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Descriptive account

Field Study of Plant Diversity: Extending the Whole-Class Knowledge Base through Open-Ended Learning

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Abstract

Students following a pre-Certificate year in biology (the preliminary year of a 4-year BSc programme) learnt about plant diversity through integrated field and classroom studies carried out in an afforested area of north-east England. The students identified, listed and made interpretive drawings of their own choice of the specimens they had collected. This open-ended approach led to the generation of a collective knowledge base, that was much wider than that of the individual students, and that was available to be drawn upon by student groups in their planning of subsequent field project work. The approach contrasts with conventional laboratory teaching of plant diversity, through use of representative specimens, in which all students tend to finish up with an essentially identical and limited range of knowledge and understanding.

Keywords: Field study, Forests, Open-ended learning, Plant diversity

Introduction

The paradigm for learning and teaching in HE is ideally one of student-centred, deep learning rather than teacher-centred delivery of superficially-learnt content. Although espoused, this ideal is not necessarily achieved in practice (Phillips, 2005). For example, in a plant diversity module at an Australian university, Phillips and Baudains (2002) and Phillips *et al.* (2002) found that although the teaching staff aimed to foster in-depth learning this was thwarted by excessive course content, over dependence on formal lecture and laboratory classes, and an examination structure that encouraged rote learning. Furthermore, the introduction of online support, to augment plant material examined in practical classes, was found to encourage cramming for examinations rather than in-depth learning. Within the context of plant diversity and identification, fieldwork is an alternative to conventional lecture and laboratory classes and offers much scope for student-centred learning.

In the UK there is evidence for a decline in field work amongst bioscience HE students, perhaps because of financial reasons (Smith, 2004).But there is a general belief amongst educators involved in field work that it is a good thing, although Maskall and Stokes (2008) point to a lack of firm research-based evidence that field work is more effective than other learning modes. A controlled experimental study by Taraban *et al.* (2004) did, however, show that students learnt plant identification more effectively through living plants in greenhouse and field environments than through online learning. This result validated the pragmatic approach to weed identification taken by US universities where a survey by Lindquist *et al.* (1989) found that learning to identify weeds included field work in 19 out of 20 universities. Indeed, the learning continuum that encompasses lectures, laboratory classes and field work, reasonably includes the fostering of learning about plants and animals through students' development of a personal and individual interest in the countryside and natural history (Westgarth-Smith, 2003), an achievement that is likely to lead to in-depth and life-long learning.

The present authors' experience of teaching plant diversity includes the conventional approach of laboratory classes in which a limited range of specimens is provided for students to examine, interpret, draw and label. The specimens are living, pressed or pickled and chosen to represent a range of taxonomic groups. For example first-year (Level 4: Certificate Level) students in Biological Sciences, University of Hull, take a module entitled *Plant and Animal Diversity* which includes a laboratory class in which they interpret, and make annotated drawings of five taxonomically-diverse microscopic algae provided in living cultures, and a class in which living specimens of four liverworts and mosses are photographed, drawn and used to produce an illustrated group report on bryophyte diversity. The students potentially acquire in-depth knowledge about the specimens provided but the range of examples which they encounter is very limited. An alternative approach is open-ended learning, where the learning outcomes do not require that all students achieve an identical knowledge base, and there is neither a closed set nor a fixed number of examples for study. This approach is possible using web-based collections of electronic images of plants; we argue however that it is a richer learning experience if students encounter a wide range of real plants growing in a field environment. The present contribution describes how students used open-ended learning to study plant diversity in an afforested landscape in north-east England.

The students were undertaking a pre-Certificate (pre-Level 4) year in biology at the University of Hull. This course, which has run since 2007–2008 when the University took pre-Certificate Level teaching in-house from FE partner colleges, is approximately equivalent to A-Levels. The students have diverse entry qualifications; some have non-science A-Levels, some have done badly in science A-Levels, some are mature students returning to education without formal qualifications, and some are overseas students. The pre-Certificate year leads to three further years (Levels 4–6) of a BSc programme at either the University's Hull campus or its Scarborough campus. Some students progress to BSc programmes that are specifically environmentally related while others progress to read Biology, Human Biology, or Biomedical Science. One sixth (20 credits) of the pre-Certificate year is made up of a module entitled *Biological Diversity*. The aims of this module include the students acquiring knowledge and understanding of the diversity of plants and animals through participation in biological field work. The module is designed so that it is self contained, for those students who do no further study of biological diversity, while not pre-empting the content of the Level 4 diversity modules that are taken later by the other students.

Students participating in the pre-Certificate *Biological Diversity* module undertake six days of field work. In 2008–2009 three of these days were used for study of inter-tidal organisms, principally animals, at Scarborough, North Yorkshire; that is two days comprising a morning observing and collecting animals from either a rocky or a sandy shore followed by an afternoon in a laboratory on the University's Scarborough campus interpreting and drawing these animals. On the third field day there were group projects on inter-tidal organisms, designed by students in consultation with tutors, which drew upon the experience gained during the initial two days of field work. The further three days of field work were devoted to the study of plant diversity at Dalby Forest in North Yorkshire; two days spent observing plants and a third day occupied by a group project.

Study of plant diversity at Dalby Forest

Dalby Forest is an extensive (about 32 km^2) afforested area. It is situated on the slopes and valleys of the Tabular Hills in the North York Moors National Park, about 7 km north-east of Pickering, and has a mixed geology of Jurassic deposits which include grits and oolitic limestone (Staniforth, 1993; Atherden and Simmons, 1996). The Forestry Commission has undertaken large scale planting of coniferous trees from 1921 onwards (Perry, 1983; Osborne, 2007). The forest was initially planted to provide a strategic reserve of timber; latterly its remit

has been extended beyond timber production to include enhancement of the visual quality of landscape, recreation, education and wildlife conservation. Forest management has included thinning, clear felling, replanting with a diversity of trees including broad-leaved species, and allowing natural tree regeneration. Also within the forest boundary are streams with distinct corridors of riparian vegetation, forest roads with well-vegetated verges, areas of beech woodland on limestone, and fragments of upland heath that predate the extensive planting of conifers. There is, therefore, much botanical diversity within the forest.

Field work at Dalby forest was carried out in March–April 2009. The first day was given over to trees and shrubs and consisted of a morning during which groups of 4–8 students walked in the forest accompanied by a tutor. The route taken was about 4 km, along paths and forest roads that are way-marked for recreational walking by the Forestry Commission; this provided easy access to a wide range of vegetation types, including first and second generation coniferous forest of various ages, thinned and clear-felled areas of forest, beech woodland, and streamside and roadside corridors. The students were asked to distinguish between different species of trees and shrubs, without at that stage necessarily naming them, although it was apparent that some of the students already knew some of the trees and tutors were able to give help with identification of others. Each group was encouraged sparingly to collect, from each encountered tree species, a sample of foliage, or of the (then) leafless twigs of deciduous trees for later identification and drawing. The students were also encouraged to take a wider view of the forest, beyond the individual trees, by looking for evidence of how the forest has been managed. The students spent the afternoon in a classroom, located within the forest at Low Dalby, which schools and colleges may hire from the Forestry Commission. They were encouraged to help one another by working in loose, self-selected groups and were asked to identify the samples that they had collected and to each collate two lists; one of coniferous trees, the other of broad-leaved trees and shrubs. The lists were to include Latin and English names plus brief notes, based on the students' own field observations, about the broad habitat occupied by each example: e.g. mature conifer plantation; clear-felled plantation; beech woodland; roadside; streamside. To help with identification, the students were each given a ×10 hand lens, and copies were provided of an illustrated key to trees in the form of a glossy folding card, published by the Field Studies Council (Oldham and Roberts, 2003). This is one of a range of illustrated habitat-based cards, designed to assist beginners to identify plants and animals; we have found that undergraduate students enjoy using them and that they can lead to use of more conventional text-based floras (Goulder and Scott, 2006). Further help with identification was provided by copies of an illustrated guide to trees (Mitchell, 1978) and by the tutors. The students were also asked individually to draw, label and annotate at least three examples of the samples of trees and shrubs that they had collected. At the end of the day the students' work was taken in for marking (10% of the module). Also in the afternoon, there was a 30 minute talk, given by a Forestry Commission Wildlife Officer, which was an introduction to the history and management of the forest and to how future developments are planned.

The second day of field work followed a similar pattern but the focus was on bryophytes and vascular ground flora. Specimens were once more sparingly collected in the morning while in the afternoon the plants were identified, using copies of an illustrated guide to the mosses and liverworts that are commonly found in woodlands (Perry, 1992), and again using the relevant Field Studies Council illustrated folding cards; i.e. the cards for woodland plants (Gulliver *et al.*, 1998), heathland plants (Jones, 1998) and ferns (Merryweather and Roberts, 2005). Copies of a guide to wild flowers (Rose, 2006) and the tutors were available to provide further help. Students were asked to make two lists, of bryophytes and ground flora, with Latin and English names plus habitat notes, and were asked to make labelled and annotated drawings of at least three of their plant specimens. The work was again taken in at the end of the day for marking.

Also in the afternoon, the students, in consultation with tutors, planned group project work to be carried out during their third day of field work in the forest.

Table 1 *Trees and shrubs identified and listed by pre-Certificate Level students at Dalby Forest, March 2009*

Coniferous trees	**Broad-leaved trees and shrubs**
Abies grandis (Grand fir) (16)*	*Acer pseudoplatanus* (Sycamore) (8)
Abies procera (Noble fir)† (13)	*Aesculus hippocastanum* (Horse chestnut) (35)
Abies species (Firs) (5)	*Alnus glutinosa* (Common alder) (18)
Chamaecyparis species (False cypresses) (13)	*Alnus rubra* (Red alder)† (5)
Cupressus species (Cypresses)† (1)	*Betula pendula* (Silver birch) (42)
Larix species (Larches) (35)	*Betula pubescens* (Downy birch) (9)
Picea abies (Norway spruce) (26)	*Corylus avellana* (Hazel) (38)
Picea omorika (Serbian spruce)† (2)	*Crataegus monogyna* (Hawthorn) (8)
Picea sitchensis (Sitka spruce) (24)	*Fagus sylvatica* (Beech) (45)
Picea species (Spruces) (4)	*Fraxinus excelsior* (Ash) (39)
Pinus contorta (Lodgepole pine) (8)	*Ilex aquifolium* (Holly) (45)
Pinus nigra (Corsican pine) (12)	*Lonicera periclymenum* (Honeysuckle) (4)
Pinus sylvestris (Scots pine) (29)	*Malus sylvestris* (Crab apple) (1)
Pinus species (Pines) (2)	*Populus tremula* (Aspen)† (3)
Pseudotsuga menziesii (Douglas fir) (14)	*Populus* species (Poplars) (1)
Taxus baccata (Yew) (4)	*Prunus avium* (Wild cherry) (5)
Thuja plicata (Western red cedar) (16)	*Prunus serrulata* (Japanese cherry) (6)
Tsuga heterophylla (Western hemlock) (26)	*Quercus cerris* (Turkey oak)† (1)
	Quercus ilex (Holm oak)† (1)
n of taxa = 18	*Quercus petraea* (Sessile oak) (2)
	Quercus robur (Pedunculate oak) (7)
	Quercus species (Oaks) (5)
	Rubus fruticosus agg. (Brambles) (3)
	Salix caprea (Goat willow) (13)
	Salix species (Willows) (6)
	Sambucus nigra (Elder) (26)
	Sorbus aucuparia (Rowan) (6)
	n of taxa = 27

**n of records from 52 students are shown in brackets.*

†Student identifications about which the authors have reservations: particularly, specimens identified as Abies procera were probably A. concolor, white fir; those identified as Alnus rubra were probably A. glutinosa; that identified as Cupressus sp. was probably ×Cupressocyparis leylandii, Leyland cypress.

It became apparent to the authors that the students, during the course of their work in forest and classroom, were engaging with a wide range of plants from a diversity of systematic groups; i.e. liverworts, mosses, ferns, conifers, and angiosperm trees, shrubs and herbs. In support of this observation quantitative information was obtained from the notebooks that had been handed in at the end of the day spent studying trees and shrubs. The 52 students who attended had between them collected, identified and listed 45 taxa; 18 coniferous trees and 27 broad-leaved (angiosperm) trees and shrubs (Table 1). The lists of trees and shrubs varied considerably between students in both composition and number of taxa. Among conifers, *Larix* spp., larch, was most frequently listed (35 students) while four taxa were listed by between 21–30 students, six by between 11–20 students, and seven by 1–10 students. Among broad-leaved trees and shrubs, *Ilex aquifolium*, holly, and *Fagus sylvatica*, beech, were both listed by 45 students; *Betula pendula*, silver birch, was listed 42 times, *Fraxinus excelsior*, ash, 39 times, *Corylus avellana*, hazel, 38 times and *Aesculus hippocastanum*, horse chestnut, 35 times. *Sambucus*

nigra, elder, was listed by 26 students while two taxa were listed between 11–20 times and 18 taxa between 1–10 times. The number of taxa listed per student ranged from six to 22 (mean = 12.2, *sd* = 3.9, *n* = 52). The individual students tended to include more broad-leaved taxa (range 2–13, mean = 7.4, *sd* = 2.5, *n* = 52) than coniferous taxa (range 1–11, mean = 4.8, *sd* = 2.3, *n* = 52).

Table 2 *Trees and shrubs identified and drawn by pre-Certificate Level students at Dalby Forest, March 2009*

Coniferous trees	Broad-leaved trees and shrubs
Abies grandis (Grand fir) (6)*	*Aesculus hippocastanum* (Horse chestnut) (5)
Abies procera (Noble fir)† (9)	*Alnus glutinosa* (Common alder) (6)
Abies species (Firs) (2)	*Alnus rubra* (Red alder)† (2)
Chamaecyparis species (False cypresses) (8)	*Betula pendula* (Silver birch) (1)
Larix species (Larches) (2)	*Corylus avellana* (Hazel) (7)
Picea abies (Norway spruce) (11)	*Fagus sylvatica* (Beech) (4)
Picea sitchensis (Sitka spruce) (12)	*Fraxinus excelsior* (Ash) (5)
Pinus nigra (Corsican pine) (7)	*Ilex aquifolium* (Holly) (28)
Pinus sylvestris (Scots pine) (5)	*Lonicera periclymenum* (Honeysuckle) (1)
Taxus baccata (Yew) (3)	*Populus tremula* (Aspen)† (1)
Thuja plicata (Western red cedar) (10)	*Quercus robur* (Pedunculate oak) (3)
Tsuga heterophylla (Western hemlock) (12)	*Salix caprea* (Goat willow) (5)
n of taxa drawn = 12	n of taxa drawn = 12

**n of drawings made by 52 students are shown in brackets. †Student identifications about which the authors have reservations.*

Individual students chose examples of their specimens of trees and shrubs, usually three, to make pencil drawings. These they labelled and annotated with help from the tree guides provided (Mitchell, 1978; Oldham and Roberts, 2003), from each other, and from the tutors. This gave them the opportunity to develop an in-depth knowledge of the examples chosen. Between them the 52 students made 155 drawings; 87 of coniferous trees and 68 of broad-leaved trees and shrubs. Twenty four taxa, out of the 45 taxa collected, were chosen (Table 2); these comprised 12 coniferous trees and 12 broad-leaved trees and shrubs. The most frequently selected coniferous trees were *Picea sitchensis*, Sitka spruce, and *Tsuga heterophylla*, western hemlock, both drawn by 12 students, followed by *Picea abies*, Norway spruce, drawn by 11 students, and *Thuja plicata*, western red cedar, drawn by 10. Among broad-leaved trees and shrubs, *I. aquifolium* was drawn by 28 students while the next popular, *C. avellana*, was drawn by only seven students.

Discussion

The use of open-ended field-based learning for the study of plant diversity at Dalby Forest demonstrated that the approach has advantages over conventional laboratory-based teaching.

- The approach led to a much wider whole-class base of knowledge and understanding. In the case of coniferous trees and broad-leaved trees and shrubs, for example, the class as a whole identified and listed 45 different taxa (Table 1) of which 24 were chosen for drawing, labelling and annotation (Table 2). This outcome contrasts with the conventional approach where many fewer specimens are generally provided and all students finish with an essentially identical and limited range of knowledge and experience.
- Because the whole-class knowledge base became much wider than that of the individual students, this meant that when student groups planned projects, to do

on their third day in the forest, they had a wide collective knowledge base to draw upon and share. Thus, for example, they were able to undertake projects that contrasted tree species and ground flora along stream corridors with those along verges of forest roads, and that related abundance and diversity of ground flora to shading by trees and to trampling by walkers.

- The students' interest was held because they were free to choose to draw those examples that particularly interested them. Student feedback on the seashore and forest experience included:

> *"This helped me as I could choose animals and plants that interested me."*

Thus, while some of the trees and shrubs that were most frequently encountered in the forest were well represented amongst the students' drawings (e.g. *P. sitchensis*, *T. heterophylla*) others that were less abundant, but had immediately striking characteristics, or perhaps personal associations, were also popular choices (e.g. *T. plicata* for its pineapple smell, *P. abies* with Christmas associations, *I. aquifolium* for its shiny spiny evergreen leaves, and *C. avellana* for its catkins).

- The plants were encountered in their field context rather than as isolated laboratory specimens; this gave the opportunity for appreciation of plant diversity, form and function within an ecological context.
- The use of an integrated field and classroom approach was appreciated, and, after a years' reflection, attracted some profound comment from a student who took the module in 2007–2008:

> *"I think it's important to consider that the field studies in 58007 Biological Diversity always included some related laboratory/indoor work – identifying & drawing specimens collected – and so it is hard to cleanly tease away the field work from the lab work. In terms of enjoyment, this is definitely preferable – to be able to view the organisms in their environment first hand and then apply that to what we see in the lab."*

- The use of integrated field and classroom days also ensured that shelter was available and that the distribution of time between field and classroom could be varied according to weather conditions. Learning and teaching continued even on snowy days; provoking student feedback:

> *"I really enjoyed all field trips no matter the weather".*

Unsurprisingly there were some potential drawbacks to the open-ended field based learning approach used at Dalby Forest which need to be set against the advantages.

- The quantity of work done varied substantially between students. For example, the number of tree and shrub taxa identified and listed ranged from six to 22 per student. There is the likelihood that less motivated students addressed fewer plants than they would have in a formal laboratory practical class; although other students evidently took the opportunity to address more than would have been possible in a conventional class.
- It is likely that some of the plants were misidentified. This would not happen in a conventional class in which defined specimens are provided. A degree of misidentification of plants collected from the field is not surprising. Scott and Hallam (2002) found that nearly 6% of diverse UK plant specimens were wrongly identified at species level by professional field botanists; it is certainly to be expected that students will make mistakes. Furthermore, tree identification can be especially problematical around Low Dalby because it is a former Forestry Commission village; forestry employees tend to have a personal interest in trees and are liable to plant examples of diverse exotic taxa. The purposes of the work at Dalby Forest did not,

however, include making reliable records of plant distribution and the view taken is that it was largely adequate for students to name plants to genus and be aware of some of the distinguishing features of the relevant genera. The information in Tables 1 and 2 was taken from the students' notebooks; identifications about which the authors have specific reservations are indicated in the tables.

- The approach demanded substantial resources. There was the cost of transporting students by coach from the Hull campus to Dalby Forest, and of the hire of the classroom from the Forestry Commission. Also, because of the limited capacity of the classroom and the large class size, it was necessary to duplicate the first two days of field work. A low student to tutor ratio is preferable for field work; the ratio was kept down to 8:1 or less by using both experienced technical staff and academic staff as tutors. To be set against these demands, however, is that academic staff and demonstrators were not needed to run conventional laboratory classes, space was not taken up in on-campus laboratories that were running at near full capacity, preparation room staff did not have to set up and clear the laboratories, and there was no need to grow and/or collect plants in advance of laboratory classes.
- Student feedback suggested that long coach journeys (about 1.5 hours each way) led to a lot of non-productive time:

> *"Field study is in a way more interesting but it's far easier to learn in the lab when you have everything in front of you and there aren't hours wasted in the day."*

The authors' subjective perception is that the advantages to the students of open-ended learning about plant diversity in the field environment outweighed the drawbacks. This conclusion, however, is based on our observations and pedagogic experience rather than on the research-based evidence sought by Maskall and Stokes (2008). If controlled experiments are to be used to explore the learning process in HE there are likely to be disadvantaged control groups. In the experiments done by Taraban *et al.* (2004), for example, students were randomly assigned to groups that learnt plant identification using living material or online resources but both groups were assessed using living material; a procedure that potentially disadvantaged the online-learning group. Such disadvantaging is apparently shown by a study in a US university (Brickman *et al.*, 2009) in which non-science students were allocated, without choice of learning mode, to groups that learnt biology laboratory skills either by following a traditional curriculum or by enquiry-based learning. The latter group did marginally better in gaining laboratory skills but enjoyed the learning experience less than the traditionally taught group. There are ethical issues here related to the need for informed consent, especially in the context of an HE structure, such as in the University of Hull, where performance in all modules contributes to either progression or degree classification. These issues need to be reconciled with the need for objective, experiment-based, evaluation of the benefits of fieldwork.

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