Geometry and measures

- The curriculum requires students to *"derive and apply formulae to calculate and solve problems"* involving 2D and 3D shapes, so this could again be applied to work outside the classroom, for example calculating how many slabs would be required around a new pond, or how many seeds can be sown in a vegetable plot (based on the information given on the seed packet about how far apart they should be planted).
- Bags of waste can be weighed and compared during school waste audits, and changes calculated over time to show any reductions, for example through greater emphasis on recycling.
- Students can interpret and use bearings during fieldwork involving maps and compasses.
- Students can work outside to carry out large-scale geometry work.

Probability

- Students can look at the probability of natural disasters/hazards (e.g. flooding, ash clouds, droughts, earthquakes) occurring in different parts of the world. They can consider how this helps these to be predicted and dealt with. They can use data to see whether the probability of some of these hazards has increased and consider the possible reasons for this (e.g. greater probability of flooding in particular areas may be due to climate change or rivers being dammed/diverted).
- They can make human Venn and Carroll diagrams outside.

Statistics

- Students can record weather patterns (using Met Office data or their own findings by setting up a weather station) and create tables, bar/pie charts, pictograms, scatter graphs, box plots etc. (depending on the age/ability of the students and the types of data collected) to analyse their data (looking for patterns/trends, explaining any anomalies).
- They can interpret graphs that illustrate climate data and discuss whether these provide evidence of global warming / climate change.
- They can devise questionnaires and surveys, for example to find out about recycling habits, record and then analyse their findings / draw conclusions.

Taking measurements in the local built environment.
Photo credit: Beth Christie

Environmental Education through History

Students can investigate how environments (local and global, natural and built) have been affected by past decisions and actions, and consider how they might be affected in the future. This can cover the general purposes and aims from the KS3 curriculum that students should "*ask perceptive questions, think critically, weigh evidence, sift arguments … develop perspective and judgement …. understand historical concepts such as continuity and change, cause and consequence… analyse trends within periods and over long arcs of time"* and in KS4 where students should *"develop the ability to ask questions of the past [and] investigate issues critically".*

Environmental history (like all history) is not just learning about the past, but also learning *from* the past; it can help students to make informed decisions and sustainable lifestyle choices, by looking at what has happened before. The 'Environmental History Resources' website (eh-resources.org) explains that environmental history offers *"valuable long-term perspective on environmental change"* and includes *"analysis of data on tides, winds, ocean currents [etc.]… and is also the story of human exploitation of the natural world".* Many aspects of this can be taught through history.

British history

- **Britain, 1745-1901:** The KS3 curriculum mentions *"the founding of the Royal Society"*, so students could find out about past and current research by members/fellows of the Royal Society (royalsociety.org) in terms of the environment, e.g. climate change, pollution, energy, GM plants.

  The curriculum also mentions Darwin's 'On The Origin of the Species' as something to study from this time period. Students could research the life and work of Charles Darwin, including the events that led him writing his famous book. This would link to learning about evolution and adaptation in biology (see the Science sections of this document).

- **Industrialisation:** The KS3 curriculum suggests that students are taught about *"Britain as the first industrial nation—the impact on society"*; this could also be extended to studying the impacts of industrialisation on the (natural and built) environment, for example pollution and population changes. Students could then go onto to look at how these changes led to the development of laws and regulations such as the 1848 Public Heath Act, the Alkali Acts of the 19th Century, and the Clean Air Acts (1956 & 1968).

- **The Second World War:** Students can learn about the 'Dig for Victory' campaign and grow their own food, trying to be as self-sufficient as possible; they could link recycling and upcycling (see the Design & Technology section of this document) to the idea of 'Make Do and Mend'.

- **Technological change in post-war British society:** Students can study the development of renewable energy technologies and nuclear power, as alternatives to fossil fuels, and explore the pros and cons of each (see the Physics section of this document).

  Students could investigate the changes in the types of waste that we produce, for example more objects are now made from plastic, which takes a long time to decompose and can pose dangers to natural environments and wildlife. They could look at society's changing attitudes towards waste, for example recycling has become much more common, but arguably people now re-use less (e.g. disposable packaging as opposed to refunds for glass bottles). This may encourage them to take action, for example re-usable coffee cups or lobbying companies like Coca-Cola.

  Students could research how changes in play have impacted on the environment, for example greater use of technology (games consoles and computers, using disposable batteries or electricity) leading to reduced engagement with the natural world, and therefore less of an interest in protecting/preserving the environment. How to encourage their peers to reverse this trend?

- **Britain's changing landscape:** There are links to geography when looking at human-induced changes to the landscape over time. For example habitat loss due to road-building and urbanisation (as a result of population growth).

Students could research the development of National Parks and the impacts of this — positive (improved access to the countryside, greater awareness and appreciation of the natural world, preservation of natural landscapes, conservation of wildlife); and negative (higher visitor numbers leading to road building, traffic, litter etc.).

- **An aspect of history before 1066:** Students could study the impacts of the Neolithic Revolution, when people moved from being nomadic hunter-gatherer communities to settled agriculture. These hunter-gatherers are commonly considered as being more 'in tune with nature', i.e. they took only what they needed, used every part of an animal etc., but they were also responsible for driving populations of some of the 'mega-fauna' (large animals such as mammoths and giant sloths) to the brink of extinction.

World history

- Students could research the spread of European Empires (British, Spanish, French, Russian etc.) across the world and the impacts (both positive and negative) that this had on the environment and society of the countries that became colonies. For example, animal collectors and 'plant hunters' of the Victorian era brought 'new' species to Britain, and to science; plantations of crops such as rubber, coffee, tea, sugar and cacao were developed overseas, with some negative impacts such as deforestation and slavery.

  Students could study historical data related to global weather patterns and temperatures, as evidence of possible climate change. They could then consider how their actions might contribute to climate change and what changes they could make to help combat it.

Local history

- **History of the local area:** Students could prepare a presentation, write a book or make a film/podcast about the history of their local area (in terms of both the built and natural environments) for a specific audience such as local primary school pupils.

  Research for this could include: studying maps and aerial photos of the local area during different periods of time; looking at old photographs and taking comparative photos during a local walk; using books from the local library or websites (e.g. bbc.co.uk/legacies, nationalarchives.gov.uk); visiting a local churchyard to look at the names on the gravestones (e.g. is there a family name that occurs on many graves?); studying census data; visiting a local museum or contacting a local history society; interviewing older local residents about how the local environment has changed.

  The website imagesofengland.org.uk is a useful and interesting *"photographic library of England's listed buildings, recorded at the turn of the 21st century"* and it includes over 300,000 images *"from lamp posts to lavatories, phone boxes to toll booths, mile stones to gravestones, as well as thousands of bridges, historic houses and churches".*

  Students could use their research to plan local history walks, mapping out places of interest, which could be printed onto leaflets and sold to raise money for the school or a local charity.

- **History of the school:** Students can find out about the history of their school or another local public building (library, church, town hall, market hall etc.). Was it designed in a particular style or by a notable architect? Can they find other buildings with the same design features?

  They could investigate how the building's usage has changed and whether it is still entirely 'fit for purpose'. What would they change, or keep the same, if they were to design the building again now? They could explore what the implications might be of adding features such as solar panels to historical buildings, particularly if the buildings are listed.

- **Traditional building materials:** Students can find out about traditional building techniques using natural materials — wattle and daub, clay, straw bales, grass roofs, wood (from sustainable sources), bamboo — and have a go at making their own structures in the school grounds. These natural building materials have a lower environmental impact than materials such as concrete (carbon dioxide is a by-product of its commercial production) or metals (there are many environmental impacts associated with the extraction of ores and the manufacture of metals such as steel).

- **Archaeology:** Set up an archaeological dig in the school grounds (if your headteacher agrees!), where students can use methods and tools used by archaeologists — there may even be a local archaeologist who could come and work with the students. This brings in lots of cross-curricular elements including maths (measuring trenches, splitting into grids using string), design and technology (using tools such as trowels, shovels and brushes), computing (taking photographs with digital cameras, creating grids for recording finds).

Working with a real archaeologist can be a very valuable experience. Credit: Elsa Lee

Students may find evidence of historical gardens (by looking for changes in soil colour) and perhaps artefacts (e.g. clay pipes, animal bones, metal buckles, coins) or foundations of former buildings. They can look in greater detail at the soil at different levels, using a 'stratigraphy key': modern = loose topsoil of light colouration with large particulates; medieval = packed soil of darker colouration and smaller particulates; Iron Age = dense clay layer with small stone inclusions; natural = gravel base layer with small quantities of soil (information from University of Bristol).

They should be encouraged to catalogue their finds as they discover them, and then process (wash, identify and record) them accurately. This can then help to give information about what the built and natural environment of their school grounds/local area was like in the past.

Alternatively, secondary sources can be used to find historical and archaeological information about the local area. For example, the 'PastScape' website from Historic England (pastscape.org.uk) has over 400,000 records of England's archaeological, architectural and maritime sites, which can be searched by key word, postcode or region. "Features include: descriptions of sites or buildings and the sources of information used to compile them; pictures (where available); basic details of investigations into the heritage, such as surveys or excavations; links to maps, satellite images and other websites..."

Environmental Education through Citizenship

The national curriculum purpose of study for citizenship (KS3 & KS4) states that it should prepare students to *"play a full and active part in society"* and equip them with *"the skills and knowledge to explore political and social issues critically, to weigh evidence, debate and make reasoned arguments".* High quality citizenship education (with strong links to SMSC – see page 43) should empower students to take positive action to try to make a difference in their local communities, the UK and the wider world.

Students can explore environmental issues through debates and role-play (linking to spoken language in drama and allowing them to consider experiences and opinions other than their own); they can create and present assemblies (for their peers or younger pupils) to raise awareness and give practical advice; they can use approaches such as the 'Sustainability Compass' and 'Ecological Foot/handprints' (see the Geography section of this document).

Environmental laws and regulations

- Students can research UK laws and regulations – such as the Environmental Protection Act (1990), the Energy Acts (2008, 2010 and 2011) and the Wildlife and Countryside Act (1981) – the environmental issues behind their development, the effects they have had and the ways that they are implemented by the Government.
- Students can find out about environmental EU Directives (e.g. the Habitats and Birds Directives, the Invasive Species Directive) and international agreements (e.g. Kyoto Protocol, Paris climate change agreement, the CITES treaty about trade in endangered species, the UN Sustainable Development Goals).
- They could also look at NGOs (non-governmental organisations, such as charities) who lobby and advise governments and companies. They can explore the different ways in which this is done (e.g. petitions, peaceful protests, direct action) and the pros and cons of these approaches.

Volunteering and community work

- One of the aims of the KS3/4 citizenship curriculum is for students to *"develop an interest in, and commitment to, participation in volunteering as well as other forms of responsible activity, that they will take with them into adulthood."*
- Students can become involved in environmental campaigns run by local, national or international environmental organisations, including fundraising, raising awareness and sharing information via social media.
- Engaging with the local community is an essential element of citizenship, and a step towards developing knowledge and awareness of the wider world. Local environmental activities can include litter picking, cleaning up graffiti, community projects, improvements to walking or cycle routes, and practical conservation work such as habitat creation (in the school grounds or local area).
- Students could calculate the carbon footprint/handprint of a local building, such as a church, and come up with ways to make this building/organisation more sustainable, including fundraising to make improvements. They could hold a community day inviting local companies and charities that can support students at the school (and other local people) to live 'greener' lifestyles.
- Students could find out about, and take inspiration from, young environmentalists, such as 'Birdgirl' Mya-Rose Craig, who encourages other young people — particularly those from ethnic minorities — to get out into nature and organises 'Camp Avalon' birding camps (twitter.com/BirdgirlUK; campavalon.blogspot.co.uk).

Mya-Rose Craig (front right)

Environmental Education through Business Studies (KS4)

Written with **Eamonn Clements** Economics Teacher

Environmental impacts of business activities

- The 'purpose and nature of business' in the AQA syllabus discusses the constantly changing business environment including the environmental implications of business activity. Here students might consider the issues such as the need to respond to consumer expectations regarding environmental consequences.
- The GCSE curriculum mentions *"the impact of ethical and environmental considerations on businesses",* which include sustainability, global warming and use of scarce resources. Here students might consider a range of positive and negative scenarios for businesses whose activities impact upon local and/or global environmental conditions.

- Influences on business include environmental considerations such as impact on traffic congestion, recycling, waste disposal, air and noise pollution. Here teachers might introduce the Circular Economy model (see the Design & Technology section of this document) and 'cradle to grave' approaches by businesses who make goods.
- Students could carry out an environmental impact assessment/survey about where to locate a new business. Transport of raw materials — would new roads need to be built? Would there be public transport links for workers? Waste — how could this be disposed of safely, cleanly and legally? (This links to environmental law — see the Citizenship section of this document.)

Impacts of businesses on individuals and wider society

- The concept of stakeholders includes environmental elements and addresses trade-offs between environment, sustainability and profit. Here students might consider conflicts of interest in how different stakeholders in local communities might respond to the setting up of a range of distinct businesses in a specific community.
- Corporate social responsibility – students might mock up policies for new companies that explain their approaches to CSR.

Environmental Education through Economics (KS4)

Written with **Eamonn Clements** Economics Teacher

- The GCSE Economics curriculum states that students should *"consider moral and ethical and sustainability issues that arise as a result of the impact of economic activity",* and sustainability comes into the specification for both the OCR and the AQA syllabuses. Students can investigate how businesses address the three pillars of sustainability: economic (e.g. sources and rates of growth), social (equality and equity) and environmental (externalities).
- The central purpose of economic activity is the production of goods and services to satisfy needs and wants given the constraints of factors of production, which includes natural resources (characterised as 'land') such as fish, oil and natural forests. Here students might consider how to classify resources as land or capital and consider consequences for the environment of turning natural resources into capital resources.
- Economic growth through availability and exploitation of natural resources can be discussed within the context of developed and less developed countries — here teachers might consider case studies of oil rich countries, such as Nigeria, where the availability of oil has led to the generation of economic activity with a range of positive and negative outcomes — socially and environmentally. Here the notion of the 'resource curse' might be considered — an influential study by Sachs and Warner which found a strong correlation between natural resource abundance and poor economic growth [NBR Natural Resource Abundance and Economic Growth, 1995]. This could be compared with a country like Norway where different outcomes have been achieved with the same resource. In each case, the outcomes for the environment might be considered, including the impact on global warming through the release of CO_2, as an outcome of exploitation.
- When evaluating the costs and benefits of economic growth, including the impact on economic, social and environmental sustainability, students might consider the costs in terms of the impact of industrial pollution through production and then the impact of pollution from consumption. Pollution is a negative externality arising from economic growth.
- When looking at international trade and the global economy, students can consider the impact of globalisation on economic, social and environmental sustainability within the context of developed and less developed countries. For example a case study of sustainability in China achieving growth and development through export led urbanisation and industrialisation with the resulting environmental consequences, and the challenge of dealing with rising inequality.
- The GCSE curriculum specifies that students should understand *"the levers employed by governments to reach desired social and economic objectives"*. This could include looking at 'green' incentives or penalties for individuals and companies, e.g. tax relief for becoming more energy efficient, congestion charges, plastic bag levy. Can the students think of any more?

Environmental Education through Religious Education

Each education authority has its own agreed syllabus for Religious Education (RE). Quotes in this document are from the Birmingham Agreed Syllabus for RE.

RE teaches students about different religions and worldviews, which should include learning about *"religious views on, and attitudes to, animals and the environment, and the importance and implications of studying the natural world"* (Birmingham Agreed Syllabus for RE). RE should also help students to develop characteristics such as selflessness, altruism and empathy, for other people, animals and the environment.

Common to many religions is the idea of 'stewardship', with humans taking care of the earth on behalf of God (particularly those religions that believe in creation) or just for the time that we use it, so that it can be left in a fit state for others. Alongside traditional religious beliefs and teachings, concern for current environmental issues has become more prominent in recent years. According to Martin Palmer, Secretary General of the Alliance of Religions and Conservation (ARC): *"Today… every major religion takes ecology seriously and is involved in environmental projects, and the world's religions are increasingly recognised as playing a pivotal role in protecting the natural world"* (arcworld.org).

Different religions also work together to develop long-term practical action for the environment. In 1986, the leaders of several major religions met at Assisi in Italy (the birthplace of St Francis, the Catholic Patron Saint of Ecology) and each faith made a statement, called the Assisi Declarations on Nature (ow.ly/m5iP30gmF0A). This also led to the development of the ARC, which now represents most of the world's major faiths and is supported by organisations such as the United Nations Development Programme (UNDP) and WWF.

Christianity

- Students can look for references to animals and nature in the creation story in the Old Testament of the Bible and consider how Christians may interpret this. The use of the word 'rule' *("God blessed them and said to them… rule over the fish of the sea and the birds of the air and over every living creature that moves on the ground"* Genesis 1:26 and 28) could be interpreted as giving people the right to exploit the environment, but many Christians see themselves as being responsible for looking after the world on God's behalf.
- Students could also consider how Jesus's teachings to "love they neighbour" can apply to environmental issues or animal welfare. They could do the same with the 'Parable of the Talents' (Matthew 25:14-30), where they draw analogies between the servants who traded their talents (coins) for something more and people who aim to leave the earth in a better state than they found it.
- Students can look at how the harvest festival is a way of thanking God for the fruits of nature.

Islam

- Students can explore Islamic beliefs about the creation of the world, with humans as 'khalfahs' (custodians/stewards or 'viceregents') to look after the world for Allah (God). They can look for references to the beauty of nature and caring for the environment in the Qur'an; for example: *"Devote thyself single-mindedly to the Faith, and thus follow the nature designed by Allah, the nature according to which He has fashioned mankind. There is no altering the creation of Allah"* (Qur'an 30:30).
- Students could also consider how the teachings of the Prophet Muhammad relate to responsibility and care for the environment. For example: *"The Earth is green and beautiful, and Allah has appointed you his stewards over it. The whole earth has been created a place of worship, pure and clean. Whoever plants a tree and diligently looks after it until it matures and bears fruit is rewarded. If a Muslim plants a tree or sows a field and humans and beasts and birds eat from it, all of it is love on his part."* (Hadith). They could look at the 'Muslim Green Guide to Reducing Climate Change' — downloadable from the website of the Islamic Foundation for Ecology and Environmental Sciences (ifees.org.uk) — which links ideas for practical action to relevant quotes from the Qur'an.

Judaism

- As with Christianity and Islam, students can explore the ways in which the creation story can be interpreted in terms of humans having a role as custodians of the earth (*"The earth is the Lord's, and everything in it, the world and all who live in it"* Psalm 24:1) with a responsibility for looking after it. In the Assisi Declarations of Nature, the Jewish statement included: *"When the world is in peril, when the environment is in danger of being poisoned and various species, both plant and animal, are becoming extinct… it is our Jewish responsibility to put the defence of the whole of nature at the very centre of our concern… The encounter of G-d and man in nature is thus conceived in Judaism as a seamless web with man as the leader and custodian of the natural world."*
- Students can learn about the Jewish festivals of Tu B'Shevat (New Year for Trees) and Sukkot (Feast of the Tabernacles) which both have links to nature and the outdoors.

Hinduism

- Students can explore Hindu beliefs about the relationship between humanity and the environment, by looking at aspects such as: the beliefs in karma and dharma, the concept of ahimsa (non-violence and respect for life), the fact that many Hindus are vegetarian, and the belief that all living things — including plants — have an atman (soul). The ARC website has a page of Hindu quotes that relate to animals, nature and the environment: ow.ly/Jn7D30fdxI9.

  In the Assisi Declarations of Nature, the Hindu statement included: *"The human role is not separate from nature. All objects in the universe, beings and non-beings, are pervaded by the same spiritual power. The human race, though at the top of the evolutionary pyramid at present, is not seen as something apart from earth and its many forms. People did not spring fully formed to dominate lesser life, but evolved out of these forms and are integrally linked with them. Nature is sacred and the divine is expressed through all its forms… Nature cannot be destroyed without humanity destroying itself."*
- Students could investigate the ways that trees and certain animals are revered by Hindus. For example, the banyan is the sacred tree of India (the god Krishna is said to have used it as a metaphor for the world) and the killing of cows is banned.
- Quotes by Mahatma Ghandi could be used as examples of the ways that Hindus respect the environment, for example: *"There is enough for everyone's need, but not for their greed".*

Sikhism

- Students can explore the Hindu belief that the world was created by one God — Waheguru — and that He is reflected in nature: *"Nature we see, nature we hear, nature we observe with awe, wonder and joy...All nature is yours, O powerful creator. You command it, observe it and pervade within it"* (Guru Granth Sahib).
- They can find out about how Sikhs show a respect for animals and the environment in their lifestyles. For example: hunting animals for sport is forbidden, many Sikhs are vegetarian, they have a strong sense of community, and believe in karma and reincarnation.
- Students can read Sikh hymns and stories about the Gurus, which contain many references to a love of nature. Some of these can be found on the ARC website: ow.ly/XkU630fdAHq.

Buddhism

- Buddhists do not believe in God and there is no creation story, but they do believe that they have a duty to protect the Earth and to leave it in a fit state for others to use after them. Students can research Buddhist beliefs and how these relate to caring for the environment. For example: the first moral precept of Buddhism states *"I will not harm any living thing"*; belief in karma and reincarnation leads Buddhists to be concerned about the planet and future generations.
- Students can find out about the teachings of Buddha on having compassion for all life and living simple lives in harmony with nature: *"Just as the bee takes the nectar and leaves without damaging the colour or scent of the flowers, so should the sage act in a village"* (Buddha).

- The Dalai Lama has made numerous quotes about the environment, which students can read. For example: *"Peace and survival of life on earth as we know it are threatened by human activities that lack a commitment to humanitarian values. Destruction of nature and natural resources results from ignorance, greed, and lack of respect for the earth's living things. This lack of respect extends even to the earth's human descendants, the future generations who will inherit a vastly degraded planet if world peace doesn't become a reality and if destruction of the natural environment continues at the present rate."* (More quotes can be found here: ow.ly/p4ad30fdBPc.)

Faith-based environmental charities

- Students can find out more about the work of faith-based charities that raise awareness and take action on environmental issues. Some examples are: Christian Aid's climate change campaign (christianaid.org.uk), the Christian nature conservation charity A Rocha (arocha.org.uk), the Islamic Foundation for Ecology and Environmental Sciences (ifees.org.uk) and EcoSikh (ecosikh.org).

Ethics and morals

- RE can provide opportunities for students to explore moral and ethical aspects related to the environment, and consider the impact of ethical choices (*"they could create a 'multi-path narrative' about a contemporary moral issue, showing what the consequences of different choices might be and evaluating the impact of moral choices with discernment"* — Birmingham Agreed Syllabus for RE). This could be done by posing questions and students acting in role to explore the different choices that could be made.
- Students can explore what different religions/worldviews say about environmental issues such as pollution, animal welfare or climate change, and how these fit in with their teachings. For example: the Pope's 2015 encyclical on climate and justice (ow.ly/MVLi30f8cSy); the Church of England's 'Shrinking the Footprint' campaign (ow.ly/zB6430f8dht); the Hindu Declaration on Climate Change (ow.ly/AHfJ30fdypw). The latter of these could be used as a basis for students to make their own declarations about a particular environmental issue.

Environmental Education through Physical Education

The most obvious way of linking PE to environmental education is through outdoor and adventurous activities. The curricula for both key stages 3 and 4 mention students taking part in outdoor and adventurous activities that *"present intellectual and physical challenges"* and where students are encouraged to *"work in a team, building on trust and developing skills to solve problems, either individually or as a group".*

Orienteering and navigation

- Orienteering skills can be taught in the school grounds and then developed further afield. For example: some local parks have fixed orienteering courses; students can use orienteering maps, compasses, grid references and GPS (linking to geography and maths); and teachers/students can design their own orienteering courses.
- Orienteering requires students to link map symbols to features of the natural and built environment, which can help them to learn more about a place. They could be asked to make field sketches or write descriptions of plants or animals they encounter, which could then be used for identification back in the classroom (science link).
- Students could learn to 'read' the landscape and use natural navigation. For example, observing tree growth to ascertain the prevailing wind direction or the direction of the sun (i.e. which side of the tree has denser foliage?); lichen on walls and stones usually indicates the sunny south side, whereas moss indicates the cooler north side; tracking animals by searching for footprints and other evidence. Aspects of the built environment can also show direction, for example churches were traditionally built with the chancel pointing eastwards and the transept having a north-south alignment.

- Geocaching is a way of using technology to explore the outdoors (geocaching.com/play). Students could take part in, or even organise, a CITO ('Cache in Trash Out') event, where participants carry out environmental improvement activities such as collecting litter (as long as it does not appear hazardous).
- Students could learn to use communication signals such as semaphore, Morse code or making symbols (arrows etc.) using sticks and stones.
- Students should consider the environmental impacts of orienteering-type activities and try to minimise these. For example: stick to paths and avoid areas that have been marked out-of-bounds; do not shout or make excessive noise; take care not to drop litter; don't damage plants or disturb wildlife such as nesting birds; follow the Countryside Code (ow.ly/QwXc30foHTB). Students could carry out their own environmental impact assessment for orienteering or a different adventurous activity.

Bushcraft and forest school activities

- 'Forest school' type activities like den building, using tools, fire-lighting and woodland obstacle courses can help develop skills such as teamwork and agility (e.g. making a log bridge to cross a stream). However, it is important to also protect and respect the wildlife of the areas where these activities are carried out. For example: do not destroy log piles or other habitats; treat trees respectfully; cut leaves from plants such as bracken, rather than pulling up the whole plant.
- Den building is a way of encouraging students to select and use materials based on their properties (e.g. strength, waterproofness) for making a den or shelter. It is also a great way of encouraging discussion and teamwork. Students can be provided with materials (e.g. tarpaulins, string) or use natural materials.

Practical conservation work

- Students could get involved in practical conservation activities such as tree thinning, planting, clearing undergrowth, laying hedges, digging a pond. Organisations such as The Conservation Volunteers and Groundwork can provide advice for work within your school grounds, or contact the local council or Wildlife Trust about opportunities in local parks or nature reserves.

Using natural materials

- Students could make string from nettles, which links to design & technology and history (traditional skills). Instructions can be found online, e.g. ow.ly/yYDI30foLH7. They could then learn some knots to try out with their nettle string.
- Nettles — along with many other plants — can be foraged for food. For example, students could make nettle tea, wild garlic pesto or hogweed biscuits. Ensure that you have someone on hand to help them recognise any harmful or poisonous plants. Foraging for wild food links to cooking and nutrition in design and technology.
- Students could learn to carve/whittle wood and perhaps create a piece of public art for the school or local area.

The Outdoor Adventure Manual: Essential scouting skills for the Great Outdoors (Haynes Publishing / The Scout Association 2013, ISBN 978-0-85733-282-0) has lots of information and practical advice about outdoor and adventurous activities.

Using metal spades to cook foraged hogweed biscuits. Photo credit: G Guy

Environmental Education through Art and Design

- The 'art' found in nature (leaf shapes, bark patterns, tree rings, flower structures, cloud formations etc.) can provide excellent stimuli for creative work. Natural objects (e.g. wood, feathers, fruit) and materials (e.g. clay) can be used to create artworks.
- A great artist to study, in terms of the environment, is Andy Goldsworthy (goldsworthy.cc.gla.ac.uk), who only uses natural objects (including using plant sap for glue and thorns instead of nails or pins) and leaves nature to 'reclaim' his artwork when he has finished. This can help to develop a 'leave only footprints, take only photographs' approach to working outdoors. Other environmental, or 'land' artists include Chris Drury (chrisdrury.co.uk), Marc Pouyet (marc-pouyet.net) and Richard Shilling (richardshilling.co.uk).
- Students could create works of art in the style of famous artists, such as William Morris (using leaves to recreate his wallpaper and fabric designs), JMW Turner (landscapes), David Shepherd (wildlife), Monet (impressionist views) and Georgia O'Keefe (detailed studies of flowers). There may also be some local artists they could study.
- Students could explore how the changing seasons affect their view of a particular area. Make simple cardboard 'viewfinders' to frame a view, sketch or photograph what they see and then students use these to create art works of the same scene at different times of the year. For example they could investigate differences in light and colours in their school grounds or local park during spring, summer, autumn and winter.
- Observational drawings can be made of natural objects such as leaves, birds visiting a feeder, invertebrates discovered outside (or bugs in resin). Students could choose from different media, for example pencil, charcoal, pastel, pen and ink. Encourage them to keep a sketch book to record their ideas at any time or place. They could also look at the sketches of famous artists and compare them to their finished artworks.
- Students can try different techniques for creating artworks based on the natural or built environment, for example watercolour (experimenting with dropping, spreading, rubbing, adding salt etc.), acrylic, decoupage, collage, batik or mixed media. They could also experiment with making recycled/scrap sculptures.
- Students could have a go at taking wildlife photographs, inspired by the Wildlife Photographer of the Year competition entries/winners (nhm.ac.uk/visit/wpy/competition.html).
- Contacts could be made with local organisations that work with art in nature, for example Cambridge Curiosity and Imagination (cambridgecandi.org.uk).
- There is a dedicated Nature in Art Museum (natureinart.org.uk) which has a *"deliberately all-embracing collection linked by its international quality and nature theme"* and includes a *"wide range of styles ... from the hyper-realist to abstract (pictures, sculptures and objects)"* represented using "*oils, watercolours, acrylics, mixed media, ceramics, glass, wood, fabrics and many other media".* The works here could be used as inspiration for students' work.

Environmental Education through Music

- Students could use the 'music of nature', for example bird songs, to inspire their own compositions, which could be developed into scores for mini-films. They could also write 'protest songs' or raps about environmental issues.
- Make links to design and technology by exploring the musical properties of natural and pre-used objects or materials and making musical instruments (e.g. rain sticks, wind chimes, drums, shakers).

Environmental Education through Languages

- Students can learn the names of plants and animals in different languages (including scientific plant names in Latin) and also talk about features such as the weather. [KS3 curriculum: *"develop and use a wide ranging and deepening vocabulary that goes beyond their immediate needs and interests, allowing them to give and justify opinions and take part in discussion about wider issues."* GCSE: *"broaden students' horizons and encourage them to step beyond familiar cultural boundaries and develop new ways of seeing the world."]*
- They could read texts about environmental issues in other countries, written in the home language of these countries, for example case studies about the rainforest in Spanish-speaking countries in Central and South America. [National curriculum aim: *"understand and respond to spoken and written language from a variety of authentic sources."]*

Environmental Education through Computing

- Students in KS3 are required to *"design, use and evaluate computational abstractions that model the state and behaviour of real-world problems and physical systems"*. This can be applied to looking at the recording and presentation of environmental data, for example climate change modelling.
- There are a wide range of apps that students can use in the outdoor environment, including wildlife or plant identification, ethical shopping guides, geocaching, citizen science projects and footprint calculators. They could have a go at making their own apps, or make QR codes to put onto outdoor signs or wildlife leaflets.
- Students can select, use and combine multiple applications to create projects and presentations about the environment. These could then be shared with younger pupils or their peers.
- Hardware such as smart phones, digital cameras, dataloggers, tablets, GPS/GIS, digital weather stations and voice recorders can be used to make observations and record data that can be used or analysed back in the classroom.
- Students could take digital photographs of aspects of the local environment that they like or dislike, giving reasons for their choices and suggestions for improvements.

Case Study: A Whole School Approach to Environmental Education

Nunnery Wood High School, Worcestershire

Nunnery Wood High School, Worcestershire, was awarded Eco-Schools Ambassador status in 2014 following four successive Green Flag Awards — the highest Eco-Schools accolade — and an innovative project to develop learning outside the classroom opportunities on campus.

At Nunnery Wood, our Eco-Schools journey started with a small group of enthusiastic student volunteers and a supportive teacher, with a project to start the school recycling. From there it has grown into a golden thread with sustainability and environmental education running through the entire curriculum, campus and out into our community. We are an Eco-Mentor school with the county council, supporting schools in the wider community, and we run Eco-Schools activities with some of our feeder primary schools, from community litter picks to hands-on 'Climate and Weather' science sessions.

There have been several key factors that have allowed Eco-Schools to flourish at our school. Firstly, the enthusiasm and energy of all the students, especially the youngest ones arriving at the school having taken part in 'eco' activities and Forest Schools (LOtC experiences aplenty) in their primary settings; secondly, having a supportive leadership team who make sustainability a priority; and finally a creative community of teachers who have got on board with new initiatives (from our 'Eco Teacher of the Month' award to our Fairtrade fashion shows).

Don't get me wrong, it hasn't all been smooth sailing; we've had our fair share of issues. From our most enthusiastic and caring students being put off attending Eco Activities by peer pressure (with taunts of 'Geeko' or 'Freako' Club instead of Eco Cub) to disgruntled staff who were unhappy about being 'Eco Spied' on. Put this alongside the impracticalities of trying to get 1350 students and 200 staff to recycle their paper, plastics and cans, and then for that mass of weekly recycling across our large campus to actually end up in the recycling area. You can appreciate it's been an uphill struggle at times!

Members of the Eco Club hosting Mandisa Masinga from their partner school in South Africa

The school's sustainably built 'world classroom'

Nunnery Wood are now ten years into the programme and we are in an amazingly positive position. Sustainability is included in every curriculum area, written into schemes of work, from environmental poetry to whole schemes of work devoted to our sustainable future (from insect eating to travel solutions). We have an Eco Action Team who meet weekly to undertake environmental action (from litter picking in the local woodland to designing bird boxes) along with a dedicated team of Eco Reps (a minimum of two students in each of our fifty form tutor groups, but as many as four can volunteer) who attend a weekly Eco -project meeting, to work on a project of their devising and a further morning registration session each week in which they undertake the recycling collection across the site.

Examples of activities chosen by the Eco Reps:

Year 11: Fairtrade Fashion show, which included upcycled garments, fashion from the UK's largest supplier of Fairtrade (M&S) and Fairtrade refreshments from The Co-operative. Year 11 students also, via assemblies, raised awareness of microbeads and collected over one thousand signatures from across the school to lobby our local MP.

Year 10: Biodiversity — whole school vote to adopt an endangered species. In 2015, the Giant Panda was chosen and was the focus of a school-wide art competition. Further to this, the Year 10 reps devised a workshop for Year 7 about the threats, habits and habitats of the Giant Panda.

Students modelling 'Trashion' (clothes made from rubbish) at the Fairtrade Fashion Show

Year 9: Water — delivering assemblies on water use at home and offering flush bags to our 270 Year 7 students.

Year 8: Keep Britain Tidy 'Clean for the Queen' campaign. Year 8 created a mural for the Queens 90th birthday, using recycled plastics. To amass the bottle tops they required, they engaged the wider school community in a collection competition along with a community litter pick event.

Year 7: Our youngest Eco Reps created an innovative litter campaign called 'Litter Lotto' with a week-long celebration of bin use this term by distributing raffle tickets to all student bin users to win prizes in a draw at the end of the week.

Our regular Eco-Schools assemblies, displays, weekly meetings and pioneering student-led projects have normalised education for sustainable development at our high school and enabled it to flourish. This would be much harder without all the hard work and dedication of my primary Eco-Schools Co-ordinator colleagues who instil a sense of environmental passion and power in the youngest of students. A supportive senior leadership team has also made the rooting of Eco-Schools possible by providing opportunities for dedicated sustainability time. Our most recent whole school SMSC days included lessons on Fairtrade and the Sustainable Development Goals. We have also established spaces on campus devoted to environmental and global education: an outdoor classroom consisting of a reptile bank, pond, bird hide, rockery and bird corridor (all designed and developed by Eco Action Team students); a nursery orchard planted with local varieties of apples, pears and plums; and finally our 'World Classroom', a low-cost housing solution built next to the orchard by our students.

The Eco-Schools programme has allowed us to link with schools in Germany, France and Australia. Our connections with these schools became the basis of a Sustainable Schools workshop delivered by our Eco Action Team students at a global youth conference in November at the Wolverhampton Science Centre.

Our Eco-Schools programme is driven by our students. It allows our students at secondary level to have a sense of ownership over their local environment, to better understand their influence and make the positive and rewarding difference to maintain and even improve it. Following the Eco-Schools programme has provided our students with high levels of motivation, enthusiasm and invention that inspire me and commit me even further.

Elena Lengthorn Eco-Schools Co-ordinator, Geography and Science Teacher

Elena Lengthorn and the Nunnery Wood Eco Club

Environmental Education and Spiritual, Moral, Social & Cultural Development (SMSC)

Spiritual

- Students can find out about religious festivals, ceremonies and stories that take place outdoors or involve plants/animals.
- Students can use natural objects to make decorations for celebrations or festivals. They could also create prayer flags related to the environment.
- Students can create their own 'sacred spaces' outdoors for quiet reflection, mindfulness, yoga etc.
- (See also the Religious Education section of this document.)

Moral

- Help students to understand the need to treat plants, animals and each other with care and respect.
- Students will develop an awareness of local and global environmental issues and consider how they can adapt their lifestyles now and as future adult decision-makers, in order to live more sustainably.
- (See also the Citizenship section of this document.)

Social

- Students can look at the resources within their school grounds and explore improvements that could be made to benefit social interaction (e.g. 'buddy benches'), behaviour and safety (e.g. separate areas for quiet and more boisterous activities).
- Develop social interaction by inviting family members to help with outdoor activities.
- Encourage students to take part in local volunteering, community and environmental activities.

Cultural / Promoting British values

- All maintained schools are expected to "*promote the fundamental British values of democracy, the rule of law, individual liberty, mutual respect and tolerance of those with different faiths and beliefs*" (ow.ly/B9cw30fqsA5).
- **Democracy:** working together to make decisions and voting for changes; utilising individuals' strengths and not leaving anyone out.
- **The rule of law:** drawing up rules for how to behave outdoors (in the school grounds or further afield); observing boundaries; following rules such as the Countryside Code; researching environmental laws and regulations.
- **Individual liberty:** making informed choices; feeling safe and secure; being able to make mistakes and learn from them; enjoying freedom.
- **Mutual respect:** understanding that their behaviour has an effect on others; treating plants, animals and the natural world with respect.
- **Tolerance of those of different faiths and beliefs:** learning about the diversity of their local community; inviting parents/grandparents/carers to help with projects such as gardening or accompanying on educational visits; visiting local places of worship or cultural centres.

Useful Organisations & Websites

Art and the environment

Andy Goldsworthy: goldsworthy.cc.gla.ac.uk
Cambridge Curiosity and Imagination: cambridgecandi.org.uk
Chris Drury: chrisdrury.co.uk
Marc Pouyet: marc-pouyet.net
Nature in Art: natureinart.org.uk
Richard Shilling: richardshilling.co.uk

Built environment / Heritage / History

Environmental History Resources: eh-resources.org
Images of England: imagesofengland.org.uk
Legacies – UK history local to you: bbc.co.uk/legacies
National Archives: nationalarchives.gov.uk
PastScape: pastscape.org.uk

Business Studies & Economics

World Inequality Report: wir2018.wid.world
The Atlas of Economic Complexity: atlas.cid.harvard.edu
Tutor2u Business Studies: tutor2u.net/business/latest
Tutor2u Economics: tutor2u.net/economics/reference/sustainable-development

Development education / Global learning

Compass Education: compasseducation.org
Global Learning Programme: glp.globaldimension.org.uk
Oxfam: oxfam.org
Think Global: think-global.org.uk
TIDE (Teachers in Development Education): tidec.org
The World's Largest Lesson: worldslargestlesson.globalgoals.org

Eco labelling

ec.europa.eu/environment/ecolabel
globalecolabelling.net/what-is-eco-labelling

Environmental education / Sustainability education

Eco-Schools: eco-schools.org.uk
National Association for Environmental Education (NAEE) naee.org.uk
Sustainability and Environmental Education (SEEd): se-ed.co.uk
UN Sustainability Goals: un.org/sustainabledevelopment/sustainable-development-goals

Environmental laws and regulations

Countryside Code: gov.uk/government/publications/the-countryside-code
Convention on International Trade in Endangered Species of Wild Fauna and Flora: cites.org
EU environmental regulations: ec.europa.eu/environment/nature/info/pubs/directives_en.htm
UK Environmental regulations: gov.uk/topic/environmental-management
United Nations Framework Convention on Climate Change: unfccc.int

Food and farming / Gardening / Soil

BBC Nature – 10 plants to encourage wildlife to your garden: bbc.co.uk/nature/22433553
Community Composting Network: communitycompost.org
Countryside Classroom: countrysideclassroom.org.uk
Farming and Countryside Education (FACE): face-online.org.uk
Federation of City Farms and Community Gardens: farmgarden.org.uk
Food For Life Partnership: www.foodforlife.org.uk
Garden Organic: gardenorganic.org.uk
Gardening with Children: gardeningwithchildren.co.uk
Permaculture Association: permaculture.org.uk
Potato Council – Love Potatoes: lovepotatoes.co.uk/kids
RHS Campaign for School Gardening: schoolgardening.rhs.org.uk
The Soil Association: soilassociation.org
Soil Net: soil-net.com

Green technology

Elif Bilgin – student, scientist, inventor: elif-bilgin.com
Green Forward News: greenforwardnews.com
Sea Bin project for cleaner oceans: seabinproject.com
Solar-Active: solar-active.com

Natural environment (plants, animals, habitats)

Botanic Gardens Education Network (BGEN): bgen.org.uk
Buglife (The Invertebrate Conservation Trust): buglife.org.uk
Bumblebee Conservation Trust: bumblebeeconservation.org
Earthworm Society of Britain: earthwormsoc.org.uk
Freshwater Habitats Trust: freshwaterhabitats.org.uk
Froglife: froglife.org
Plantlife: plantlife.org.uk
RSPB: rspb.org.uk
SAPS (Science and Plants for Schools): saps.org.uk
The Tree Council: treecouncil.org.uk
Whale and Dolphin Conservation: uk.whales.org
Wild About Gardens: wildaboutgardens.org
Wildfowl and Wetlands Trust: wwt.org.uk
Wildlife Photographer of the Year: nhm.ac.uk/visit/wpy/competition.html
Wildlife Trusts: wildlifetrusts.org
Wildlife Watch: wildlifewatch.org.uk
Wildscreen Arkive: arkive.org
Woodland Trust: woodlandtrust.org.uk
World Wide Fund for Nature: wwf.org.uk

Outdoor learning

Council for Learning Outside the Classroom: lotc.org.uk
Field Studies Council: field-studies-council.org
Geocaching: geocaching.com/play
KS3 forest school ideas: forestschools.wordpress.com/ideas/programme-ideasthemes/6-practical-themed-session-ideas-aimed-at-ks3
I'm a teacher, get me OUTSIDE here! creativestarlearning.co.uk

Institute for Outdoor Learning (IOL): outdoor-learning.org
Scout Association: scouts.org.uk

Recycling

Recycle Now: recyclenow.com/recycling-knowledge/getting-started/recycling-at-school
School recycling guide: recycling-guide.org.uk/schools
Waste and Resources Action Programme (WRAP): wrap.org.uk

School grounds development (ideas or practical help)

The Conservation Volunteers: tcv.org.uk
Groundwork: groundwork.org.uk
Learning Through Landscapes: ltl.org.uk

Science

Royal Society: royalsociety.org

SMSC / RE / Citizenship

Alliance of Religions and Conservation (ARC): arcworld.org
A Rocha — caring for God's earth: arocha.org.uk
Black Environment Network (BEN): ben-network.org.uk
Christian Aid climate change campaign: christianaid.org.uk/campaigns/climate-change-campaign
Church of England's environmental campaign: churchcare.co.uk/shrinking-the-footprint
Dalai Lama's messages about the environment: dalailama.com/messages/environment
EcoSikh: ecosikh.org
Hindu Climate Declaration: hinduclimatedeclaration2015.org
Islamic Foundation for Ecology and Environmental Sciences ifees.org.uk
Pope Francis's Encyclical on the Environment: earthministry.org/advocacy/pope-francis-encyclical-on-the-environment
Promoting British Values: gov.uk/government/publications/promoting-fundamental-british-values-through-smsc
REEP (Religions and Environment Education Programme): reepinfo.org

Subject associations

Association for Science Education: ase.org.uk
Design and Technology Association: data.org.uk
Earth Science Teachers Association: esta-uk.net
Geographical Association: geography.org.uk
Historical Association: history.org.uk
Mathematical Association: m-a.org.uk
Royal Geographical Society: rgs.org

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