Putting earth science teaching into its outdoor context

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Try ESEU's stepwise approach to developing the educational potential of the outdoor environment – from *Earth science through the window* to the school grounds and beyond

Engaging with the earth

How can you help pupils to understand that the earth processes they learn about in science lessons are acting on the earth all the time? The Earth Science Education Unit (ESEU) has devised a gradual approach to taking science teachers and their pupils out of doors, where they can see evidence of earth processes actually happening.

The steps involve:

- using an *Earth science through the window* worksheet to develop understanding of Earth science processes and products;
- realising the potential of the school grounds for teaching earth science principles and the usage of earth materials;
- running investigative activities in graveyards or on building-stone trails;
- applying ESEU's *Any quarry guide* to any local rock exposure, to develop its educational potential.

ABSTRACT
You can learn much about how earth processes work and the evidence they leave behind by analysing the view from the window and there is even more potential in the school grounds. A visit to a local graveyard or building-stone trail provides more scope for scientific enquiry. By using these approaches in a visit to a local quarry or cliff face, you and your pupils can tackle the scientific questions that earth scientists address. The materials you need to do this are here or on the Earth Science Education Unit (ESEU) website.

But why should teachers consider taking steps like these? Why is it important to use the outdoor context?

There are a number of reasons, but the key ones are as follows:

- Most pupils spend hours a day in the outdoor environment, in the school grounds during break, lunchtimes and games, walking to school, or in streets, parks, gardens, sports fields and the countryside during leisure time. The outdoor environment is thus very relevant to them and an important context for teaching and learning.
- The outdoors is a great resource for learning, providing contexts and investigational situations not otherwise available indoors.
- Earth science takes place outdoors in both built and natural environments, and that is the place where earth science processes and their products can best be seen and understood.
- Most earth science investigation takes place out of doors. Earth science data must be gathered outside before it can be analysed, modelled and otherwise investigated indoors. Earth scientists must therefore be adept at collecting outdoor data.
- Realising these important issues, and the power of outdoor learning opportunities, the UK Government is currently seeking to broaden and develop out-of-classroom education through its manifesto, *Education outside the classroom* (see Teachernet website).

You can try out activities that ESEU has devised to lead you and your pupils out of doors, as described below.

ESEU's steps towards the earth

Earth science through the window

Ask your pupils to complete an *Earth science through the window* worksheet like the one shown in Box 1, where possible 'answers' are indicated in italics. Part 1 of the worksheet asks them to consider which of the rock-cycle processes operating on the surface of the earth can actually be seen in action through the window, and what evidence for their activity remains in the materials (products) left behind. Part 2 goes on to consider which of the processes and their products can be seen through any strategically placed window anywhere in the world. As with all ESEU worksheets, the emphasis is not on getting the 'right' answer but on the discussion that takes place around the answers while the worksheet is being completed and afterwards. For this reason, pupils are asked to tackle the worksheet in groups.

Part 1 allows the distinction to be made between weathering (the break down or break up of material in place) and erosion (the removal of material – by wind, water, gravity or ice). It also enables the processes of erosion (picking up), transportation (carrying) and deposition (laying down) of sediment particles to be discussed, from sand grains to tin cans. It helps pupils to distinguish between 'process' and 'product' and to understand that rock-cycle processes are going on around them all the time.

Part 2 of the worksheet emphasises that all surface earth processes are happening all the time somewhere on the earth and that the products of all the processes can be found in most parts of the earth, including the UK. Some pupils respond by writing a type of environment, whilst others write a specific place name – and either is good. The remarkable finding is that many surface processes can be seen acting outside the window today and that most processes and their products, with the exception of those that occur only in the deep Earth, can probably be seen through a window somewhere on Earth.

Earth science in the school grounds

The school grounds provide many opportunities for teaching earth science principles and considering how earth materials are used. You can try out the different approaches yourself by accessing the *Earth science out of doors* workshop materials on the ESEU website. They include the following:

- **Preserving the evidence**. Discuss out of doors the processes active where the pupils are standing. Then consider the evidence for these processes taking place. If the area were to be suddenly buried by ash from a volcanic eruption, which parts of this evidence might then be preserved? This reasoning is the reverse of that used by an earth scientist trying to 'reconstruct' an ancient environment from the evidence buried at the time.
- **Neighbourhood stone watch**. What materials have been used for the school buildings and what were their original sources? This approach reveals that all the materials used, if not organic, originally came from the ground. These findings are reinforced if pupils continue the exercise on their way home.
- **Sorting out sequences**. You can teach the key relative dating principles that earth scientists use to sort out the geological histories of rock sequences, using patched road surfaces and cracked walls – sometimes leaving unanswered questions, as happens in 'real life' for an earth scientist.
- **Tackling rock exposures scientifically**. Using this worksheet on any sedimentary rock exposure, from a window sill of natural stone to a nearby road cutting, you can ask and answer four key questions:
  – What was it like here when the sediments were laid down and buried?
  – What changes happened before the sedimentary rocks came back to the surface?
  – How is the rock being attacked now? What effect has this had on the shape of the land?
  – What could the rocks be used for? Have they been used in the past?

Will my gravestone last?

Gravestones in a Victorian graveyard provide a wonderful resource, not only of a variety of rock types with cut and often polished surfaces, but also the date when each individual stone was first exposed to weathering and erosion. Questions like those below can be addressed by methodical recording of data along an avenue of graves from the church (where the oldest graves are usually found) outwards:

- Which rock type is most resistant to weathering and erosion?
- Which rock type is most prone to the growth of lichen and moss?
- Do north-facing faces on gravestones weather more quickly than south-facing faces?
- Which parts of gravestones weather most quickly – the tops, most affected by rain, or the bottoms, most affected by water rising though capillary action?

- How have the types of rock chosen for gravestones changed over time?

You could build your own worksheets around these questions; more background, including issues to consider, more scientific questions that could be tackled, suitable recording sheets, a rock key, and so on can be found on the ESEU website.

Building-stone trails

Many localities have their own building-stone trails. Local ESEU facilitators across England, Wales and Scotland are familiar with these and are willing to lead visits through the local urban wonderland of building, facing and monumental stones and their impact on the local area.

Any quarry guide

ESEU's *Any quarry guide* (King, 2004a and the ESEU website) is prepared for teachers with little or no experience of using rock faces as educational resources. It offers a series of investigational approaches that may or may not be appropriate, depending on the quality of the exposure and types of rock sequences available in the local area. The guide provides insight into how rock faces can best be used through a series of questions. The questions focus on: weathering, erosion, soil, rock group, grains, sedimentary structures, fossils, crystals, tilted rocks, folds, faults, metamorphism, sequencing, tectonic plates, landscape, quarry economics, quarry potential and recording.

The Earth Science Teachers' Association has published further information for teachers beginning fieldwork, to accompany the *Any quarry guide* (Britnell and Whiteley, 2004; Kennett, 2004; King, 2004b).

The *Steps towards the rock face* alternative

An alternative approach to moving from classroom to field, is provided by ESTA's *Steps towards the rock face* publication (Kennett and King, 1991) (Figure 1). This uses a sequence of three lessons:

- **Thinking it through**. Pupils are asked to consider how and why fieldwork is carried out.
- **Rocks from the big screen**. A picture on a screen and associated rock specimens are used as the basis of 'virtual' fieldwork observations.
- **Rock trail**. Guidance is provided to pupils on preparing their own rock trail in and near the school.

Figure 1 From the cover of ESTA's *Steps towards the rock face – introducing fieldwork* publication (Kennett and King, 1991).

Each *Steps towards the rock face* lesson has pupil worksheets with teacher guidance.

Feedback on ESEU's outdoor activities

ESEU's outdoor workshops, which include many of the activities described above, are less frequently requested than the 'popular' ESEU workshops (Figure 2). However, when they are requested, they are well received, as the feedback evidence shows (Table 1). The evidence also indicates that the teachers are neither more nor less likely to undertake earth science outdoor activities as a result of the workshops (2.5 on a 1–5 scale). This suggests the scale of the challenge to ESEU, and to other agencies offering professional development to science teachers, in developing the use of the outdoor environment for teaching.

Meanwhile, outdoor investigations, such as in graveyards, have been actively encouraged in England through the recent Key Stage 3 Strategy optional module, *Strengthening teaching and learning of geological changes in KS3 science* (DfES, 2004). Whilst delivery of the related professional development workshop is supported by ESEU facilitators, ESEU does not receive detailed feedback on the impact of individual activities.

Table 1 Feedback from 436 participants attending ESEU 'Earth science out of doors' workshops (often in tandem with other workshops) since 2003.

Factor	*Mean feedback on a 1–5 scale (1 = high; 5 = low)*
I found the effectiveness of the INSET to be:	1.7
The interest of the INSET was:	1.7
The relevance of the INSET was:	1.7
The value of the INSET to me was:	1.7
The workshop:	*(1 = strongly agree; 5 = strongly disagree)*
has improved my earth science knowledge and understanding	1.7
has given me new ideas for ways of teaching earth science	1.5
has improved my confidence in teaching earth science	1.9
will increase the amount of earth science practical work I teach	1.7
will increase the amount of earth science investigational work I teach	2.1
will increase the amount of earth science out of doors I teach	2.5
will increase the total amount of earth science I teach	2.4

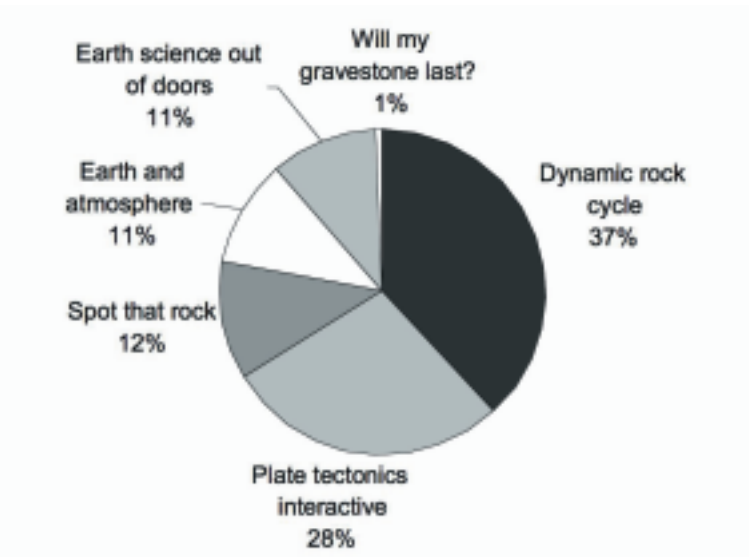

Figure 2 The frequency of presentation of ESEU's workshops – 471 workshops since 2002.

Conclusion

Earth science teaching can be greatly enhanced through use of the local environment. It is relevant to pupils (since it is where they spend much of their time) and it provides a wide range of contexts for investigation and learning. Scientists studying the earth must collect data and this data is mostly collected locally, so pupils collecting local data are 'walking in the footsteps of scientists'. For these reasons, use of the outdoor environment is being strongly supported by the UK Government through its *Education outside the classroom* manifesto.

However, you don't have to launch straight into the field. Try ESEU's stepwise approach to building the confidence of pupils in developing their understanding of how the earth works through the local environment. The materials to do this are either provided in this article or can be found on the ESEU website. ESEU also provides workshops to help you with using these materials and you can book one of these workshops free of charge using the details below.

Not only have all children an entitlement to knowledge and understanding of the environment in which they live, but key future environmental decisions that will affect our planet will be made by those being educated in our schools today. The importance of learning about the environment is best brought home by studying it out of doors. The Earth Science Education Unit will continue to do all in its power to promote the use of the outdoors as a key educational resource.

Acknowledgements

Many thanks to Peter Kennett and Cally Oldershaw of ESEU for their comments on an earlier version of this piece. Many thanks also to Roger Lock and Steve Tilling for their work in developing an 'outdoor theme' for the ASE Annual Conference at Reading in January 2006 and for including an earth science dimension, as described here.

References

Britnell, A. and Whiteley, M. (2004) Getting fieldwork off the ground. *Teaching Earth Sciences*, **29**(2), 5–6.

DfES (2004) *Strengthening teaching and learning of geological changes in KS3 science*. London: Department for Education and Skills.

Kennett, P. and King, C. ed. (1991) *Science of the Earth 11–14: Steps towards the rock face – introducing fieldwork*. Sheffield: Earth Science Teachers' Association, Geo Supplies.

Kennett, P. (2004) Using South Elmsall Quarry (SSSI) as an example of how we can use our local quarry. *Teaching Earth Sciences*, **29**(2), 18–19.

King, C. (2004a) The Earth Science Education Unit *Any quarry guide*. *Teaching Earth Sciences*, **29**(2), 7–15.

King, C. (2004b) How can we use our local quarry? *Teaching Earth Sciences*, **29**(2), 16–17.

Websites

ESEU *Any quarry guide*: www.earthscienceeducation.com/workshops/worksheets/any_quarry_guide.PDF

ESEU *Will my gravestone last?*: www.earthscienceeducation.com/workshops/worksheets/will_my_gravestone_last.PDF

ESEU *Earth science out of doors workshop*: www.earthscienceeducation.com/workshops/worksheets/ES_out_of_doors.PDF

Teachernet *Education outside the classroom* (UK Government manifesto): www.teachernet.gov.uk/teachingandlearning/resourcematerials/museums/outsideclassroom/

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The Earth Science Education Unit

The ESEU offers free workshops (apart from travelling and incidental expenses) to secondary science departments and science teacher training institutions in England and Wales and to groups of primary teachers and primary trainees in Scotland, from its network of 48 facilitators across England, Wales and Scotland.

Contact the ESEU administrator at 01782 584437 or eseu@keele.ac.uk or consult the ESEU website, www.earthscienceeducation.com, for more details.

BOX 1 ESEU's *Earth science through the window* worksheet (possible answers are given in italics)

Part 1 What can you see outside today?

What rock cycle processes are happening today? What products have they left? Answers in ***green*** have been done to help you.

Rock cycle activity	*Rock cycle process*	*Tick if this is happening now, cross if it isn't (√ or x)*	*Rock cycle product I can see:*	
Weathering – break up or break down in situ with no movement of material away [three types working separately or together – physical, chemical, biological]	Physical weathering	*Ticked only if it is freezing/thawing outside.*	Physically weathered material I can see:	• *wall brick or stone cracked by freezing and thawing.* • *surfaces of bricks/stones breaking away (spalling) due to freeze/thaw.*
	Chemical weathering	*Ticked – even if it is not raining or the ground is wet – chemical activity of water in the pore spaces of permeable bricks/rocks will be causing slow breakdown.*	Chemically weathered material I can see:	• *white stains on walls where calcium carbonate has been dissolved and redeposited.* • *blackened surfaces where pollution has produced iron sulfides.*
	Biological weathering	*Ticked if any plants or soil are visible.*	Evidence of biological weathering I can see:	• *soil is a product of biological weathering.* • *the rootlets from lichens or mosses will be causing biological weathering.* • *the roots of any plants will be forcing rock or soil apart.*
Erosion/ transportation – the removal of material/ the beginning of transportation [four agents working separately or together – wind, gravity, water, ice]	Wind erosion/ transportation	*Ticked if wind is blowing.*	Evidence of wind erosion/ transportation I can see:	• *the wind picking up and moving anything.*
	Gravity erosion/ transportation	*Only ticked if anything is seen falling, e.g. leaves from trees in autumn.*	Evidence of gravity erosion/ transportation I can see:	• *falling objects/leaves.*

BOX 1 ESEU's *Earth science through the window* worksheet (continued)

Rock cycle activity	*Rock cycle process*	*Tick if this is happening now, cross if it isn't (√ or x)*	*Rock cycle product I can see:*	
	Water erosion/ transportation	*Ticked if water is flowing during/ after rain.*	Evidence of water erosion/ transportation I can see:	• *water picking up and moving anything, as it flows over the ground or in gutters.*
	Ice erosion/ transportation	***X – ice erosion/ transportation doesn't occur in the UK today.***	Evidence of ice erosion/ transportation I can see:	***• none – only occurs when ice flows over the surface.***
Deposition – material being laid down [by agents of transportation: wind, gravity, ice]	Wind deposition	*Ticked if the wind is blowing – if it is, there must be areas where eroded dust at least is being deposited.*	Evidence of wind deposition I can see:	• *drifts of leaves.* • *drifts of litter.*
	Gravity deposition	*Ticked if things can be seen that have fallen to the ground and not moved, e.g. leaves/ twigs/ litter.*	Evidence of gravity deposition I can see:	• *sediment particles at the foot of walls.* • *leaves/twigs on the ground.* • *litter on the ground.*
	Water deposition	*Ticked if water is flowing – if it is, there must be areas where eroded mud at least is being deposited.*	Evidence of water deposition I can see:	• *sediment in gutters.* • *leaves/twigs washed into piles.*
	Ice deposition	***X – ice deposition doesn't occur in the UK today.***	Evidence of ice depositon I can see:	***• none – only occurs when ice has flowed over the surface.***

BOX 1 ESEU's *Earth science through the window* worksheet (continued)

Part 2: What might you see outside – if you looked through the right window?

Where on Earth might you look through a window to see a rock-cycle process happening – or a rock-cycle product (shown in bold)? Those in ***green*** have been done to help you.

Rock cycle process or product	*Where I might see it through a window*
Ice eroding, transporting and depositing	***View of a glacier.***
Sediments deposited by ice	*View of glacial deposits (e.g. moraine).*
Sediments deposited by water	*View of river or beach deposits.*
Sediments changed into rocks by cementation /compaction	*View of a mountain/cliff/quarry/cutting of sedimentary rocks.*
Metamorphic processes in action	***These could never be seen through the window because they happen deep in the Earth, usually as mountains are being formed on the surface.***
Rocks that have been metamorphosed (formed by metamorphic processes)	*View of a mountain/cliff/quarry/cutting of metamorphic rocks.*
Rocks melting	***This could never be seen through the window because it happens deep in the Earth.***
Molten rock	*View of lava flowing from a volcano.*
Igneous processes in action	*View of an erupting volcano – erupting, lava, bombs or ash.*
Rocks formed by igneous processes	*View of a volcano.*
	View of a mountain/cliff/quarry/cutting of igneous rocks.
Rocks fracturing under great Earth pressures	*View of an earthquake – as the house with its window collapses!*
Rocks deformed by great Earth pressures	*View of a mountain/cliff/quarry/cutting showing folding or faulting.*