GEES Subject Centre
Learning and Teaching Guide

Teaching Geoscience through Fieldwork

Rob Butler

Funded by the Higher Education Academy Subject Centre for Geography,
Earth and Environmental Sciences (GEES)

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Contents

About the author

Rob Butler is Professor of Tectonics at the University of Aberdeen, having moved at the start of 2008 from the University of Leeds. He previously held positions at the Open University and the University of Durham. His research has spanned 27 years with a consistently strong emphasis on fieldwork. This has embraced the Himalayas, Arabia, the Alps and Apennines and even NW Scotland. As a strong believer in active research making for better teaching, he has taken a leading role in developing field training programmes for all undergraduate and postgraduate levels, and to industry professionals. Rob has a keen interest in science communication, outreach and geological conservation, and is currently involved in projects on art and geology in NW Scotland, is a lead author in the forthcoming Geological Conservation Review of Moine Thrust Belt sites and is the Principal Investigator of the Virtual Seismic Atlas Project.

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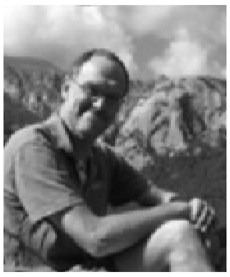
1. Introduction

It is quite possible to acquire a considerable knowledge of Geology by the mere intelligent perusal of text-books. Without having engaged in practical work, one may even learn to read a geological map, and come to understand in a general way the structure of the region it portrays. Knowledge obtained in this fashion, however, is necessarily superficial, and can never supply the place of personal observation or study in the field.

James Geikie (1912).

Graduating geologists who have trained without the benefit of extensive geological fieldwork is like training doctors without ever allowing them to dissect a cadaver.

Mark Cooper (Vice President, Encana, 2007).



Rob Butler

The two quotes, separated by a century in time but by not a blade of grass in belief, capture the central role of field teaching in the geosciences. Of course, the discipline has changed out of all recognition since 1912! As with medicine, teaching objectives and learning outcomes are delivered now in new, increasingly technological ways. Class sizes have increased perhaps twenty-fold. Global travel has brought a vast array of locations into the range of field classes. In recent years there has been increased legislation promoting and demanding wider participation in higher education, reinforcing health and safety provision, bringing access and conservation to the fore. At the time of writing, for the first time the British Standards Institute has become involved in advising on fieldwork, a development that could have far-reaching ramifications for the activity. Educational methods have changed – empowering students to learn without close supervision. Tour-guide style lectures in front of scenery are an increasingly rare teaching method. Students have changed too – in their number, background, experience and expectations. And so have the staff, with decreasing proportions coming from a geoscience first degree. But biggest of all, the science of the Earth has changed together with the communities it serves, demanding constant revision of curricula. It is no surprise then that many departments are re-examining the role and delivery of fieldwork in their various geoscience degree programmes. This guide has been prepared to meet some of these needs and to assist practitioners in making field teaching more effective.

It is worth asking why we continue to teach in the field. And one simple answer is 'because we have to'. The relevant UK's subject benchmark states that 'the integration of fieldwork, experimental and theoretical investigations underpins much of the learning experience in Earth and Environmental Sciences' (QAA, 2007).

Indeed, the Quality Assurance Agency go further, stating that 'it is impossible to develop a satisfactory understanding…without a significant exposure to field-based learning and teaching, and the related assessment'.

In part, this reflects the traditional natural sciences approach where knowledge is founded on good observations. A provision of high quality fieldwork lies at the heart of the requirements of the Geological Society for accrediting degrees. And there is an international dimension to these drivers. The Earth Sciences Subject Area Group in the Tuning (Bologna) Project in Europe, which involves 45 countries, argues that:

> *… appropriate fieldwork (is) a fundamental part of earth science education. All earth scientists, whether or not their employment subsequently requires fieldwork, must understand the methods of acquisition and the limitations of field data.*
>
> (source: Paul Ryan, chair of the Earth Science Subject Area Group, 2007)

Mapping in the Alps - a demanding place for project work

Of course, there is more to fieldwork than just making measurements and observations away from the lecture theatre or laboratory. Consider the four key paradigms identified by the QAA (2007) for earth sciences: uniformitarianism; the extent of geological time; evolution and the history of life; and plate tectonics. These great themes draw on a wide range of science - physical, chemical and biological - and are researched using a vast array of laboratory and modeling approaches. But they also require field observations and the related interpretational skills. Uniformitarianism demands understanding of processes operating in the modern world and the comparison of their products with those in the geological record. The extent of geological time was first deduced by Hutton by the careful observation of unconformities – still important today in interpreting rock sequences and building stratigraphic knowledge. The evolution of life on earth demands careful palaeontological descriptions coupled with palaeoecological deductions that come from the rocks. And the evidence for plate tectonics and a mobile earth is all around us.

Employers and higher degree recruiters place great store on the quality of independent project work amongst applicants, especially when they involve a strong independent field component. In these situations, questions relating to field training and experiences occupy substantial amounts of selection interviews. Apart from the vocational requirements of geoscience degrees, practioners have long recognised the benefits of effective teaching through fieldwork. This is supported by recent pedagogic research – ‘fieldwork is good’ (e.g. Boyle *et al*., 2007). Most departments use fieldwork in their marketing and recruitment campaigns to attract students to their courses. Additionally, it is increasingly being realised that generic scientific investigative skills and personal development, through increased self-reliance and team-building, are greatly enhanced through teaching and learning in the field.

So fieldwork is as important today for effective geoscience training as it was in Geikie’s day. It is within this context that this guide to learning and teaching geoscience through fieldwork has been prepared. The content of the guide has been planned in discussion with colleagues in many geoscience departments, chiefly within the UK, but also internationally. Unlike many other GEES Learning and Teaching Guides, this one relies very little on bringing together previously published studies. There is, however, a long tradition of innovative teaching methods and strategies widely dispersed through the community. Much of the information presented here arises from experiences shared by colleagues around the UK and beyond. Testimony from practioners, students and employers is used to add colour and promote debate. The educational content is placed within a context of duty of care, to individuals, groups and the field resource itself.

The UK’s professional body, the Geological Society, has specific expectations of fieldwork provision for the degree programmes that they accredit. These issues are addressed explicitly under various headings here. In some respects they follow the narrative of more general guides of field teaching (e.g. Williams *et al*., 1999).

The individual chapters in this guide are designed to stand alone wherever possible. While this may have resulted in some repetition, it is hoped that the format is useful for those who wish to dip in and out of a few issues. A number of ‘activity boxes’ (as below) are included to help readers to frame the

ACTIVITY 1

What issues are you facing in your field teaching?

Note: Your answers, as an individual reader, or collated from a group discussion, may be used to prioritise the order in which you access material in this guide, and to interrogate content in more detail as appropriate.

material to their needs. It is hoped that at least some parts will be useful to everyone, from new staff with no significant field teaching experience to the ‘old field dogs’ who have spent more days than they would care to admit out on a rain-soaked mountainside attempting to motivate several dozen students.

So, it is hoped that the guide will promote discussion between colleagues in geoscience departments. The activities may be used to generate components for departmental workshops. It is certainly not intended to give the impression that there is a right way to deliver teaching and learning outcomes in the field. There is a diversity in the design, delivery and support of geoscience teaching through field-work that should be cherished and shared more widely. Although most of the content is structured for integration into first degree programmes, it is certainly not the intention here to imply that field training is only for undergraduates.

Fieldwork is a common requirement of Masters and PhD-level programmes, increasingly requiring formal training. For geologists wishing to maintain their Chartered status, the Geological Society requires that they participate in Continued Professional Development activities. Existing course provision, provided by companies and the higher education sector, is strongly focused on delivery through fieldwork. Many of the broader issues in this guide reach beyond formal training into all aspects of fieldwork, including research.

In the interests of keeping this guide reasonably brief, any additional supporting materials will be hosted on the GEES Subject Centre website. These may include fact sheets based on a series of field classes run by different departments within the UK, workshop notes for staff development purposes and sundry other resources. Many areas of the guide deal with issues where technology and legislation are evolving rapidly and wherever possible, these will be updated on the GEES Subject Centre website at www.gees.ac.uk .

2. Perceptions of fieldwork

As Earth Science teachers, we have all been students and many of us are also recruiters of graduates. Consequently, it is worth reflecting on the key question in Activity 2.

ACTIVITY 2

What do you consider to be the THREE most important reasons for teaching through fieldwork?

2.1 Teacher perceptions

A sounding of professional geoscientists taken in late 2007 yielded the following quotes in response to the question 'why teach fieldwork?'

Because geology IS fieldwork! No point in students knowing what to do in theory, if they can't actually do it in practice.
(Yani Najman, Lancaster University).

Fieldwork facilitates the students' ability to see and understand three dimensions.
(Mary Hubbard, Utah State University).

To me, teaching fieldwork is worthwhile, because during fieldwork students digest and synthesise a broad range of previously obtained (theoretical) knowledge to develop a much deeper understanding of geological processes.
(Fraukje Brouwer, Vrije Universiteit Amsterdam).

I regard geological field work as an essential to learn the kinds of observations on which our entire field is based. The student needs to learn how to judge uncertainties and distinguish between observation and inference.
(Eric Essene, University of Michigan).

The field is where the truth resides; it is the essential core of geology. Models are essential figments of the imagination which must be tested by observation. Those who do no fieldwork and do not gather data will never understand geology.
(John Dewey, University of California at Davis and University College Oxford).

Besides the obvious geological benefits, field schools provide students and faculty with a concentrated period of intense and intimate exposure to one another that is simply not possible within the confines of the classroom. Most field schools require teamwork, and for many students, field school is the first time they learn that it is not enough to be smart, you also have to be able to work with people. Finally, many students will tell you that friendships forged during field school are some of the most intense and long lasting.
(Stephen Johnston, University of Victoria).

Field geology is the BEST way to teach/learn the scientific method - observe, create a hypothesis, make a prediction based upon your hypothesis, test and modify the hypothesis.
(Peter Crowley, Amherst College).

These responses demonstrate a number of key priorities as far as the teachers are concerned. First, there is a clear content driver to teaching through fieldwork: students should experience rocks, landforms and, where appropriate, geological processes. There are some tasks, most notably geological mapping and the inherent 3D visualization skills, that can only be delivered through fieldwork. It is the surgeon and cadaver issue quoted in the Introduction. Similarly, specific data-collection methods and equipment-based learning requires a field rather than classroom setting, most notably in practical geophysics. But there are also more generic learning outcomes that can be delivered efficiently through fieldwork – especially a direct confrontation between data, interpretation and uncertainty, through geological mapping. It is an issue that has been greatly under-represented in academic studies of fieldwork – and is addressed specifically later in this guide.

Intuition from field teachers, that students learn ‘deeper’ in the field, is supported by some educational research. Elkins and Elkins (2007) report findings, albeit from a rather limited sample of first year undergraduates on a single programme, that there are significant improvements in the retention of geoscience knowledge for those students who participated on field classes. Although less formally documented (but see Boyle *et al.*, 2007), there is a general perception amongst staff that field classes deliver a whole range of social benefits, from breaking down teacher-student barriers to enhancing self-reliance amongst students. These personal development aspects are, of course, not restricted to educational fieldwork – they’ve been implicit in educational use of programmes such as the Duke of Edinburgh Award scheme and Outward Bound movement for years.

One might expect the views of geoscience professionals on fieldwork along with many other teaching and learning activities, to be favourable, especially when derived from recollections of their own experiences as students. Yet even the academics identified fieldwork as capable of generating bad experiences. These included remembering being set over-ambitious tasks, visiting poor locations, working in bad weather, being taught by poorly trained or inappropriate staff, being disoriented by lack of context. And, of course, these experiences have informed their own teaching strategies.

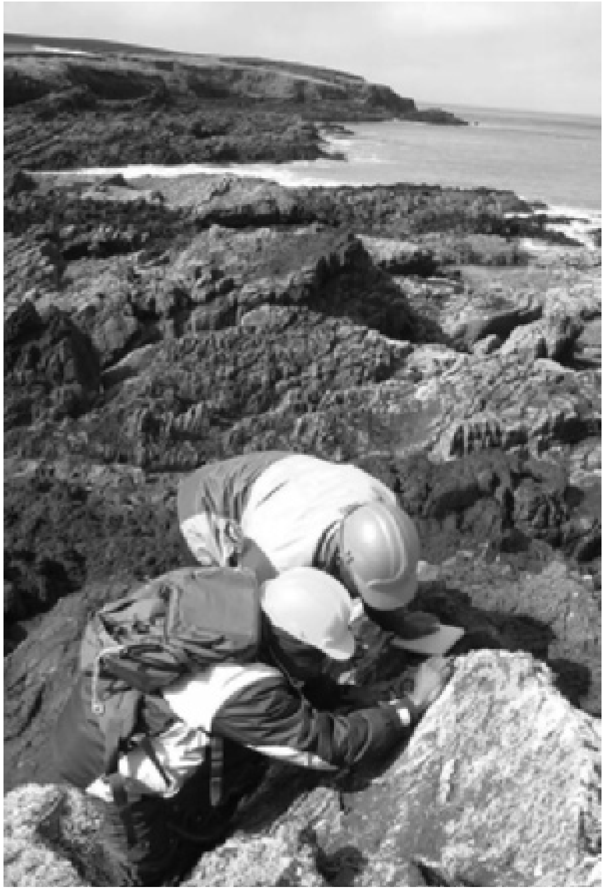
2.2 Student perceptions

> *I really enjoyed the fieldwork – it’s where everything began to make sense.*
> (anonymous Geological Sciences graduate, University of Leeds).

Experience suggests this is a sentiment common to many (if not most) students. Departments have long collected this kind of student testimony on their degree programmes, especially through end-of-course questionnaires and meetings with external examiners. It is common for these to exude praise for the field teaching. These quotes from recent earth science students at Glasgow University are typical:

> *Even in torrential rain everyone was smiling.*
> *The field trips are amazing: you won’t want to come home.*
> (http://www.gla.ac.uk/departments/gesinfo/studenttestimonials/
> Student Testimonials)

Frank Beunk (2007) from the Vrije Universiteit Amsterdam provides this quote from first year geology students after one month of study and an intensive one-week field course in the Ardennes: *'We've learned more than in a month of lectures*.'



Practical measuring skills being honed in Pembrokeshire

Boyle *et al*. (2007) recently presented a larger statistical study of student perceptions of fieldwork. This has the advantage of reaching entire student cohorts, avoiding the potential bias arising from testimony from a few motivated students. The study featured 365 students on 9 field classes from six different institutions. They found that positive feelings towards fieldwork (it being worthwhile, enjoyable and educationally successful) amongst students out-scored negative feelings (didn't enjoy it, found it hard) by a factor of nearly 8:1. Boyle *et al*. (2007) note that their study serves 'to validate what many field-leaders have already learnt anecdotally from their informal and formal evaluations of field courses'.

It is reassuring to staff that they have had a generally realistic appreciation of students' perceptions of fieldwork. This generally positive view is further reflected in the use of images of students learning in the field in marketing and advertising programmes by departments, for recruitment purposes. However, Boyle *et al*.'s (2007) study also showed that many students had strong misgivings about fieldwork before they went on the field class. In general, these fears were greatly diminished by actually going on the field class, an outcome that is presumably reflected strongly in the overall positive views expressed afterwards. But, this does raise an important issue that may reflect changing backgrounds, gender and experiences and of students entering higher education. A practical consequence is that briefings should evolve to account for the changing demographics.

2.3 Employer perceptions

Almost all the information on the perception of fieldwork by employers of geoscience graduates is anecdotal. However, the testimony can be compelling. Consider this quote from Ian Sharp (Chief Researcher – Geology at StatoilHydro, 2007):

> *The industry perspective is clear - the skill to visualise, think and sketch models in 3D gained from field work is absolutely invaluable - if you don't have this then it does not matter how good you are at producing nice attribute images from seismic: if you do not know what you are looking for (i.e. what the geological element/geobody looks like) you cannot find it.*

And it is not just geology. Ken Hamilton of Norfolk Landscape Archeology (2007) says:

> *I think teaching fieldwork is worthwhile because up until recently I worked for a geophysics company where people could go on at length about seismic profiles and interpretations, but had no idea how to set out a grid or relocate a survey on the ground, rendering all of their lovely interpretations irrelevant. This was also the case when I taught geophysics to forensic archaeologists: they understood the geophysical theory (up to a point), but had no idea about how to set up a survey outside.*

Apart from this type of individual testimony, there is little direct data from employers on the value of geoscience fieldwork in the 21st century. A notable exception comes from a 2004 Graduate and Industry Survey conducted by the Irish Geologists' Institute. This showed that, across the whole range of vocational employers, 65% rated field mapping as the most important skill for geology graduates. (http://www.igi.ie).

Of course, some key vocational employers use the field for their own training, commonly carrying out activities that are very similar to those within the conventional educational sector. Consider this testimony (2007) from Frank Peel, an exploration geologist with 20 years experience, with BHP Billiton:

> *Quite simply, we find that the experience of seeing real-world exposures in outcrop, at a scale comparable to that of our seismic data, gives interpreters a feeling for geological architecture that enables them to make better seismic interpretations, which in turn enables us to make better business decisions. When the cost of a single 9-square mile block in the Gulf of Mexico can approach $100 million, the investment of money and time in field workshops can pay off thousand-fold if the right decision is made.*
>
> *We also have found that the experience of combining important technical meetings with meaningful field work can greatly improve relationships with partner companies, and enhance internal communication and understanding.*
>
> *In the era of remote sensing, high-tech geophysics, and ever-more-complex downhole logging, it is more vital than ever to be aware of the basics and the look and feel of real geology that can only be obtained by hands-on experience in the field.*

Nothing beats seeing the real thing - folds at the scale of oil field reservoirs in the Alpine foothills of SE France

3. Fieldwork - what, why, how much?

3.1 What is it?

Fieldwork may be considered to be any activity carried out away from the parent department. For a period, one UK research council operated using this very broad definition to direct resources that otherwise would have funded the collection of data and samples in the natural world to support postgraduate students visiting other laboratories, museums and libraries. Likewise 'fieldwork' describes the activities of not only the Apollo astronauts on moon landings but also the natural scientists that descend into the deep ocean in submersibles. However, for the purposes of this guide such a broad definition is unhelpful.

> *Here fieldwork is held to involve all outdoor teaching and learning activities. Fieldwork in mines, caves or other underground sites raises specific health and safety issues and operating protocols that lie outside the scope of this guide.*

As we shall see, even the narrow definition encompasses a vast range of activity, even when restricted to geoscience sub-disciplines. For some specific details consult chapter 5 of this guide.

ACTIVITY 3

What are your reasons for teaching fieldwork today?

3.2 What's it for?

As we saw in the Perceptions discussion (chapter 2), commonly cited reasons for maintaining a component of fieldwork within curricula, include:

- it is the real world – the only place to learn and practise core subject skills
- it is the only place students can make their own field observations and learn from the experience
- it is the best place to acquire 3D visualisation of concepts and relationships, e.g. the relationship between rock units, and with topography
- it is a great place to promote robust attitudes to data acquisition, especially for equipment-based activities
- uniquely, it can provide motivational / inspirational activities
- it is a great way to enhance social and teamwork skills
- it promotes deeper learning through first hand experience and immersion.

Team-based structural analysis on a road section in SE France

As discussed in the introduction, data from the field underpins the key paradigms of earth science. In many instances, it is more practical (logistically and intellectually) to take students to the current frontiers of knowledge through appropriately designed fieldwork than it is through laboratory experiments or computer modeling exercises. Consider designing a practical exercise to allow students to link their own observations to the ‘Snowball Earth’ hypothesis. A field exercise to observe and interpret a Neoproterozoic tillite could engage all students. On the other hand, geoscience departments are unlikely to have the facilities for any more than a few students to measure paleoclimatic proxies by geochemical analysis.

3.2.1 Key skills and other benefits

Field teaching offers far more than just the opportunity for learning and teaching outcomes of a curriculum-specific nature. It is increasingly being recognised that the field environment offers opportunities for teaching a suite of graduate key skills. Many have found that the field environment is particularly good for:

- setting student-led tasks
- reinforcing scientific method through hypothesis-testing
- developing integrative skills (‘joined up science’)
- problem solving, particularly through the interpretation of incomplete data-sets and managing uncertainty
- dealing with real-life, real-time interdisciplinary problems
- showing the limitations of observations / measurements in problem solving
- developing self-reliance amongst students, taking personal responsibility for safety practices.

All of the above fall within the Graduate Key Skills identified by the QAA Earth Science benchmarks (QAA, 2007). In addition, fieldwork, especially when residential, offers excellent opportunities for quality staff-student and student-student interaction that can greatly enhance the morale of a department.

The general value of fieldwork is recognised beyond the conventional undergraduate forum. For example, many companies with a geoscience base use field activities to foster personal development and team-building. These activities commonly involve a technical geological component, but the participants may have no formal geoscience training. In these situations, it is the opportunity to experience cross-discipline interaction and decision-making in unusual (non-office) situations that is most prized.

3.2.2 Vocational aspects

While it may, of course, be true that, with increasing numbers of students being admitted to courses with geoscience components, the proportion of geoscience graduates being employed within their vocational sector is declining, nonetheless, the actual number of professional geoscientists is steadily increasing. Vocational employers value fieldwork higher than other aspects of the curriculum (see chapter 2). Therefore, there is still a profound vocational driver for including fieldwork within at least some degree programmes. This is especially relevant for departments seeking accreditation of their courses by the Geological Society.

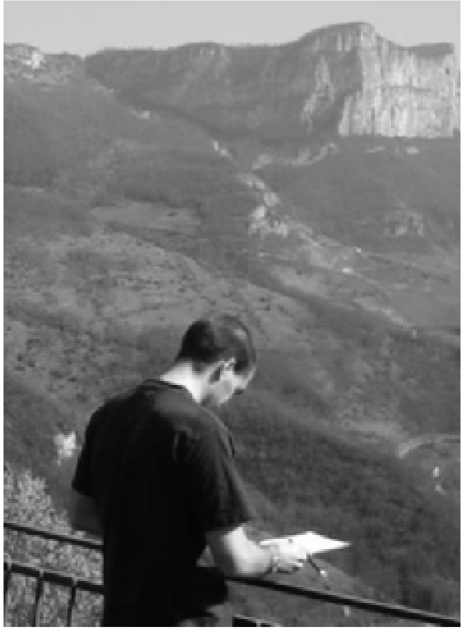
> *Field study has a central role in geoscience education and training and an accredited geoscience degree course must include an extensive programme of field study with clearly defined learning outcomes.*
>
> Accreditation Scheme for First Degree Courses in Geoscience,
> The Geological Society, May 2001)

The scheme defines broad academic requirements in Geoscience degrees that allow graduates to attain Fellowship of the Geological Society and Chartered Geologist status. The amount of taught fieldwork required for accreditation depends on the degree programme (see Table 1). Even without this driver, external examiners have criticised courses with low levels of provision.

3.3 How much taught fieldwork?

The answer to this question will depend on several factors:

- The curriculum requirements of particular degree schemes designed to match the skills, experience and expectations for graduates of the particular degree, and possibly the background of incoming students, together with the expectations of employers or professional bodies (e.g. as stipulated through Geological Society accreditation)
- The resource implications of delivering a field programme, in terms of financial and time commitments for staff and students together with equipment availability
- The availability of suitable sites in the right geographical location.



Basin studies– getting the broader context makes the expense of travelling to SE France worthwhile

There is currently a wide variation in the amount of fieldwork provision within HE. This reflects the duration and specialisation of particular degree programmes. Table 1 relates to compulsory taught field days for those courses accredited by the Geological Society (data provided by Colin Scrutton, Accreditation Officer, 2007).

Programme	Compulsory taught field days
Geology (3 year)	65-87
Geology (4 year)	70-102
Environmental Geoscience (3 year)	42-88
Environmental Geoscience (4 year)	51-83
Applied Geology (3 year)	51-83
Applied Geology (4 year)	56-89
Joint Honours Geology with xxx (3 year)	37-60
Joint Honours Geology with xxx (4 year)	42-72
Geophysics (Geological blend, 3 year)	34-73
Geophysics (Geological blend, 4 year)	42-83
Geophysics (Maths/physics blend, 3 year)	31-32
Geophysics (Maths/physics blend, 4 year)	31-32

Table 1: The Geological Society accredited course—compulsory field days

These numbers exclude optional field classes and project work carried out independently by students. However, it is important to recognise that there are no explicit statements on the number of field days required for accreditation. Within any programme a useful guiding principle should be one of quality over quantity. There is an old adage that 'the best geologist is the one who has seen the most rocks'; oft quoted by those who promote large numbers of field days in a curriculum. It is worth noting, however, that seeing is not the same as understanding. People who see a lot of rocks include operators of excavation machinery or dry-stone wallers who, despite their individual attributes, would rarely claim to be great geoscientists!

ACTIVITY 4

What do you believe constitutes a viable fieldwork programme for each stage of your course?

You might list the teaching and learning outcomes and consider how much time should be devoted to delivering them at the various levels of progression.

The QAA Earth Science subject benchmarks are available on-line at:
http://www.qaa.ac.uk/academicinfrastructure/benchmark/statements/EarthSciences.asp

4. Fieldwork and the curriculum

There are many different ways in which fieldwork can dovetail with the curriculum. Traditionally, fieldwork is used to illustrate and reinforce aspects previously introduced in a lecture or laboratory class. Indeed, a still-common rhetorical question is: how can students be expected to understand something in the field when they have not been introduced to it before? Yet lessons learnt in the field are commonly seen as more deeply embedded and vital than those learnt indoors… So, should fieldwork be driven by lectures? Should curricula be fieldwork-centred, or fieldwork-driven or fieldwork-informed? How much fieldwork should be project-driven? Does the role and positioning of fieldwork depend on which type of fieldwork is being discussed (see chapter 5)? Then there are other issues – particularly tracking skills progressions (both subject-specific and key) through an array of field courses.

With increased modularisation and the division of degree programmes into distinct portions, fieldwork, like many other parts of the curriculum, can appear at times to be a semi-detached activity, removed from other learning outcomes. As bureaucracy increases in higher education, there may be increased reluctance to modify modules with complex logistics, such as field classes, which may reduce curriculum links as other parts of a programme evolve. Clearly, it is beneficial if students integrate their experiences with the rest of their degree programme and, increasingly, these links are defined explicitly in module / course documentation. In some instances, fieldwork can be embedded within modules and explicitly supported by lectures and practical classes. The use of Google Earth and equivalent internet tools (chapter 6) may provide a convenient bridge between the field and the classroom.

ACTIVITY 5

One way to reflect on these issues is to choose a particular collection of knowledge – perhaps a learning outcome – that is delivered in your existing curriculum, partly through lectures, and practicals and partly through fieldwork. For example, understanding the 3D geometry of planar surfaces through their interaction with landscape.

Traditionally, this issue is taught perhaps first through a lecture describing how sedimentary rocks are deposited sequentially in layers, quoting the ‘law of superposition’. Practical classes may go on to apply this to published maps, involving the construction of structure contours. Finally, students may be introduced to a real example in the field where they could be asked to map a boundary and then draw structure contours on their own mapped boundary.

Could you turn this teaching strategy on its head, starting with the field and then leading up to the ‘law of superposition’? What changes would this demand of your curriculum? What are the pros and cons of these two approaches? Can you think of other examples where such a redesign might lead to more successful delivery of learning outcomes?

Students confronting their posters (created before leaving on a field class) with the outdoor reality - a great way of integrating laboratory and field teaching

A major challenge facing many geoscience programmes lies in the definition of credit weighting for fieldwork. Here are two sides of this argument: from the student point of view, a two-week field class is approximately 8% of an academic year; if, however, the class is viewed in terms of hours of staff-student contact time (say 70-80 hours) it may equate to >25% of the annual load. In at least one geoscience department a conventional, on-campus ten credit module (out of an annual 120 credits for full-time students) is viewed as equating to 100 hours of student activity. This will generally split into about 25 hours of contact lecturing / practicals with the balance taken by student-driven learning (reading, working up notes and so forth). The same department equates 10 credits for a two-week field class (of which 11 days are taken by field work, the others are travel / rest days), with a working day being about 9 hours. These activity hours are roughly equivalent provided no further periods of activity (including reflection, revision or other forms of exam preparation) are required by the students. Thus, it might be viewed as inappropriate to assess this field class by an extended report (which might occupy students for many more hours).

4.1 Design issues

There are many issues relating to broader curricula that arise when designing or reviewing a field class. One approach is to view a field class as an investment in the learning and teaching of a student group. By electing to run a field class later in the programme, the investment can be directed at students more likely to use the experience in future careers. This viewpoint recognises and values the vocational education strand. However, field classes are commonly cited by students, especially the less academically-driven, as providing extremely effective teaching and learning environments. Consequently, although a field class that takes place early in a degree programme may be delivered to a large group of students, the investment may be repaid by greater retention of students and a more receptive student group for other teaching and learning exercises. A similar balance can be struck when considering if a particular field class is optional or compulsory. In general, it is easier to integrate teaching and learning outcomes from particular field classes with the rest of the curriculum, if the field class is compulsory and run relatively early in a degree programme. Optional field classes run at the end of a programme are far harder to integrate.

ACTIVITY 6

How does your department currently resolve the intensity of field teaching with other forms of teaching and learning activity?

Do you feel that that balance is correctly drawn for staff and students alike?

4.2 Progression and development of field skills

One of the key aims of field classes during the first two years of degree schemes is to prepare students for their independent project work. This involves carefully developing and nurturing skills.

One example of skills progression for geoscience students is:

- operating and navigating in the countryside
- use of equipment (e.g. compass-clinometer)
- elementary observations, measurements and recording (e.g. simple lithologies, structural relationships, use of compass-clinometer, keeping a good notebook field sketching)
- more advanced observations, recording and analysis (e.g. hazard assessment, sedimentary logging, stereonet plotting, model building)
- synthesis (e.g. cross-sections, sedimentary environments, simple geological histories)
- making a geological map and related cross-sections
- advanced synthesis skills (e.g. complex geological histories, model building and testing, report writing).

ACTIVITY 7

Why not list or brainstorm the skills acquired by students through the successful delivery of learning outcomes during fieldwork for a specific degree?

Now list these in the desired order of acquisition.

How do these tie into your field programme?

How well-paced is your schedule?

Acquisition of these general skills can run alongside the development of training in specific aspects that link explicitly to modules / material delivered in-house (e.g. rock description / petrology, sedimentary environments, map interpretation, geophysical data processing).

ACTIVITY 8

A conundrum

A key milestone in the development of field skills by students is their dissertation project. To maximise opportunities and to make project work effective, students might reasonably expect that the bulk of their field training will occur in the early part of their degree programme. However, many departments offer common teaching through early parts of the courses to maximise transferability between degree programmes. Consequently, some of the more specialised teaching and learning outcomes for particular degree schemes may become part of a wider curriculum. Investing in such a strategy may represent an inefficient use of resources.

Do you relate to these statements?

How might you strike the right balance?

5. Mode of fieldwork

The logistics of field classes can be highly variable depending on their duration and location. These can be grouped into 'modes', each of which raises distinct issues.

There is more information on field locations in chapter 8.

ACTIVITY 9

Characterise the portfolio of fieldwork learning outcomes through a particular degree programme, placing them under the following headings:

- Non-residential fieldwork
- Short residential (e.g. weekend)
- Longer residential (in country of HEI)
- Overseas field classes
- Student-driven project work
- 'Virtual fieldwork'

Now do the same for the key skills.

Are these outcomes and skills best achieved by your current programme design?

5.1 Non-residential fieldwork

In this scenario, students are based at their home institution. The fieldwork may take the form of a short, specific exercise. Examples include learning to use instrumentation (e.g. a magnetometer or portable field colorimeter), collection of samples (e.g. local river waters) or visiting sites that demonstrate concepts taught in the lecture theatre (e.g. local geological outcrops, wastewater treatment facilities, working mines or quarries, etc.). Clearly, all these activities strongly depend on what is accessible from the home institution. If the exercise forms part of a conventional working day, there may be issues relating to, for example, clothing (including sitting around in lectures in damp or muddy clothes) to be considered with respect to the other activities students might attend. Short exercises may readily fit into conventional work-plans. Perhaps a more common form of fieldwork occurs when the exercise occupies the full day. Many departments run single-day field classes, scheduled either during the normal working week or the weekend. Again the ability to deliver fieldwork in this way is strongly influenced by the location of the home institution, and the availability of staff and students.

5.2 Residential fieldwork

5.2.1 Weekend residential

Many departments run residential field classes at weekends to allow access to sites that are beyond the reach of single-day classes. These can be easier to schedule in the teaching programme, certainly compared with longer-duration residential classes. Further, it may be easier to integrate fieldwork with conventional in-house teaching. However, the costs per student / field day may be higher than longer excursions. For many departments, weekend field classes were once a key component of their training programme. However, as society has changed, for example, with students increasingly taking on part-time weekend employment during term-time, this mode of fieldwork is increasingly difficult.

5.2.2 Longer residential

In some countries either without the variety of appropriate field sites within relatively easy reach, or with harsher climates than the UK, fieldwork is delivered in concentrated ‘summer camps’. Although this tradition does not exist in the UK, longer (1-2 week) residential classes still form the cornerstones of fieldwork provision within all geoscience degree programmes. In general, the justification for these classes rests on curriculum decisions – technical content determines the location and hence the delivery. For example, the particular focus of a field class (e.g. mapping terrain, specific rocks, materials or experiments) may not be deliverable locally. In general, a series of tasks can be combined in a distant site over the duration of a single residential class located appropriately. There are also distinct advantages in this style of delivery. These include:

- ‘total immersion’ in a teaching and learning environment can bring home key outcomes
- greater opportunity for teamwork – both educationally and socially;
- better interactions between staff and students
- cost-efficiency – as travel is commonly a major expense.

Traditionally, long residential field classes are scheduled for periods outside the conventional teaching period of the home institution. However, it is increasingly being realised that this can put unacceptable demands on students, who otherwise could be in employment, and on staff, who could be engaged in research or simply enjoying a well-earned break. Residential field classes complicate striking an appropriate work-life balance, regardless of specific timing in the academic year. But it may be very difficult to schedule field classes within a teaching term, particularly when students are taught by more than one department (e.g. combined honours students, modular degree courses). Further, some students may find the experience of long periods away with their peers, in an alien environment, disturbing, as noted by Boyle *et al*. (2007). All these factors make good planning and early notification of logistics especially important (see chapter 6).

5.3 Virtual fieldwork

With the development of increasingly powerful visualisation software, many groups are exploring delivering some part of their fieldwork provision ‘virtually’. Over the coming years, full 3D visualisation suites are likely to become available for some departments (some already exist for interpreting 3D seismic data). At present ‘virtual field trips’ are delivered on conventional computer monitors, commonly via the internet. More elaborate data-rich exercises are delivered via DVD and other media.

There are clear advantages if field skills can be taught via virtual exercises rather than physically visiting sites. Commonly cited reasons are:

- cost
- widening access (e.g. to mobility-impaired students or those with carer-responsibilities)
- easier to timetable.

But can virtual fieldwork replicate effectively the teaching and learning outcomes of real fieldwork? There are many who believe that it does not, nor can it. Some indeed view the concept of virtual fieldwork as deeply damaging to their discipline. They cite issues such as:

- the virtual environment is too controlled
- virtual materials cannot replicate real objects (e.g. rocks) – only visual aspects (e.g. views of landscape or outcrops)
- students may treat a virtual field trip as a computer game and thus not learn the analytical workflows or problem-solve in the same way as when confronted by the ‘real thing’
- a virtual environment cannot recreate the challenges of doing science in a ‘hostile’ setting, which develops self-reliance and professional attitudes
- it can’t recreate the social benefits of field classes, especially residential ones
- funders may see it as a way of avoiding support for seemingly expensive residential classes
- it devalues the skills and experience of field teachers.

It is worth noting that many oil companies strongly encourage their geoscientists engaged in seismic interpretation (activities that lie at the technological cutting edge of the virtual experience in spatial data analysis) to ground their understanding in ‘real world’ field experience. Thus, rather than viewing virtual environments as opportunities to replace outdoor geology, perhaps a better approach is to promote virtual field exercises as a way of making laboratory materials more exciting and applicable. They can also enhance briefings and de-briefings of field classes, integrating with the broader curriculum. Computer-based materials can provide valuable support for student-driven learning. These are addressed elsewhere in this guide.

5.4 Independent fieldwork

Almost all geoscience degree programmes require some form of project work. In many cases, particularly for Accredited Degrees, this involves fieldwork for periods of between 4-6 weeks. There are many different styles to these projects. Some of the issues are discussed in chapter 9.

5.5 Fieldwork on a work placement

Some geoscience degrees provide opportunities for internships as part of their curriculum. These may take the form of an entire year with a company (commonly the third year of study in a four-year programme) or shorter periods (for example during the summer vacation). There are a great many companies and not-for-profit organizations that have hosted students otherwise enrolled on geoscience degrees over the years. These range from geological surveys, geophysical acquisition companies, engineering firms and environmental consultancies. The range is almost as great as the variety in employers for geoscience graduates. Many provide opportunities for fieldwork, or may require participation as part of their internship agreement. It may be desirable for departments to ensure that the activities proposed by the host organization are consistent with those run by the university. These may include ensuring that the project work and tasks are appropriate, and that the levels of supervision are adequate. Health and safety aspects of internships are covered in the UK by statutory legislation (see chapter 11). For overseas activities the situation is complex – it falls under the area of BS 8848 (see chapter 8). A brief on BS 8848 has been developed by the GEES Subject Centre and is available at www.gees.ac.uk.

6. Preparation for fieldwork

Failing to plan is planning to fail...

With increased student numbers, changing student expectations, limitations on staff time and availability of accommodation, many field classes are planned years in advance. Some information may be needed well ahead of the delivery. There are issues relating to health and safety and equal opportunities that impact on field class preparation. Furthermore, if your host institution claims adherence to the new British Standard (BS 8848; British Standards Institute, 2007) that addresses the provision of fieldwork outside the UK, then there will be specific protocols that will be required. The overarching principle of BS 8848 is incontestable and applicable equally to all field teaching, namely that all participants in a field class should know what to expect before they commit to going on the field class. For compulsory classes, this information may be needed by prospective students before they enrol on the degree programme. Certainly, students could expect to know the amount and general timing of field classes for their programme ahead of enrolment to assess the impact on their finances or responsibilities as carers during their degree. Specific aspects are discussed in chapters 9 to 11. The apprehensions noted by Boyle *et al*. (2007, see chapter 2) that some students have towards fieldwork might be addressed by involving them in briefings, at the start of the course and well ahead of specific field classes.

The bulk of this chapter consists of a check-list for the preparation of field classes. Such approaches unavoidably are incomplete – but hopefully the main aspects in planning a field class are caught here. You may prefer to use this material through examining one or more scenarios.

There is much experience of rapid redesign of field classes widely dispersed within the UK geoscience community. The 2001 outbreak of Foot and Mouth Disease and the consequent access restrictions to UK countryside meant relocating field classes to numerous overseas venues in a matter of weeks or months. It is worth seeking out those who implemented these changes to share the lessons in logistics.

Aspects of logistics and delivery once field classes are running are discussed elsewhere in this guide. The following check-list covers issues that may arise in the period leading up to and following a typical residential field class.

ACTIVITY 10

To the following general scenarios, you might like to add your own specific details:

Scenario 1:
You are relocating an existing field class from its current field location to an entirely new location, because an increase in student numbers renders the existing site untenable. You have one year's notice to deliver the new programme. Itemise the necessary steps in the redesign.

Scenario 2:
Pressure to save resources requires you to cut one day from an existing 7 day field class. How will you approach this problem?

Over a year ahead

- develop the broad objectives of the particular field class within the context of the wider curriculum and with reference to the desired learning outcomes
- for overseas classes, establish local contacts to support the pre-delivery logistics and provide critical liaison and support once the class is running
- establish any licensing requirements for equipment (e.g. satellite phones, ground penetrating radar etc.) that may exist in some countries
- plan the finances
- inform incoming / applying students of dates, costs and necessary equipment / clothing requirements
- book accommodation (if visiting popular sites – many departments have rolling bookings of field centres or holiday complexes)
- establish staffing requirements. Note if the student cohort includes under 18s then there may be statutory child protection checks for all staff on residential classes
- identify whether the group (students and staff) include any individuals with disabilities
- establish any location-specific health requirements (e.g. vaccinations) and plan appropriate implementation
- for overseas classes, check visa requirements, including for all the nationalities of participating students
- establish general permissions to key sites
- check tide times for coastal sites.

Months before field class

- arrange transport
- review bookings
- confirm permissions
- review field locations (hazard assessments)
- confirm specific dates with students
- confirm staffing and expertise (including first aid training)
- check any equipment is serviceable.

Weeks / days leading up to the field class

- organise any financial advance for the class
- collate student details (contact information)
- collate medical information (update for any recent conditions – e.g. sports injuries!)
- brief students with general aims of class, logistical details etc. (as noted above, the timing, costs and general requirements of the class should be notified to students much earlier, perhaps prior to enrolment)
- run preparatory classes to revise specific techniques etc.
- prepare field guide and other materials
- organise all technical and health / safety materials
- brief staff and agree duties
- confirm transport arrangements with external operators
- confirm arrival plans etc. with accommodation / sites
- prepare final student lists (for monitoring on the class)
- leave contact details for the class, the attendance and any other relevant information with home department.

After a field class

- report any incidents (e.g. health and safety breaches) to appropriate safety officer
- debrief the exercises with staff involved
- assess student work – give feedback to students (this may also have happened during the class)
- review practices that can feed back into planning of future field classes.

Please add items to this list that you may have encountered, exploring the scenarios at the start of the chapter (or others)!

7. Field activities

The range of activity undertaken on geoscience field classes is vast so that this chapter can only provide a brief introduction. Commonly there are strong vocational/practical reasons for this diversity: graduating geoscientists are expected to have particular subject-specific skill sets. Training in these commonly requires a high level of staff involvement, especially at an early stage in the exercise, with staff-student ratios dependent upon the specific tasks. However, the move over recent years to historically large class sizes can place significant strains on the delivery of core subject-specific technical field skills. Some of these issues are discussed later in the chapter.

Geoscience fieldwork might involve some or all of the following:

- sample collection (e.g. river water, soil, rocks, fossils)
- experimentation (e.g. water quality measurements, gravity or magnetic survey)
- data collection
- observing materials in their natural state
- establishing the relationship between rock units (at an outcrop scale)
- geological mapping.

7.1 Activities

Fieldwork can involve a wide range of activities. In its Guidelines on Fieldwork in Accredited Geoscience Degree Courses, the Geological Society (2001) identify four types of field-based study:

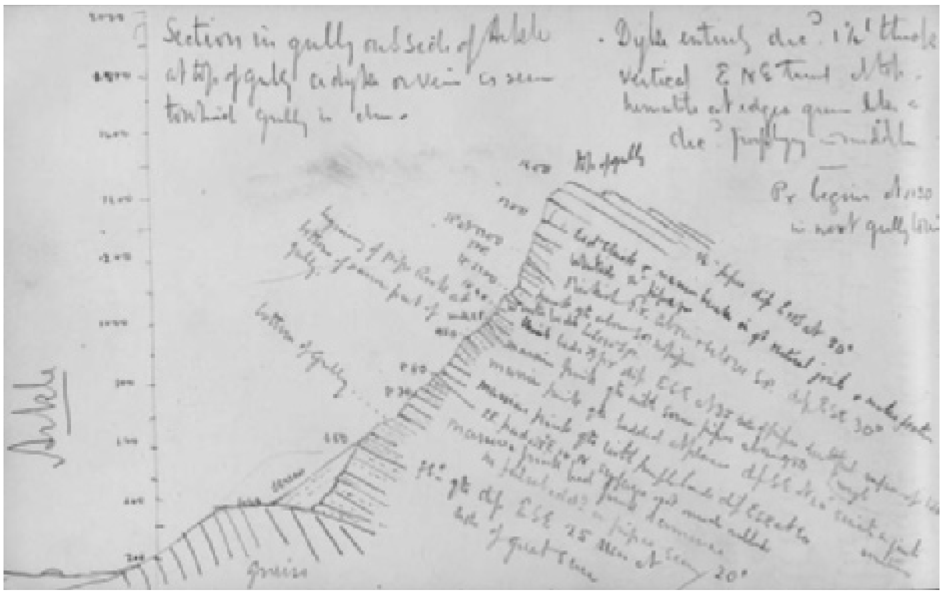
- basic field study
- equipment-based field study
- mapping
- investigative field study.

Full details are available in the guidelines themselves (The Geological Society, 2001). Note, however that some activities may straddle one or more of these headings. For our purposes it may be more helpful to outline some specific skills and activities.

7.1.1 Notebook skills

These include the practice of keeping a notebook as a document of scientific research, where hypotheses, methods, data, observations, interpretations, hypothesis modification and planning the rest of the task are distinctly and systematically laid out. In this regard the field note book, at its most basic, serves as a well-structured laboratory record. Students may well have been trained to keep such records as part of their pre-university education. However, fieldwork commonly requires more complex ‘experiments’ that demand constant course-corrections in the testing of hypotheses. These may be summarized in the notebook, along with the results, in an ‘end-of-day’ synthesis.

Fundamental to geological fieldwork is the requirement to record the geometric relationships between objects. This will commonly be achieved using sketches. Carefully drawing the relationships between objects and their orientations apparent in the outcrop focuses students on the careful interrogation of geological features, enhancing their observational skills. Photography can never achieve this. Furthermore, data and more detailed observations can be tied into a field sketch to show the spatial relationships between them. Generally, a sketch that records the basic observations will be supplemented by further diagrams that portray an idealized version of the deduced geology (e.g. a sketch cross-section) and its evolution in time.



Notebooks – as important today as they were for Henry Cadell in the 1880s. A page from one of his NW Highlands notebooks shows how observations can be tied to locations – shown on a hillside profile on the mountain Arkle

There are challenges in training students to make effective field sketches. It is not un-common for them to think of sketching as an art-class and an activity that requires some intrinsic drawing ability. There are large numbers of ‘how to sketch’ guides available in art-stores and other retail outlets. However, simple recommendation of these will generally not serve to make students better interpreters of geology! In the experience of many field teachers, the best training strategy is through direct demonstrations, with teachers in the field drawing sketches in front of students, rather than pointing out features on some hillside on a large photograph acquired on an earlier visit!

For many field classes, student field notebooks are a prime focus of assessment (see chapter 13), especially during the field class itself. However, a field notebook can also serve as a reflective teaching and learning diary specific to a student. Many departments also insist that students record factors that might influence their performance as field investigators (e.g. meteorological conditions, time available, mood). Documenting perceived hazards and the strategies for their mitigation may also form part of a health and safety awareness strategy (discussed further in chapter 11).

7.1.2 Field description of rocks

Making basic descriptions of rocks in hand-specimen is commonly regarded as a key skill for geologists, a necessary precursor for many, more-involved tasks. Many students find this especially difficult, not only because of the difficulties of operating in the field, perhaps in non-ideal meteorological conditions, but also because of the great variety of colour, hue, shape and habit shown by the same mineral phase in different rocks. Handling this variety demands experience that can be difficult to obtain over a few field days. In part, the problem can be addressed through linking fieldwork to laboratory exercises using appropriate hand specimen collections. This approach might also be adopted for enhancing field studies of fossils and other materials.

The Geological Society's Society's handbook series provides lots of subject-specific information on the collection of geoscience data, particularly applied to the main groups of rocks (see Table 2).

Some of the Geological Society's handbook series:

Barnes, J. (1995) Basic Geological Mapping, Geological Society of London Handbook Series (Chichester: John Wiley and Sons Ltd.).

Fry, N. (1991) The Field Description of Metamorphic Rocks, Geological Society of London Handbook Series (Chichester: John Wiley & Sons Ltd.).

Goldring, R., (1991). Fossils in the field. Longman Scientific, Harlow. 217 pp.

McClay, K. (1995) The Mapping of Geological Structures, Geological Society of London Handbook Series (Chichester: John Wiley & Sons Ltd.).

Thorpe, R. & Brown, G. (1991) The Field Description of Igneous Rocks, Geological Society of London Handbook Series (Chichester: John Wiley & Sons Ltd.).

Tucker, M. (1996) Sedimentary Rocks in the Field (Chichester: John Wiley & Sons Ltd.).

Table 2

7.1.3 Lithostratigraphic logging

Lithostratigraphic logging is the recording of the variation in a succession of rocks. Most commonly this is applied to sedimentary rocks and, to a lesser extent, to igneous units such as cumulates and volcanics. However, the methods are equally appropriate to all materials, especially when layered. In effect, logs are line-scans that capture the spatial scales of variation of attributes (e.g. grain size, composition, texture). In more advanced examples, particularly in sedimentary logging, a whole range of depositional and palaeo-biological information can be drawn together – with the log format providing immediate spatial correlations between different geological attributes.

Practical information on the construction of graphic sedimentary logs is available in many sedimentology text-books (e.g. Tucker, 1996; Nichols, 1999).

Logging sandstones demands careful observations

7.1.4 Basic measuring skills

Almost all fieldwork in the geosciences involves the collection of quantitative data using various forms of measuring instruments. In geology a key tool is the compass-clinometer, used to measure the orientation of linear and planar rock features. Measuring skills generally underpin the use of more specialised equipment as discussed below.

7.1.5 Equipment-based field studies

Beyond the use of very simple tools, there is a wide range of equipment-based field training in the Earth Sciences. These fall into broad categories:

Geophysical fieldwork has classically involved surveys collecting potential field data (using gravimeters and magnetometers), resistivity measurements and shallow seismic experiments (e.g. using a hammer and plate as a seismic source). Increasingly, project work involves monitoring of natural seismic sources (e.g. active volcanoes), in collaboration with permanent observatories. Geochemical fieldwork may take the form of sampling – solid materials, water etc. Each requires its own strategies, particularly concerning safe practice.

The advent of relatively cheap, portable and/or disposable analytical field kits has increased the opportunity of carrying out geochemical studies and integrating the results with other data sets while still in the field. These can be integrated with monitoring equipment such as pH and resistivity meters. However, it is generally necessary to carry out careful reconnaissance, for example to ensure key differences in water chemistry along a river fall within the sensitivity of the equipment / field test kits.

The nature of equipment-based fieldwork varies very greatly between different degree schemes and institutions. Nevertheless, the Geological Society states that, as part of accredited geoscience degrees, 'Students need to be aware of the principles and applications of equipment-based field study and should also have the opportunity to use appropriate equipment in any independent field-based investigations that they carry out.' Further details and specific expectations are outlined in the Guidelines on Fieldwork in Accredited Geoscience Degree Courses (Appendix 2, The Geological Society, 2001). An example of literature to support equipment-based geoscience fieldwork includes:

Milsom, J., 1996. Field geophysics (Second edition). John Wiley & Sons, Chichester. 189 pp.

7.1.6 Geological mapping

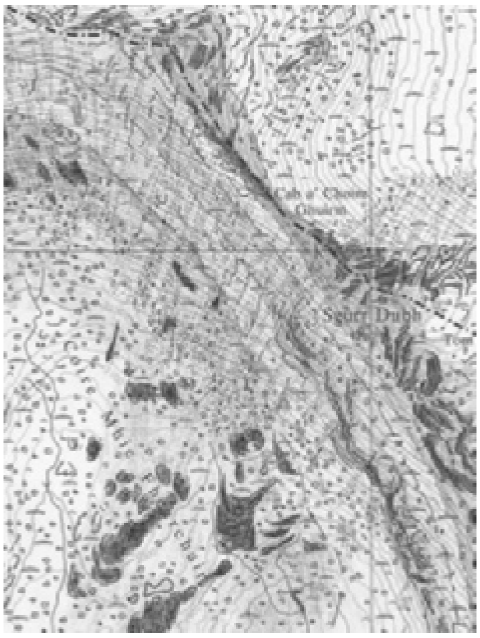
Making a geological map was once the cornerstone of geological fieldwork. However, there is an increasingly prevalent view that field mapping is an old-fashioned and outmoded training element. Few graduates are employed by geological surveys. There is increased use of remotely sensed data for map-making. However, there is a counter-view supporting the continued teaching of mapping:

> *Having worked in industry for 24 years I can think of no better training than field-mapping projects for maturing ability in effective interpretation of 3 dimensional geological structures.*
>
> Steve Matthews, Arctic Regional Project Manager, BP
>
> *Spatial 3D visualisation skills are best gained by trying to think and visualise (in your head) in the field, especially through mapping projects or section construction. This is how I and colleagues of my era gained competence. I have noticed with new hires and summer students that they are not given enough time or opportunity to build up this skill, but that they seem very keen to gain it. This skill lies at the core of an exploration geologist.*
>
> Ian Sharp, StatoilHydro

Consequently, geological mapping is explicitly mentioned as a subject-specific skill in the QAA benchmark statement (QAA, 2007). 3D structural geology is a critical vocational demand in the hydrocarbons industry and increasingly in the environmental sector in studying aspects such as ground-water pollution. The ability to map effectively requires a rigorous approach to data collection and management (rather than wandering randomly through a landscape) and for dealing with scientific uncertainty. This in turn offers efficient platforms for training in problem solving and scientific method, in a potentially stressful and non-laboratory environment, that has far wider application than merely the making of geological maps.

There are many different types of geological map. The mapping referred to by the industry-based geoscientists quoted above is conventional lithostratigraphic mapping at scales of 1:25,000 to 1:10,000. Working at these scales, the interplay between geology and topography must be appreciated if a geological map is to be constructed effectively. However, this scale of working is not appropriate for all problems. Consequently many geoscience departments give training in more detailed approaches, such as grid-mapping on individual outcrops, plane-tabling and base-line and compass methods. In these situations additional surveying skills may need to be introduced, perhaps using modern global positioning systems (GPS) and laser-ranging technologies.

Many departments engaged in conventional-scale map training emphasise the importance of making all decisions on boundary positions (including faults) directly in the field. In this way additional, non-outcrop features (e.g. sink-holes and other subtle geomorphological features) can be checked and incorporated into the map. Far more critically, the student is then required to assess the distinction between data and inference in building a coherent interpretation. Making decisions as to the position of a boundary 'on the hoof' means students can start to predict its position in the unmapped ground ahead, then go in to test the prediction. No wonder geological mapping is viewed by its proponents as one of the most effective ways of teaching the scientific method of hypothesis building and testing.



Reconnaisance field map of part of NW Scotland

There are many different techniques that are used to make geological maps. Perhaps the easiest to contemplate, and also the most widely-adopted model, is where the mapper visits all outcrops and walks out all boundaries between units (including faults). Not only can this be very time-consuming; it can also be impractical because of the nature of the terrain. In more mountainous countryside, boundaries and rocks may need identification from a distance, only ground-truthed sporadically. Many students find themselves using this approach during their project work. Consequently, it may be necessary for departments to consider appropriate training in only partially accessible landscapes. Similarly, it may be appropriate to introduce the use of remotely sensed data (satellite and / or air photographs) to field classes.

Field mapping can be very challenging for students as it requires complex multi-tasking and problem solving. It requires high levels of motivation, maintained for hours (and days) on end. Often the only direct reassurance that a result is being achieved will come from the map itself. This makes it especially important that students consolidate their mapping each evening, traditionally done by 'inking-in' their data and line-work. But it is also an activity that is well-suited to staff performing the task in parallel, including the evening 'ink-in'. Thus they can serve as role-models and show that the results can at times only be won-hard!

New technologies in mapping

The availability of GPS receivers at affordable prices is driving a move towards using direct geographic information systems (GIS)/computer-based recording of field data and real-time digital mapping. Proponents might list the following as advantages of integrating GPS receivers explicitly into field teaching:

- rapid and accurate location of outcrops
- opportunity for tracing boundaries by direct digital mapping
- readily generated output
- compatibility with GIS analysis of data
- some students are covertly using GPS already.

Others view the use of GPS negatively, citing these reasons:

- devalues role of students, who can become human cursors
- possible unreliability of equipment in hostile weather conditions
- still relatively expensive (compared with existing hard-copy approach)
- difficulty in mapping boundaries in from a distance (across inaccessible ground)
- problems with thick tree-cover
- battery recharging, especially in remote areas
- reliance on technology – with the possibility for typographic or grid-system errors going unrecognised.

Doubtless there are opportunities for striking a balance and using GPS and other GIS methods directly during field training. However, in some cases students are implementing GPS technology themselves on field classes on an *ad hoc* basis, which may not be entirely desirable. As these issues are still subject to active debate and evaluation in the community, further discussion here is unwarranted.

Google Earth (http://earth.google.com)

The advent of open-access GIS platforms on the internet such as Google Earth greatly enhances teaching opportunities. Given the progress of developments of these resources any detailed comments here are bound to be superceded before publication. However, existing tools on Google Earth are worth noting. Chief amongst these is the ability to drape any image over the digital elevation model held by the program. Thus students can drop scanned versions of their own field maps onto a virtual topography and then inspect it with perspectives views. This can allow a rapid appraisal of the plausibility of geological interpretations, especially for simple boundary forms and structures.

While this is unlikely to be carried out while actually in the field, increasing availability of the internet (or cached imagery on self-standing computers) at field class accommodation sites makes these strategies increasingly practical. Additional functionality in Google Earth includes the ability to link field sketches, photographs and interpretational commentary, creating 'virtual field trips'. Several institutions are using these approaches in tutorials and other small group environments to enhance debriefing and formative feedback strategies.

Another use of Google Earth technology is to set up pre-field class exercises so that students can assess not only the geology but also the terrain prior to a particular class. The increasing availability of digital geological data products greatly enhances opportunities here – and thus for linking student fieldwork directly to other parts of the curriculum (see chapter 4).

7.2 Class sizes

Modern class sizes represent significant challenges to teachers attempting to deliver the range of technical geoscience training in the field. All practical work in science education can be intensive on staff involvement. In the field, health and safety issues (as discussed in chapter 10) are likely to constrain levels of staff supervision. Specific staff-student ratios required to maintain appropriate safety levels depend on the nature of the task, the environment within which it is taking place and the experience of the participants. Here we are concerned with delivering the teaching and learning outcomes. Consider this testimony:

> *Fieldwork is a key area of learning in geology since the natural world forms the main laboratory in which most of our studies are carried out. In the field, a broad range of skills and techniques have to be learnt quickly and applied to complex problems, often in quite difficult conditions (poor outcrop, preservation or weather!). This means that you [the student] are on a steep learning curve from the outset and one-to-one teaching combined with oral feedback and discussion is needed. You have to draw together a diverse range of facts and skills learnt previously during lectures and practical classes and to apply that knowledge to non-idealised real examples.*
>
> (Bob Holdsworth, University of Durham, 2007)

A more jaundiced (although typically forthright) view is taken by a vocational employer.

> *The fundamental thing that defines our science is field mapping and section construction, otherwise we should be doing materials science, chemistry or fiction writing. Most interviewees at PhD level and beyond are incapable of drawing a cross section that is compatible with a map. Concepts which were fundamental to geology courses 25 years ago are not being taught. Undergraduate mapping classes are handed off to graduate students so there is no real experienced map interpretation and field work mentoring in many places.*
>
> (Alan Gibbs, Midland Valley Exploration, 2007)

The impassioned plea to refocus on geoscience field training challenges us to do a better job, although Gibbs points out that we should be wary of thinking of this simply as a return to a ‘golden age’. We can certainly improve on the teaching methods of yesterday. But both commentators note the importance of intense and attentive teaching. Yet it is not uncommon for field class sizes to exceed 100. In these situations Holdsworth’s desire for one-to-one teaching is unattainable, at least for large periods of a field class. A number of strategies have been in play for at least the past 15 years to manage the delivery of appropriate levels of field training which are outlined below, although, if Gibbs’ views are generally valid then perhaps these will need appraisal in the future!

Strategy 1 – group work

For activities that use expensive equipment (e.g. gravimeters) or complex equipment arrays (e.g. field seismology), group work may simply be the only option. Even without these logistical constraints on teaching, an effective way of delivering formative feedback 'on the hoof' to students on field classes (the mentoring expected by Gibbs) is to divide the class into small teams. These may then be assigned an individual from the teaching team to follow the progress of individual students and provide immediate feedback as the activity develops. It can be effective for ensuring basic levels of technical competence, in repeated use of equipment or following simple analytical workflows. There are other benefits too. Students in a group can pool results to create more robust datasets for subsequent analysis. Furthermore, there may be clear inter-personal benefits through enhancing teamwork skills.

There are, of course, counterpoints to the benefits identified above. Reticent students may hide within a group, relying on the efforts of others. Additionally, it requires expertise amongst the teaching team to be devolved to individuals. These potential problems can be avoided through careful management, including full briefing, additional staff training and reconnaissance by way of preparation together with attentive teaching by the individual staff member assigned to the group. Teamwork devolved to students demands that the teaching staff work as a team too!

Strategy 2 – specialised vocational training

The technical skills identified by Gibbs arise most readily from geological mapping. One solution is to deliver this training to specialised classes, for example, to final-year students. However, curriculum requirements usually mean that students undertake independent project work (see chapter 9), prior to their final year of study. Thus, the necessary training must be delivered relatively early in a degree programme. Furthermore, geological mapping is generally recognised as having the broadest benefits to students, with a strong component of key skills.

Although anecdotal, there is substantial evidence that commonly it is the weaker students who benefit most from effective field classes. At the simplest level, bad attenders of conventional classes may have no option but to participate on activities during a day in the field. For other cases, the intensity of fieldwork may inspire a more professional attitude to study through the rest of their programme.

Strategy 3 - reducing the size of the field class

While the number of students enrolled on a degree programme may be beyond the control of the teaching team on a field class, there is always the option of dividing the class and running an excursion several times. While this may resolve issues of staff-student ratios, it is, of course, extremely expensive in terms of staff resource. There are also potential issues of unfairness that can be perceived by students, for example if the weather is particularly bad for one group. For some key components of field training, however, such as basic techniques, it may represent a practical solution, if these can be taught on single day-trips. The challenge lies in striking the correct balance, as discussed in chapter 9.

ACTIVITY 11

In a recent gathering of field teachers the following conundrum was raised:

We'd like to save resources. We'd like to focus the resources on future professionals (and protect the vocational value of the degree). But, which students are the future professionals? In any case, most of the benefits of fieldwork are general. And commonly it is the weaker students that benefit most…

Q: Do you relate this debate within your own department?
How might you set about resolving it?

7.3 Integrated fieldwork

Increasing modularization and the need to satisfy the field training needs of various degree programmes offers the opportunity to design field classes that integrate various tasks to a single scientific goal. Many departments are delivering multi-disciplinary activities. For example, Paul Ryan writes from Galway that:

> *We now have a modularised degree and so we need some multifunction field modules to teach the Oceanographers, Geophysicists and Geologists some basic skills such as location, map reading, sampling techniques. All also participate in an integrated survey (simple field map, water sampling and flow rates, ground radar and drift map). The idea is to give them basic recording skills and to generate some appreciation for what others do.*

7.4 Further information

As fieldwork is a central part of many aspects of the earth and environmental sciences it is not surprising that many undergraduate text books have material that may be appropriate to enhance not only the preparation but also the delivery of field teaching and learning outcomes. Listing all of these resources is beyond the scope of this guide. However, there is also a range of computer-based resources developed by the now-defunct Earth Sciences Courseware Consortium. The 21 modules include topics such as 'Basic Skills for Earth Sciences', 'Fieldwork Safety', 'Visualising Geology in 3D' and 'Using the Compass Clinometer', along with many other aspects of the Earth Sciences.
Further information is available on-line at:
http://www.ukescc.co.uk/

8. Field locations

The decision as to which field sites are visited generally comes down to a compromise between logistics / cost and the nature of the desired learning / teaching outcomes. Within this, the proximity of individual institutions to field sites is commonly an important part of the decision-making process, although surprisingly in many cases this may not be of paramount importance. In some cases, perhaps even the majority, field classes continue to visit specific sites even as the curricula demands and desired teaching and learning outcomes have changed, simply because of the problems of establishing new logistics associated with relocating a field class. Please refer to the case studies on the GEES Subject Centre website at www.gees.ac.uk for further information.

8.1 United Kingdom

For a variety of historical, financial and logistical reasons, most UK departments conduct much of their field training within the UK. There are a huge number of sites visited by students on Earth Science degree programmes – but there are no comprehensive figures available either on places or number of visits. Documenting the specific locations lies outside the scope of this guide. Indeed, some departments jealously guard the information relating to their field programme in fear that another department might book up their accommodation! While this illustrates problems in creating potential 'honey-pots' of activity, local communities commonly benefit from field classes visiting their area, bringing significant income outside conventional (high summer) vacation times.

8.2 Overseas fieldwork

The UK is blessed with a stunning range of field locations. Indeed, the locations are used by numerous groups from overseas in their training programmes. Nevertheless, there is strong demand within the UK to travel to overseas locations for fieldwork, a trend that gained some considerable momentum during the Foot-and-Mouth outbreak in 2001. There are some specific reasons for traveling to overseas sites. For example, it is necessary to leave the British Isles to provide hands-on field experience of active tectonic, volcanic or glacial processes. However, it is not the intention here to list all the various reasons for visiting specific sites on the basis of specific need. There are general issues that arise with overseas fieldwork that can be considered here.

For many years some departments have been visiting European field locations (e.g. Cyprus), using charter holidays to minimise the financial costs of travel and accommodation. Others have driven overland to places such as the Alps, although with increased EU legislation on driver qualifications and hours these types of field excursion are rather uncommon now. However, with the availability of cheap scheduled flights, departments are increasingly visiting southern Europe on field classes. In some cases it is possible to run field classes for less money by traveling to Europe than by remaining in the UK, particularly given the lower cost of accommodation in many southern European destinations.

To take advantage of the cheaper deals departments have become more flexible in the timing of field classes. This can be a critical factor during the Easter vacation when running classes before the Easter weekend can work out substantially cheaper than later in the holiday period. Further discussion on the costs of fieldwork can be found in chapter 9.

Long-haul destinations are only occasionally used for field classes, with North America being the most visited continent. Apart from increased travel costs (financial and environmental), traveling outside the EU can present greater demands on the activity through increased insurance costs, different liability risks and health demands.

Regardless of the educational reasons for visiting overseas field locations, a foreign field class is increasingly seen as an essential marketing strategy for many degree programmes. However, while a chance to visit a new culture or just to bask in the warm sun while their own institutions are entombed in a cold British spring may certainly appeal to many students, others may be discouraged from applying, or may be unable to continue with their studies, because of the cost. Some departments offer alternatives, with an expensive overseas field class running alongside a budget version in the UK. Other departments have not followed this strategy to avoid operating an overtly two tier training system. In the future, however, it is likely that many departments may look closer at their portfolio of overseas field classes as part of a general audit of the environmental, sustainability and ethical impact of their activities.

- All field classes outside the UK offer logistical challenges additional to home-based versions:
- visa / passport requirements for different students (UK, other nationalities)
- inoculation / health issues
- language / culture-shock issues
- lack of back-up for staff (longer lines of communication)
- potential problems taking large numbers of, predominantly 18-21 year olds to what are otherwise holiday venues.

8.2.1 British Standard 8848

In 2007, the British Standards Institute published a specification of the provision of fieldwork (amongst other ‘adventurous’ activities) outside the UK. UK-based activities are covered by existing health and safety law (see chapter 11). The motivation came from a number of serious accidents and incidents, some fatal, on overseas expeditions (not necessarily academic) - the designator 8848 comes from the metric height of Everest. Fieldwork counts as an adventurous activity because it involves an accepted element of risk and requires specialised skills (experience) for its safe management. As with all British Standards, BS 8848 is not part of UK law. However, British Standards are commonly used as definitions of good practice in the case of legal disputes. It might therefore be expected that higher education institutions will implement BS 8848 within their own protocols.

Full discussion of BS 8848 is outside the scope of this guide. Although it is operational, there is an-ongoing consultation process scheduled for completion in April 2008 (see Butler, 2007). The GEES Subject Centre has produced a brief on BS 8848, available at www.gees.ac.uk. However, the guiding principles are worth noting here:

- A single entity (i.e. the higher education institution) is accountable for the entire field class. This includes elements generally provided by secondary suppliers, such as transport and accommodation.

- A complete Risk Analysis and Management System (RAMS) needs to be in place, in the terms and language defined by BS 8848, that fully documents the hazards and support structures, strategies for incidents and contingency plans etc.
- Participants (students) must give 'informed consent' – so must have full information about the risks to which they will be exposed – before they are committed to participating. They need to know the limitations of duties of care by venture providers (staff).
- Participants (students) must agree to particular standards of behaviour.
- Effective operational management requires full documentation of staff expertise to deliver the activity to the standard identified in the RAMS – and this information needs to be available to participants for their informed consent to the activity.

While many of these protocols are doubtless in place for overseas field classes already, a practical requirement of BS 8848 is to follow the same terminology – such is the nature of a 'standard'. There are useful definitions of levels of supervision that could readily be applied to existing protocols for field classes regardless of whether a host institution claims to conform to the standard itself. It is, however, worth noting in passing that BS 8848 also explicitly applies to overseas placements, for example in partner universities or companies.

8.3 Reasons for choosing destinations

Field classes are always compromises between competing factors:

Quality of location features / exercise	
Background	Available field guides, experience of staff, links to curriculum, other datasets (e.g. departments run basin analysis exercises to the Dorset coast, in part, because the onshore geology can be linked to subsurface geology via published well logs and seismic data).
Logistics	Cost, availability of suitable accommodation, accessibility (e.g. coach access down narrow lanes).
Recruitment / marketing	Many departments actively build into their programme a foreign field class, often to an exotic destination, to aid recruitment of students.
Environmental impact	Especially associated with travel to and from the field location.
Staff preference	Field teaching commonly reflects the passions of individual staff members for specific places that may transcend the specific geological or educational qualities of a site.

8.4 Access and conservation

The following comments are drawn from a UK perspective but clearly have importance for all fieldwork, regardless of the country within which it is taking place.

Field locations may be considered as important natural resources that should be conserved and access privileges protected. In the UK this philosophy is enshrined in the designation of Sites of Special Scientific Interest (SSSIs). Almost all fieldwork requires the goodwill of people at and around the individual field sites. Inappropriate behaviour by a single group or individual can lead to permission to visit being denied to the whole community. Fieldwork in the UK commonly involves working on private property.

Access to classic coastal outcrops like these in Pembrokeshire is critically important for UK geology

In the past decade access rights and conservation laws have changed dramatically within the UK. However, the current situation is not simple as environmental issues are devolved in the UK with different laws and rights applying in the constituent countries.

The most far-reaching changes have been 'north of the border', where the Land Reform (Scotland) Act (2003) established statutory rights of responsible access to land for outdoor recreation. These are described in the Scottish Outdoor Access Code (SOAC), published by Scottish Natural Heritage and launched in 2005.

Information is available at: http://www.outdooraccess-scotland.com.

SOAC outlines access rights for the public for recreation and, importantly, educational purposes that are amongst the most favourable in Europe. However, these rights come with important responsibilities, particularly the requirement to leave places undamaged. This includes hammering and collecting samples. Anything other than simple observational science requires the permission of the landowner.

For England and Wales, the Countryside and Rights of Way (CROW) Act received Royal Assent in 2000. http://www.defra.gov.uk/wildlife-countryside/cl/index.htm

As with the Land Reform (Scotland) Act, CROW has created new rights of access on foot and strengthened conservation laws, especially protecting SSSIs. Information on current access rights can be found via Natural England's information hub:
http://www.openaccess.gov.uk/

For Wales, access and conservation is overseen by the Countryside Council for Wales, overseen by the Welsh Assembly Government. CROW was implemented in 2005 throughout the country. Access information can be found at:
http://www.ccw.gov.uk/enjoying-the-country.aspx

The coastlines of England and Wales are not covered by CROW – a serious limitation for geological fieldwork given the importance of such areas in UK field training. According to Natural England about 70% of the English coast is currently accessible (defined as being within 200m of the high water mark). In 2007 the UK Government announced that it planned to legislate for full access through a forthcoming 'Marine Bill'. One of the desired outcomes of the bill passing to law would be to encourage 'people to enjoy and understand this environment'. It is likely then that the access situation will continue to evolve over at least the next few years.

Regardless of the legal position, as a general principle field parties should follow guidelines such as the 'countryside code' and the Geological Society's Code of Conduct for Fieldwork. The basic philosophy of responsible access remains valid even though codes have changed and been reissued through the past decade. Even if there are statutory rights of access to land, it may be courteous to approach landowners ahead of any visit. This is particularly important when experiments or sampling are to be carried out, which require permission beyond the new access rights. Furthermore, seasonal aspects may impact on access, such as the disturbance of nest sites of specific bird species.

From time to time some entrepreneurial landowners attempt to charge field parties when hitherto access had been permitted without penalty. In general, this is regrettable. While paying charges may seem expedient when faced with otherwise relocating a field class, many view this as giving a hostage to fortune. Not only could a restricted example of charging lead to a widespread charging policy to field sites, it could also impact on other countryside users. Many of the, admittedly rare, cases of attempted charging for access have been resolved through lobbying by local communities who otherwise were liable to lose income from the reduction in visitors.

Given the large numbers of Earth Science students visiting sites in the UK and overseas, some popular sites are showing significant signs of distress, exacerbated by excessive or unscrupulous collection of samples (e.g. geological materials taken for commercial purposes). It seems increasingly necessary to adopt a 'no-collecting' stance for all sites apart from those where material would in any case be lost (e.g. working quarries), although in these places there are issues of ownership to be established. Additionally, many popular locations are legally protected, as discussed below.

More insidious damage is caused by indiscriminate hammering, with some popular mapping areas containing few exposures that have not had their corners chipped off by generations of geologists. Not only has this defaced many sites, the rock fragments can represent hazards to other land-users and livestock. In this regard it is perhaps unfortunate that the hammer is still retained as a symbol of geology. Geoscience field class leaders should only recommend hammering a natural outcrop (as opposed to part of a working quarry) when students need to examine a fresh surface while primarily suggesting that students scout around first for fresh surfaces or lose pieces (possibly created by other geologists!). The impact of large groups can be mitigated by sharing freshly hammered samples around. Notwithstanding these approaches, some believe that, on natural outcrops, hammering should be restricted to researchers only.

Many places visited by Earth Science students are SSSIs, and as such they are protected under the terms of the CROW and the Scottish Land Reform Acts. Many geological sites are linked into networks based on their content and form part of the Geological Conservation Review. Part of the rationale for these networks is to promote the utility of the constituent SSSIs as educational resources. However, there are clear responsibilities on parties or individuals visiting sites to minimise their impact upon them. In general, this requires groups to not remove any materials from the site (including for example, rock specimens even collected from spoil heaps or scree slopes), not to hammer or otherwise damage outcrops, not to remove or damage flora / fauna or otherwise harm the local environment. It is worth remembering that sites visited by specific student parties may be SSSIs for reasons other than those of relevance to the group concerned (e.g. sites visited by geology students may feature rare plant species). Therefore, a high level of general care should be adopted at all times to avoid damaging any of the special characteristics of the site.

The Geologists' Association Geological Fieldwork Code is available at:
http://www.geoconservation.com/GCCdocs/fieldworkcode.pdf.

Web resources on access and conservation in the UK are in a constant state of flux. At the time of writing, information on SSSIs is available from:

- Joint Nature Conservation Committee.
  http://www.jncc.gov.uk/
- Countryside Council for Wales.
  http://www.ccw.gov.uk/
- Natural England.
  http://www.english-nature.org.uk/special/sssi/
- Northern Ireland Environment and Heritage Service.
  http://www.ehsni.gov.uk/landscape/earth_science.htm
- Scottish Natural Heritage.
  http://www.snh.org.uk/about/ab-pa01.asp
- The Geological Conservation Review.
  http://www.jncc.gov.uk/page-2947

Further information on conservation can be found at:

- Nature Net.
  http://www.naturenet.net/
- Friends of the Earth.
  http://www.foe.co.uk/

Those wanting information on Scottish landowners (useful for access) try: 'Heading for the Scottish Hills' published by the Mountaineering Council of Scotland and the Scottish Landowners Federation.

Given the likelihood of change in access rights, especially in England and Wales, in the coming years, future readers may wish to consult the web sites of outdoor organisations, such as:

- Ramblers Association. http://www.ramblers.org.uk/
- British Mountaineering Council. http://www.thebmc.co.uk/

Both employ access and conservation officers who maintain web resources.

9. Resource issues

Challenges facing staff delivering a programme of fieldwork may be grouped into:

- financial resources
- support of colleagues
- logistics
- safety – the field offers environments that are less ‘controlled’ than laboratories
- personal liability of the staff.

All of these place pressure on delivering an effective programme of geoscience training through fieldwork. It is worth rehearsing some of these issues.

9.1 Costs to the institution

Staffing of field classes is generally far higher than other forms of teaching (certainly lecturing, see chapter 6). Consequently, institutions invest heavily in field classes through the allocation of staff time. They may also invest in specialist technical equipment. Many go much further than this by not passing to the students the subsistence / travel expenses incurred by staff. Departments may go further still and absorb part or even all of the subsistence / travel costs of the students. As Boyle *et al*. (2007) recognise, an interesting facet of the charging of top-up fees, is that many universities in England and Wales have chosen not to charge students for compulsory field classes. Rather, the costs are borne directly from the running costs of individual departments. However, as the full economic costs of all activities within UK universities are devolved to departments, including for basic infrastructure, many are recognising that field teaching is actually cheaper than say, running a specialised teaching laboratory.

In many departments serious resource issues are mounting as decreasing members of faculty feel willing or able to teach in the field. In the short term this may put unacceptable pressure on a few staff and in the long-term may prejudice the delivery of some or all of a field programme. Addressing these issues requires fieldwork delivery to be part of the strategic planning of a department or institution.

9.2 Costs to the staff

Residential field classes especially require substantial commitment by staff. Few, if any, institutions recompense staff involvement with time in lieu that recognises the time spent, not only at weekends but also in the evenings. There is also the question of personal liability associated with teaching field classes and, in many cases, travel to / from the field location. These are issues that staff should take up with their Head of Department, authorities within their institution and trade union.

9.3 Costs to the student

Notwithstanding some universities subsidising the logistical costs of field classes, others feel obliged to pass increasing proportions of the financial costs of running field classes directly to students. Further, the time spent on fieldwork can represent a substantial potential loss in earnings for students, and can impact directly on their responsibilities as carers and on personal relationships. These

aspects are increasingly important, particularly in the case of residential fieldwork operated during weekends or vacation periods. These issues can represent serious negative factors influencing the health and welfare of students, and therefore their retention on courses, and on admissions. Additionally, the purchase of outdoor clothing necessary for fieldwork can place severe financial burdens on students, particularly at the outset of courses.

The financing of classes is widely seen as a critical problem for the future of geoscience fieldwork, not just in the UK but all over the world. There are a number of innovative schemes being developed, some with the support of governmental or national institutions. For example, the US National Association of Geoscience Teachers offer scholarships for field study. In the UK there are similar schemes, although these generally operate within individual higher educational institutions. A quick internet search will usually draw these out.

ACTIVITY 12

How much is it fair to charge students for compulsory fieldwork relating to their course? How much of their vacation time should it be required that they give up?

Do your answers vary depending on whether or not students are studying for vocational reasons?

10. Support for student-driven fieldwork

Almost all students studying for a geoscience degree can expect to complete a substantial project, generally during or immediately prior to the last year of their programme.

> *An accredited course must include a major component of independent project work in geoscience.*
> (The Geological Society, 2001)

In practice, the proportion of project work for accredited courses varies from about 15-30% of a year's activity. In many cases, these projects will be field-based, or include an element of fieldwork, with work often carried out in the summer vacation before the final year. Given this common background, it might surprise some people to know that the level of support provided to students varies very widely between departments. The common rationale for including project work within geoscience programmes may include the following:

- an opportunity for students to demonstrate flair, originality ('research potential') and intellectual independence
- the chance to demonstrate that students can deliver a product (thesis) to a fixed deadline, requiring the acquisition / enhancement of organisational skills
- the chance to apply skills and experience picked up earlier in their course
- the chance to immerse themselves in a particular topic for a long time, so that they can appreciate the depth of part of their chosen discipline.

ACTIVITY 13

How does your department support students during dissertation work?

Do you think that the balance between independence and intervention is appropriately struck?

In their guide to dissertations in Geography, Livingston *et al*. (1998) point out that a list of opportunities such as the above can generate a similar list of pitfalls for some students. Health and safety together with logistical issues (see chapter 10) may mean that field-based projects are not physically independent. Although able, motivated students may be able to operate as intellectually independent, others may opt for the apparent support of their peers. Often this can be detected during the assessment, but can make the project work itself less rewarding. Similarly, students may be insufficiently organised to deliver their thesis or may be unable to manage the stress associated with the exercise. The project itself may not build naturally upon the skills learnt during earlier parts of the course. And deep immersion may be a negative experience, if the project proves less interesting or too difficult for the individual.

Ways of avoiding the pitfalls centre on giving students the capability of making informed choices about the nature and execution of their project before it begins. Departments offer this support in a variety of ways:

- briefings about projects ('project fair') before choices are made
- tutorial and/or mentoring support ahead of the project (with the option of switching project)
- top-up sessions on specific skills before or at the start of the project.

As a general comment, Livingston *et al*. (1998) raise the question: does the existing curriculum prepare students to do a good job on their dissertation? This preparation should include teaching students sufficient and appropriate geoscience principles to yield worthwhile, rewarding projects. But it should go beyond this basic curriculum point. There are general skills needed too, such as training in scientific inquiry, synthesis and report writing.

Support in the field during the progress of project work is highly variable between courses and institutions. In some departments students receive no visit by staff in the field. Others, in contrast, may keep staff on hand throughout the project duration. The former model clearly minimises the impact of dissertation work on departmental resources and maximises the students' level of independence. The other extreme may be required where highly specialised equipment is in use (for example, a geophysical survey). In many instances the particular levels of support are governed less by educational reasons than by interpretation of health and safety issues (discussed in chapter 10) and by staff availability.

Most departments expect project work to be written up during the autumn or spring of the final year. Some make allowances for this work by reducing the taught course programme during part or all of the period. However, this behaviour is probably the exception. Support during dissertation writing can take many different guises, from non-existent to regular one-to-one tutorials with staff. Others provide guides to dissertation writing, including on-line materials. Another strategy is to set report-writing tasks on field data collected by the students themselves on earlier field classes. Some departments give students access to old dissertations (on different areas / topics, to reduce plagiarism risks) – although this can perpetuate errors if unrestricted access is permitted.

11. Health and safety issues

Please be aware: These notes are not intended to replace or detract from any statutory legislation (e.g. the Health and Safety at Work Act 1974) or the recommended working practices of host institutions. Indeed, many universities aspire to health and safety standards that exceed the statutory requirements. In all cases, teachers on field classes are urged to consult with appropriate safety officers on a departmental, faculty or institutional level. They might also consider taking legal advice (e.g. with their institution's legal advisors) concerning practices and liability.

The information included here is not intended to be comprehensive. Section 11.4 provides a list of further sources of information.

Health and safety issues are of paramount importance for all fieldwork and different departments have adopted a number of practices to manage risk in the field. If your host institution is considering claiming conformance to British Standard 8848 (see chapter 8), existing protocols are likely to need significant modification. Yet there is considerable variety not only in the nature of tasks that might be carried out in the field but also in the degree of student independence. Department practices are correspondingly highly variable. Nevertheless, as an overarching principle, staff / field class leaders and individuals have a duty of care to themselves and others. It is strongly advisable that strategies reinforcing the importance of individual responsibility for safety and risk management are put in place and acted upon. Accredited degrees (both by the Geological Society and through on-going discussions within the Bologna Declaration for standardization of European degrees) require students to receive health and safety training. It is not the intention here to outline best practice (as this will depend on the individual situations) nor is it a 'code of practice'.

ACTIVITY 14

What health and safety procedures does your department currently operate?

Do you feel that this matches the needs and expectations both of staff and of students?

Note: It might be worth examining some scenarios in a two-team-based exercise. Each team invents a scenario (or recalls one from their own experience) and offers it to the other side to suggest a protocol to follow. Further pressure can be added by placing a strict time-limit on the exercise, followed by a debrief of the exercise where the actions taken are discussed and shared…

For ‘conventional’ taught fieldwork, staff may consider using some or all of the following strategies:

- Information on the requirements of field equipment (boots, clothing etc.) prior to purchase
- Carrying out hazard assessment of all field locations (and activities) prior to the field class, including managing the response to possible incidents, together with regular revision of these
- Clearly notifying students of field hazards in advance both verbally and via the supporting documentation (e.g. field handbook)
- Staff acting as good role models for health and safety procedures (including equipment)
- Field class leaders being clearly identified on handout materials and their accommodation unit (e.g. caravan) being identified to students
- Staffing levels being planned to ensure adequate cover to maintain the necessary level of task supervision
- Long journeys being undertaken with professional drivers to minimise the risk of accidents due to driver-fatigue. It may be necessary to make coach drivers aware of hazards and risks
- Students completing medical forms before residential field classes. These are considered by the leader so that the teaching team can be briefed on any problems before the class
- All field classes might have copies of student lists with contact details, as lodged with the department
- The students can be given emergency contact numbers for the residential field classes, which they can pass to next of kin before departure. These numbers may also be left with the parent department
- Sign-in sheets can be used to check students for each day’s activity
- Where possible, fully-qualified first-aiders can be on the field class and identified as such to all participants
- Staff can be responsible for ensuring that all students have adequate equipment by either providing it (e.g. helmets, fluorescent coats, goggles) or excluding poorly equipped students from the exercises
- Classroom tuition may be given on the use of correct clothing, discussion of response protocols following incidents and accidents, including survival strategies etc.

Rather a range of examples are listed – this list should not be considered exhaustive!

Departments might consider some / all of the following measures directed at students attending taught field classes:

All students being required to study notes on Advice to Students on Geological Fieldwork and Behaviour (or similar fieldwork safety advice documentation) and sign a declaration stating that they have done so, prior to the main field programme

- Students being notified of hazards specific to the site under investigation
- All students completing a medical questionnaire prior to fieldwork and making this available to staff teaching on field classes
- Students being required to be equipped with suitable clothing and safety gear (e.g. hard-hat, safety goggles)
- Students being required to assess risks at each locality, recording these in their notebooks and being given explicit training in this on early field classes. This could be enhanced by classroom training sessions
- Students being expressly forbidden to engage in potentially dangerous pursuits such as climbing, scrambling, caving or diving during all field classes;
- Students being encouraged to gain first aid training, perhaps under the auspices of their host department, and to carry their own first aid equipment;
- On classes where students operate away from direct supervision of staff, the students being told of the international distress signal and given additional training in safety. They might also be required to carry an emergency record card with key phone numbers and simple action plans to follow in the event of an emergency.

11.1 Project work

Many degree programmes require students to produce dissertations that are the product of unsupervised research, commonly carried out in the field and / or the laboratory. If students are working in the field away from close supervision, they might expect to have received prior training in hazard assessment and management. In many cases, this will require developing a progression of hazard assessment and documentation skills running alongside the academic skills progression. They might also expect to receive a briefing on any safety equipment.

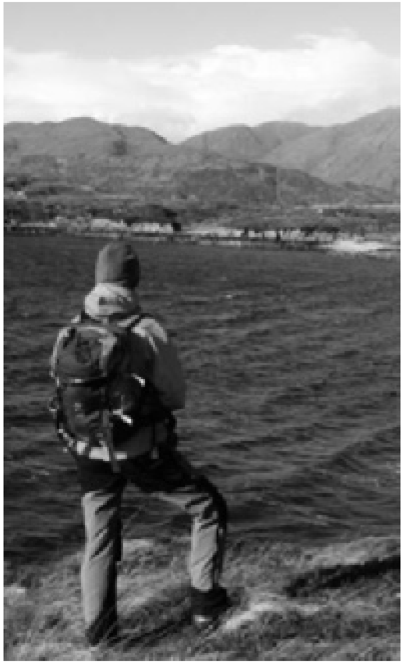
Different institutions have developed different strategies to meet the additional safety issues posed by unsupervised working. Different exercises and environments have different safety requirements and levels of personal responsibility. So, the following list is not definitive:

- *Supervised field camp.* This involves operating out of maintained accommodation (a field camp) where a staff member is present. Thus, while the student might be working independent of staff supervision during the day, staff are available to call out emergency services or seek medical assistance on their behalf

- *Student-maintained field group*. Students live in a group (4+), maintaining their own logistics and providing mutual support (for calling out emergency services). In this model, if a student fails to return at the end of a field day the remaining group can call the emergency services. Having a total group of 4 makes this outcome likely. With smaller group sizes there is an increased likelihood of irrational decisions being taken (e.g. individuals conducting a search for a missing person without first calling in the emergency services)

- *Working in pairs*. In this model students are always in close proximity with a ‘buddy’ and they look out for each other. This allows a rapid response to an incident in the field. However, there may be compensating disadvantages that can include: peer pressure to expose themselves to riskier situations than they might on their own (the meek being led on by the bold); irrational action by the second student in the event of the first injuring themselves (e.g. attempting to effect a rescue through hazardous terrain); injuring each other (e.g. rock-fall, hammering).

- *Working alone.* The student lives and works alone. This strategy represents the most extreme case of independence. The student cannot rely on there being any support in the event of any incident. This model, once common-practice in many geoscience departments for the dissertation work, is now rarely practised. Some degree of safety support can be provided by nightly check-in by telephone, although in practice it may be difficult to arrange this late into the evening or at weekends. Some organizations use an external call-centre provider, buying-in a solution. It should be noted that many university safety protocols now advise against or strictly forbid the authorization of lone working practices in the field.



Lone working, even in access areas such as the coast of Loch Linhe in Scotland, raises serious health and safety issues for geologists

In all these cases individuals might expect some/all of the following practices:

- students receiving advice and guidance about safety procedures, terrain, climate, fitness and insurance issues from a staff member before the project (to facilitate matching students with appropriate projects and their inherent levels of risk)

- staff visit students at the start of their project to advise on hazard assessment, and provide training on operating within particular environments

- students leaving details of the planned route and destination(s) for each day, together with estimated times for return and bad-weather abort routes etc.

- students carrying emergency/survival materials (e.g. extra clothes, food, emergency shelter etc.) if they are working in remote areas. They might also have whistles and bright clothing to attract attention

- students being based close to a telephone / other mechanism to raise alarm

- students given instruction on the types of response to make in the event of an incident (i.e. notifying the authorities of any emergency).

11.2 Strategies for students taking responsibility for their own health and safety during fieldwork

As noted above, most departments expect students to undertake a certain amount of ‘independent’ fieldwork where they are not under the close (i.e. within full communication and surveillance that can deliver instantaneous assistance) supervision of staff. For their part, students might reasonably expect to receive some training in hazard awareness, assessment, management and documentation. Some departments have an explicit programme for such training. This can include instruction in first aid (with emphasis on outdoor environments), navigation and terrain assessment, tide prediction, briefings on appropriate equipment (including outdoor wear). One approach is to integrate hazard assessment into good field notebook practice, so that students document issues in the field while making their own assessments.

Independent project work, away from the supervision of staff, may require further training, so that students can assess risks that on other occasions are usually managed by staff. These could include:

- Driving in strange environments (e.g. overseas);
- Choosing appropriate accommodation (e.g. campsites away from areas prone to flash floods);
- Environmental issues (e.g. hazardous wildlife, disease).

11.3 Safety management in the field – a personal note

Health and safety management systems are increasingly strict in recognition of our duty of care to our students and others. Understandably, there are increasing numbers of protocols, procedures and policies. But their effective implementation requires training and good leadership. Consider the following experience, involving two different groups of professional geoscientists (from international energy companies with strict health and safety protocols). The setting was a coastal outcrop that was approached beneath a cliff section. The cliff clearly had a recent history of stone-fall, with debris littering the wave-rounded boulders on the beach. The first group had a relaxed attitude to wearing hard-hats and the majority of the participants opted to wear sun-hats. They walked to the outcrop, passing under the cliff but remained vigilant, watching for stone-fall as they went. They avoided particularly unstable areas. The second group (on a different day) had a strict hard-hat policy. All wore their hard-hats and also walked under the cliff to the outcrop. However, none of the second group watched the cliff. Indeed, they loitered under it without regard to the potential for rock-fall (despite a briefing a few minutes earlier). They did not evaluate or avoid particularly unstable areas.

While there were no incidents of rock-fall that affected either group, the second group – while following a strict company policy, nevertheless exposed themselves to a greater threat than group one – by remaining longer within the hazardous area and by not being vigilant. Clearly, an ideal strategy here would have been both to wear a hard-hat and to have been individually vigilant. The best safety protocols empower individuals to take personal responsibility – but this takes experience. On their own, excessive lists and published protocols can act against this personal empowerment.

11.4 Further information

The following two publications offer substantial advice and guidelines, many of which are incorporated into the above discussion. Many departments require staff and students to study and adhere to these guidelines.

- Association of University and College Lecturers (1994) Guidelines and Code of Practice for Fieldwork, Outdoor and other off-Campus Activities as part of an Academic Course.

- Committee of Heads of University Geoscience Departments / The Geological Society (1994) Safety in Geoscience Fieldwork: Precautions, Procedures and Documentation.

A useful tide calculator can be found at: http://www.wxtide32.com

12. Equal opportunities

The whole education community has obligations to maximise participation and to operate within a framework of fostering equal opportunity. Courses with a component of fieldwork may be less attractive to students because of a number of factors:

Financial limitations
Passing the costs of fieldwork to students may act to reduce access to courses, particularly where fieldwork is a compulsory component.

Social limitations
The nature of, e.g., accommodation, living conditions, diet, 'drinking culture' may be unattractive to individuals and members of particular communities or faiths. These issues are of increasing importance as UK society becomes more diverse and the numbers of international students increase. Fieldwork in isolated locations can make minority societal groups feel even more isolated.

Personal limitations
Students who are also parents or have other caring responsibilities towards individuals may find it difficult to devote time to fieldwork, particular when delivered in longer, residential components.

ACTIVITY 15

How varied is your group of students about to undertake a particular field course?

Have you asked them about their apprehensions of the forthcoming field class?

Have you collected feedback so as to reflect the diversity of student background on field classes and matched their views?

What do you perceive to be the challenges in successfully delivering the desired learning outcomes to each individual on a field class?

Disabilities
There are specific issues that now arise that are discussed below.

The Disability Discrimination Act Part 4, which was amended by the Special Educational Needs and Disabilities Act (2001) (SENDA), is intended to broaden access and opportunity. It impacts on all aspects of Higher Education as reflected by the QAA's expectation that:

> *Institutions should ensure that, wherever possible, disabled students have access to academic and vocational placements including fieldwork and study abroad.*
> (QAA, 1999, precept 11)

The spirit of the SENDA legislation can be interpreted most meaningfully in the case of fieldwork by striving to ensure that the teaching and learning outcomes delivered by fieldwork programmes can be achieved by all. Ultimately this may require a long-term rethinking of the style and delivery of fieldwork programmes to produce a more inclusive curriculum for all individuals. It is by no means clear how these requirements will impact on the accreditation of degree courses by professional bodies such as the Geological Society, In the short-term appropriate supporting resources should be made available (by the department and / or the LEA) to individuals with special needs to ensure that fieldwork learning outcomes can be achieved in the field itself or through the completion of alternative, non-field based activities (e.g. virtual fieldwork exercises).

12.1 Project work

The traditional field-based project demanded by geoscience programmes may be significantly unappealing to a variety of students (particularly those with care / work commitments which inhibit travel away from home for extended periods, or those with mobility restrictions or other disabilities). To maximise access some departments set up extra laboratory-based or even literature-based project work in place of a field-based exercise.

12.2 Further information

The community is still evaluating the impact of SENDA and subsequent legislation. It is worth checking internet forums and other commentary. The Geography Discipline Network (GDN), working in association with the GEES Subject Centre, has published a series of six guides on ‘Providing Learning Support for Disabled Students Undertaking Fieldwork and Related Activities’: http://www.glos.ac.uk/gdn/disabil/index.htm.

ACTIVITY 16

Do you feel that your department currently provides enough information about the nature of fieldwork to allow applicants to make informed decisions about enrolling in your courses?

Is there anything you could do that might increase access and availability of your field teaching?

13. Assessment and feedback for field classes

In common with all teaching and learning activities, fieldwork is amenable to many different strategies for enhancing the feedback given to students on their performance and progress and for providing assessments. Aspects are covered explicitly by Hughes & Boyle (2005). Given the investment made towards field teaching, by staff and their host departments and by the students, many departments have developed elaborate processes to maximise ongoing feedback to students during field classes. Often these rely on the dedication of staff on the field class who commonly turn around a piece of work overnight after a full day in the field and social interaction in the evening. Traditionally, field classes have run evening Q and A sessions or group presentations. Here are a few other examples:

Field materials: notebooks, maps

The classic type of feedback takes the form of commenting on and perhaps assessing field notebooks during periods in the field class when students are not actively working (e.g. days off or evenings). Although this can place staff under considerable pressure, undoubtedly students benefit from the reassurance of having their work 'checked' and bad practices nipped in the bud. This type of feedback seems particularly important early in a programme of fieldwork and for novel tasks. Written comments in notebooks provide a monitor of progress to students and staff alike. Students also benefit from direct comments on their early attempts at field mapping. However, unlike notebook-based exercises, maps commonly provide a single chance to attempt a task, as corrections are difficult for the student to implement. Field teachers may consider limiting early mapping training to daily (or shorter) exercises upon single field trips so that early errors are not inherited into subsequent parts of the field class. Further, it may be more appropriate for comments to be made on 'post-it' notes rather than directly on the working map.

Measuring and recording data, such as here in Anglesey, can be readily assessed during field classes – giving students valuable running feedback

This form of feedback 'in action' is often best at highlighting the strengths and weaknesses of basic observations and scientific method rather than more advanced forms of synthesis (although basic synthesis of an exercise or the day's work should form a part of a good field notebook). But it can also provide direct evidence of individual student function in the field, from academic progress to the implementation of safety procedures and hazard assessment. For complex equipment-based experimental fieldwork, staff assessment of field notes and data may be essential to ensure the integrity of these results. However, on an educational level, it can be difficult to provide relevant examples of good practice – akin to model answers – ahead of a particular exercise without undermining the students' own work. A particularly powerful solution is for field teachers to make their own field notes etc., working alongside the students in the same environmental conditions, in essence teaching by example.

Individual presentations in the field

On occasion, it can be difficult to promote active discussion by students in the field. One strategy that can be adopted is to ask individual students to give spot talks after an exercise, synthesising their own findings and leading discussion with their peers. This seems particularly useful for more experienced students later in their courses. While it may be best to give informal feedback on performance to the speaker in private, it is important for the staff member to correct any errors or omissions to the group directly after the presentation. This can require careful handling to avoid undermining the speaker. Given that different field sites / exercises may offer different challenges to students, it may be best to allow an individual several opportunities to speak during a field class if this strategy is adopted for assessment.

Short poster displays

While notebook commentaries and spot talks can gauge student progress on basic observational skills, providing feedback on their skills at synthesis and reflection on their observations / data may require different approaches. In many cases it may be desirable to promote these ‘higher-order’ skills during the field class so that students can apply their reflections to exercises the following day. For example, it may be desirable for students to assess whether they have sufficient data to test hypotheses adequately. One approach is to ask students to prepare simple poster displays (say A3-sized) that synthesise observations and integrate their various data-sets. Some departments use regular group poster exercises on field classes to promote team-work and to allow students to combine data-sets. This can be particularly useful for providing a level of feedback to large classes where commenting on individual work may be impractical. A useful adjunct can be to display the posters – perhaps with staff comments added on ‘post-it’ notes. There are benefits for student morale and for peer-learning. As with all formative assessment, this is especially effective if delivered during a field class, perhaps using an evening. Clearly, this has implications for the nature of accommodation used on field classes, not only in providing adequate space for students to prepare material but also for suitable ‘gallery space’ for later viewing. But the approach also works even if posters are only displayed when back in the department.

Web-based field ‘tutor’

Some field centres offer the opportunity of using computer-based support for teaching in the field. Consequently, several departments, either individually or in consortia, are developing resources. One example, used to support field mapping in geosciences in NW Scotland, is accessible on-line at: http://www.see.leeds.ac.uk/structure/assynttrip/

The site includes ‘hidden’ links to extra tutorial material and ‘solutions’ (click on the boulders on the homepage image!). There are further opportunities using internet GIS packages, such as Google Earth (see chapter 7).

Informal quizzes

Many groups use evening quizzes to provide an opportunity to interact with students and to give a simple level of feedback. These can be fun, very informal (‘team-based pub-quiz’), inter-twining amusing events and trivia with more critical information. They can also be a good way of filling otherwise tedious coach journeys!

Post-field class assessment
Assessment of student performance on field classes can take many forms, from simply marking of notebooks through to the requirement to produce dissertations and reports or to sit examinations.

13.1 Dissertations and field projects

> *An accredited course must include a major component of independent project work in geoscience.*
> (Geological Society, 2001)

At least one major piece of independent project work is generally seen as a fundamental requirement of all geoscience degree programmes. For three year (BSc) degree schemes, this is generally worth 20-30% of the final year of study. Four year (e.g. MGeol) courses usually have greater proportions of project work. Most students on geological degrees commonly base their dissertations on extensive periods of independent fieldwork. Other programmes tend to involve additional components of team-based field experiments, laboratory analysis and/or computer modelling.

13.1.1 Safety and logistics

Departments still have a duty of care over their students, even though an activity may not be formally supervised. The challenge faced by departments for field-based project work is to provide mechanisms and training appropriate to the needs of the student, the nature of the field activity and the location. (See chapter 10 for further discussion.)

13.2 Further reading

Many of the assessment strategies described in the reference below are directly applicable to teaching and learning in fieldwork: indeed, it includes some relevant case histories:

Hughes, P. and Boyle, A., 2005. Assessment in the Earth Sciences, Environmental Sciences and Environmental Studies. GEES Learning and Teaching Guide. University of Plymouth. 41pp.

14. Closing remarks

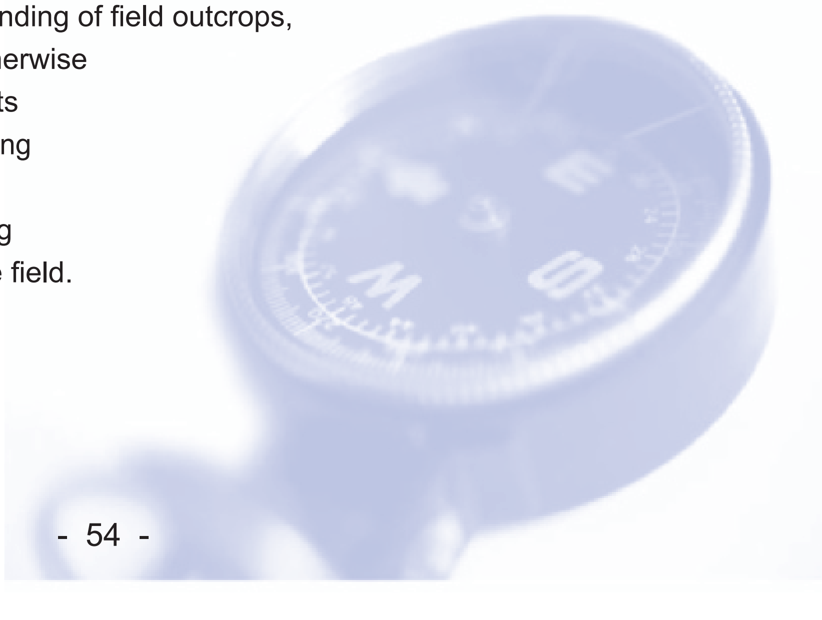
Fieldwork remains the distinctive feature of geoscience degrees and competence in it is highly valued by employers. Accreditation of degrees by the Geological Society and as part of the Bologna Declaration, requires training to be relevant to the workplace and, thus, fieldwork is a compulsory part of a geoscience degree. Nevertheless, there are concerns expressed within some areas of the university sector that teaching through fieldwork is threatened. These concerns are voiced not just in the UK, but around the world. Boyle *et al.* (2007) identify and discuss six, citing tendencies to replace fieldwork with classroom alternatives; the expense to students; the cost to institutions; the drain on staff time; problems accommodating students with special needs and disabilities; and fear of litigation. But dwelling on these threats misses the point.

There is a fundamental requirement for students who are well trained, not only in the skills specific to geoscience fieldwork, but also able to problem-solve in three dimensions. Additionally, the social and personal skills that are gained through being immersed in an investigative environment for days at a time are highly valued across an increasingly broad range of employers. Boyle *et al.* (2007) conclude that fieldwork is good – students enjoy it and learn more effectively because of it.

The last testimony in the guide illustrates the generic importance of teaching through fieldwork. It comes from Art Sylvester, from University of California, Santa Barbara:

> *My own anecdote about field work concerns one of my field camp students who went on to a very successful career as an environmental lawyer. He visited me after some years and attributed his success in the courtroom to his ability to think quickly on his feet - an ability gained, he said, from all the field course work as a geology major in this university.*

In this guide, a series of practical strategies and advice have been presented. But, these can only go so far. The key to effective teaching through fieldwork has less to do with protocols and strategies than the motivational and leadership qualities of the teachers. It is about inspiration. There is little better for turning students on to the science of our planet, than being thrown into investigating a geological process or product using their own observations, with the added spice of a challenging environment. Changing society or fashions in geoscience research do not change the importance of teaching geoscience concepts and skills in the field. Improvements in remote sensing and geophysical imaging require better understanding of field outcrops, the physical analogues for subsurface or otherwise inaccessible geology. Long may geoscientists continue to foster these experiences, enhancing them with new ideas and technological opportunities where appropriate and extolling the virtues of this spectacular resource – the field.



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