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Exciting practicals for all

Laboratory classes in the biosciences ought to be exciting and stimulating. It is therefore disappointing that both students and staff have recently registered disquiet with current teaching practice *(www.bioscience.heacademy.ac.uk/ftp/reports/1styearlabs.pdf, www.bioscience.heacademy.ac.uk/ftp/reports/pracworkshopreport.pdf)*. Each group agrees that, wherever possible, we should replace lengthy, repetitive, predictable and boring practical classes with challenging, enquiry-based exercises that embrace the Scientific Method and encourage students to engage more deeply with course content. The Centre for Bioscience is keen to address these issues by assisting in the introduction of effective, cutting edge approaches to practical teaching not only in laboratory but also in fieldwork settings.

This can be achieved, in part, by raising awareness of high quality teaching resources described in the literature. There are several educational journals that support bioscience teaching and these abound with accounts of good, original practice in laboratory and fieldwork teaching. Together, these publications provide compelling evidence that students engaged in enquiry based learning (EBL) perform better and enjoy laboratory classes more than students taught by traditional methods. Examples of EBL approaches in the teaching laboratory are found in a very wide range of bioscience disciplines extending from molecular biology to ecology fieldwork; some involved mock research projects that mimicked the activities of the scientific community. An obvious extension of this approach is to give undergraduates the opportunity to contribute to genuine cutting edge research in teaching laboratories. Surely this must be the most effective way to ensure student engagement in practical classes. Recent examples have included cancer research with mouse mammary tumour cells, the use of the yeast *Saccharomyces cerevisiae* to test the mutagenicity of household compounds, 'prospecting' for novel antibacterial agents and investigations of polymorphisms, within the class, of a so-called 'God' gene. Students may even have the opportunity to publish the results of such research in journals introduced recently and specifically for this purpose. For a more detailed review of novel EBL approaches and undergraduate research in bioscience teaching laboratories see *www.bioscience.heacademy.ac.uk/journal/vol13/beej-13-3.aspx*

One of the key recommendations to stem from our recent workshop on first year practical teaching was that the Centre for Bioscience, with appropriate partners, should explore the possibility of developing a bioscience Dynamic Laboratory/Field Manual. This originated from an excellent presentation, at the workshop, by members of the Bristol ChemLabS initiative *(www.chemlabs.bris.ac.uk/)* who described their interactive, online Dynamic Laboratory Manual (DLM) for chemistry teaching. The Bristol DLM contains background information about each practical session along with video clips and simulations that allow students to observe and practice the techniques they will use prior to visiting the laboratory. Interaction with virtual instruments helps give students the confidence they need to use complex, sophisticated equipment during practicals. All of this means that students are better prepared for laboratory sessions and as a result may be assessed on their performance in the laboratory. This helps eliminate lengthy and tedious write-ups following each practical session.

Chemistry students and staff appear to benefit greatly from the Bristol ChemLabS approach and a similar Dynamic Laboratory/Field Manual for the biosciences is a very attractive proposition. Many of you will be aware that recently the Centre sought expressions of interest from colleagues who may wish to be involved in a 'BioLabS' initiative. I am pleased to report that we had a very strong response from practitioners with a wide range of interests. We thank colleagues for their enthusiasm and look forward to working with them in the development of resources that should benefit all members of our community.

David Adams
Director, Centre for Bioscience
d.j.adams@leeds.ac.uk

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2 | Instant Feedback via Peer Assessment

"Assessment tends to shape every part of the student learning experience"

(Orsmond *et al.*, 2000)

However, students continue to express dissatisfaction with many aspects of assessment and feedback practices in universities in the UK. In the 2008 National Student Survey whilst 82 % of the students professed to be satisfied with their courses generally, 44 % of students complained that feedback had not been prompt and had not helped them in their studies. For this reason, much effort has been expended across the sector to improve assessment and feedback practice.

There may be many reasons for the dissatisfaction. On the part of the students, they may not be readily able to identify what constitutes feedback, what its purpose might be and how they might use it to improve their future academic performance. For staff, especially in laboratory-based sciences, large class sizes lead to large marking loads with the same practicals often being repeated in a rota system. Prompt marking of work would consequently lead to fears about collusion or plagiarism from subsequent groups. Nevertheless, it is often stated that feedback should be given as quickly as possible after an assessment deadline. If feedback is delayed then students will have lost interest in that piece of work as it does not relate to their current situation and will not be of benefit to their future learning. In addition the degree of variation in the nature and extent of feedback may lead to the whole process being viewed negatively by the student.

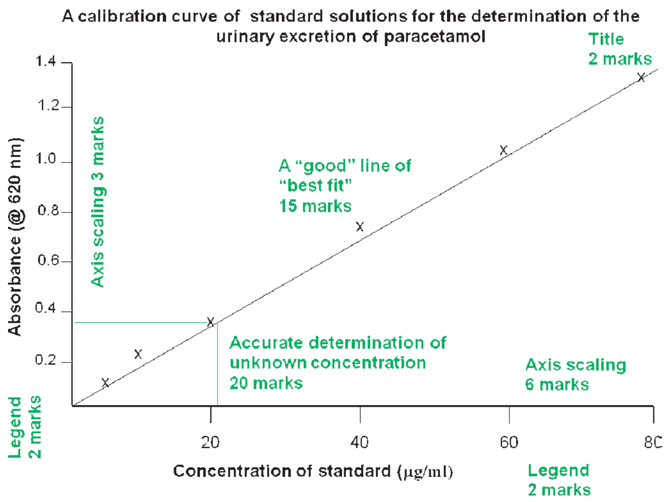
Aims

1. To speed up the feedback process.
2. To introduce peer assessment and thereby inculcate critical and evaluative skills in undergraduate students.

Here we describe a tutor-directed 'instant feedback' mechanism using peer assessment to provide prompt feedback which is designed to improve future performance whilst at the same time demonstrating clear assessment criteria and a transparent marking scheme.

Method

In this case, level 3 students (usually a cohort of approximately 100 students do this practical, in groups of 20, in sessions a week apart) undertake a practical with the aim of determining the concentration of a biological analyte. Students use a spectrophotometric method to construct a standard curve (5, 10, 20, 40, 60, 80 µg/ml standards) from which they can determine the concentration of the unknown analyte. After the practical component of the session students are told to immediately plot the data and thus work out the concentration of the unknown analyte from the standard curve. These graphs and the raw data, identifiable only by the student's university number and not by name, are then collected by the lecturer and redistributed randomly throughout the group. The lecturer then presents data showing how the plot should look. Students are told to mark their peer's work based on criteria presented on the lecturer's 'idealized' plot as shown below (appropriate title, axis legends and units, linearity of plot and accuracy of unknown determination etc.). The unknown analyte concentration is changed each session.



Finally, a full report is written up by the students in the normal manner and the work assessed by the tutor to make up the rest of the marks and quality control the peer marking process.

Conclusion

Students are given immediate feedback on the accuracy of the data they have generated in the practical session. When audited for their opinions on this approach students have made comments such as the following:

"It showed in what fashion work is marked, and explained why marks could be lost due to seemingly insignificant errors."

"I gained an insight into the positive and negative aspects of my work and how this affected my overall mark. This will aid me in future assignments."

Thus students are involved not only in the final judgements made of other student's work but also in the selection of evidence of achievement which may give them insight into their own performance. Finally by using the students as a teaching resource academic staff may make gains in efficiency by active management of peer marking processes rather than marking large volumes of student work.

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Nicholas Freestone
Kingston University
N.Freestone@kingston.ac.uk

Fieldwork:

E-Learning Benefits The Part-Time Student

E-learning teaching strategies might not seem an obvious choice for field-based modules, but they can help a part-time student get more out of their course. Fieldwork in the biosciences can be an effective way to free the learner from the straitjacket of regimented laboratory-based practical work, so introducing them to the real world of biology, the world of variability. The formulaic nature of laboratory practical work is particularly disadvantageous for part-time students as they usually have little time to explore the practical's implications with tutors or peers. Also it is desirable that practical work results in a concrete outcome, for, if students are to develop communication skills in report writing, critical analysis and presentation, there has to be some data with which to work. The drawback is, then, that students seldom appreciate the nature of biological variation, because they do not see it. This makes it difficult for them to appreciate how heritable variation is essential for evolutionary processes — the key to understanding biology. For much laboratory-based practical work variation is not easily incorporated; yet in fieldwork students can observe variation and some of its consequences, whether it be snail shell colour polymorphism or the variability of replicates when sampling populations.

For fieldwork investigations we have used computing technology to create time for the face-to-face tutor/peer interactions that are often minimal for part-time students. For example, a whole day field study measuring plant abundance in a succession generates very large amounts of data. With multiple student groups the data transfer from recording sheets and its collation can take nearly the whole of the subsequent evening teaching session. To circumvent this we used personal digital assistants to record the data directly in the field. This tactic produces a useable dataset within an hour or so, and, using bespoke software provides it in an accessible form ready for student discussion *(www.bioscience.heacademy.ac.uk/ftp/events/elearn111207/Baggott.pdf)*. Technology here has eliminated a painfully boring data collation exercise, so allowing students to focus on evaluation and gain a meaningful appreciation of ecological complexity and sampling variation.

The maritime plant community for which PDAs were used to collect data on plant abundance.

For part-time students there are yet other advantages of learning biology in the field: often it provides their only sustained exposure to the so-called 'hidden curriculum' of interpersonal skills and self-management of learning. Yet there is a conflict here between providing a rich, biological, learning experience and the temptation to expand activities designed to enhance the hidden curriculum. In other words, a tendency to squeeze too much into a fieldwork module, with a consequent reduction in quality of learning. In our own second-year undergraduate module, consisting of five evening sessions plus a residential six days, we have used e-learning to create more time for productive learning activity (Baggott and Rayne, 2007). Students are given two CDs of tutorial computer-based assessments: the first CD, focused on theory, before the residential portion of the course, and the second during the residential period, containing e-tutorial assessments to support the field investigations. The e-tutorials were constructed specifically to capture the 11 conditions under which assessment support student learning (Gibbs and Simpson, 2003); and student responses and performance indicate this tactic was a success. Moreover, this approach helped to develop learner self-regulation, so meeting six of the principles of Nicol and McFarland-Dick (2006): e-tutorials clarified good performance, facilitated self-assessment, delivered high-quality feedback, encouraged teacher and peer dialogue, delivered positive motivation and provided opportunities to close the 'learning gap'. One can learn a lot of biology in the field — with only a hand lens, notebook and waterproofs — but with targeted e-learning you can deliver much more.

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Glenn K Baggott
Birkbeck, University of London
g.baggott@bbk.ac.uk

4 | Designing Laboratory Spaces

For a number of reasons the design of learning spaces has taken centre stage in the development of estate. Firstly, there has been funding available and secondly, there is an increasing realisation that the quality of the estate is important to the student experience. Thirdly, the numbers of students has increased, placing a strain on space designed to cope with smaller student cohort. Changes in GSCE and A-level curricula (and assessment) have meant that students are coming to university with different skill sets to those possessed by the students of 20 years ago. This has necessitated changes in the role of, and approach to, practical teaching. Finally, there is a realisation that the effective design of learning spaces can increase student engagement with learning. This should inform the development of novel and innovative laboratories.

The recent report '1st Year Practicals: their role in Developing Future Bioscientists' *(www.bioscience.heacademy.ac.uk/events/themes/1styrpracticals.aspx)* identifies a series of pressures on the provision of practical teaching. These include decreasing resources, increasing student numbers and less practical experience in schools. It also reflects the decreasing importance of practical training, given that 50% of all biosciences graduates take employment outside the biosciences. There is also evidence that students find first year practicals demotivating, which may contribute to a failure to follow laboratory-based careers. However, practical work is considered fundamental to bioscience programmes yet it is not often clear how they support the learning outcomes of the programmes. For example, are they designed to develop practical skills or support the acquisition of knowledge? Prior to starting laboratory redesign it is valuable to determine this so that space can be designed appropriately.

Despite the design of teaching space receiving considerable attention recently, particularly in terms of refurbishment, there is relatively little about the (re)design of laboratories. The JISC Flickr site *(www.flickr.com/photos/jiscinfonet/)*, a very useful source of examples on how to design teaching space has relatively few examples of bioscience laboratories. The JISC project 'Designing spaces for effective learning' *(www.jisc.ac.uk/eli_learningspaces.html)* uses the London Metropolitan University Super Lab as a case study and Bristol ChemLabS *(www.chemlabs.bris.ac.uk/.)* has developed an innovative space for laboratory teaching. These are large-budget projects designed to transform the teaching of science, and as such have of the freedom to design appropriate space. It is clear from the JISC work that novel and innovative spaces can be motivating and inspiring for both staff and students.

At Bradford, in common with others, we are faced with building structures that are poorly designed for the numbers of students we currently teach, in need of refurbishment and we only have relatively modest budgets to work with. In addition we need flexibility so that many subject areas can use the same space, and to consider potential future requirements, particularly in light of the declining level of students' prior practical experience. The declining amount of practical work means we are reviewing the purpose of practical work, especially the relative roles in skills and knowledge development. The first and most important consideration is that the laboratories at Bradford are long and thin (21 metres by 7.2 metres would be typical) with benches running parallel to the short axis with teaching benches at one end. These were designed to accommodate relatively small groups (c40 students) and do not accommodate the 80 plus students which can be a group size at level 1 and 2. Recent solutions to this have included using various bench layouts including peninsular benching — useful in focussing student activity on a particular area and movable benching that can be locked in place — services being provided at the locking points with benches running parallel to the long edge. Peninsular benching is particularly effective as it can allow for group spaces and limits the movement around the lab whilst not compromising safety. This helps with the management of large classes and can be used to facilitate communication both within groups of students and between staff and students.

Consideration of the movement of students through the laboratory and the ability of students to communicate with both staff and each other is important. The increase in size of our laboratories created large long spaces with the lecturer's bench at one end resulting in poor visibility for both staff and students. Correct placing of the podia and the use of appropriate AV facilities can permit students to see demonstrations and allow staff a clear view of the whole space.

Flexibility is a major consideration in laboratory redesign in Life Sciences so all laboratories are designed to a Class II standard. This costs little more than a general purpose laboratory. A standard set of services is supplied with more specialised services being provided on a more local basis assuming the plumbing is appropriate.

The IT setup for large laboratories is important but the level that exists in, for example, the ChemLabS will be beyond most refurbishments. The key consideration is that it should be enabling: i.e. it is not simply what you need for current use but also how IT might be used in the future. The use of IT in terms of, for example, SMART Boards and as support for the audio-visual set can be very effective. Installing bench PCs to allow simulations and computer assisted assessment should be considered. Even if you do not do this it is worth ensuring that the wiring is in place to allow easy installation at a later date.

Sustainability is an important consideration for the University of Bradford. These principles are informing the process particularly using the outcomes from the Labs21 project *(www.labs21century.gov/)*. The Harvard Green Laboratories website *(www2.umdnj.edu/eohssweb/aiha/technical/green.htm)* is another useful resource.

The budget for this work covering over 3000sq metres is about £6.5 million or £2,000 per square metre for Class II space. This is a useful benchmark costing figure when planning refurbishment and bidding for resource.

Much of this seems common sense. However, thinking through clearly what the purpose of the space, the sorts of teaching that the space will accommodate and whether there is an imaginative solution to these issues will be time well spent.

Nigel Lindsey
Associate Dean for Learning and Teaching
University of Bradford
N.J.Lindsey@Bradford.ac.uk

Teaching Scientific Methods

Luck and Wagstaff (*Bulletin* 24, p4) ask about teaching the scientific method to bioscience students. Here at the University of St Andrews, we have a second year scientific thinking module available to all students which does just that. The module 'Science Methods' is an interdisciplinary module taught presently by the schools of Mathematics and Statistics, Computing Science, Psychology, Philosophy and Biology. The students are taught about different definitions of science and by extension non-science and pseudoscience, introductory philosophy of science; basic logic (deduction, induction, abduction and most importantly logical fallacies); the use of authority in science; the scientific method(s) and their applicability or not to science, basic experimental design; the rationale for using statistics (often not given in basic stats classes); biases encountered by scientists and a little history of science. However, it is very much NOT a philosophy class, the emphasis is on scientific thinking day to day.

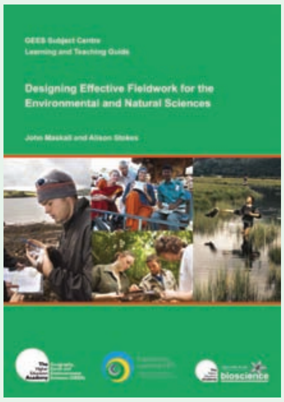
The module was created to correct a clear gap in the teaching of science students, in that the philosophy underpinning their decision making is not always justified. We have found that students have rarely discussed the scientific method since the early years of secondary school. They do not know why scientific literature ought to be more reliable than a popular magazine article and certainly more reliable than *Wikipedia!* As only a small minority have any knowledge of Occam's Razor (also, alas, like many scientists), for example, they do not really have any strong philosophical basis for choosing between supernatural and natural hypotheses for a given phenomenon. Further, some students cannot even explain why they are doing science. Despite this we have found some fellow scientists sceptical of our endeavours, although many are in favour. Opposition has come from those that regard such teaching as an unnecessary luxury, as students will pick up these skills anyway. They do not, we have evidence. Also they feel that the material taught is unnecessary for scientists (i.e. they got by without it, so why should current students be taught it?). Again quantitative evidence will be forthcoming but it cannot be appropriate that any graduating honours science student should fail to recognise for example, that a relevant control is missing from an experiment, a blatantly circular logical argument or not know about the processes involved in producing a scientific paper to name but three gaps we aim to fill in.

With regard to *the* scientific method, we point out to students that there are different opinions on this. There are scientific investigations which do not necessarily use the scientific method e.g. some aspects of archaeology and palaeontology, yet these are still regarded as science. Hence the idea of a single scientific method may be simplistic. We also try to integrate the use of the scientific method with the application of statistics.

Finally, in answer to Luck and Wagstaff's question on whether understanding the scientific method is part of becoming a bioscientist, I would argue that not only is it worthwhile, it is essential. In my (partial) role as a statistical consultant, I am amazed at the number of biologists who come to me for advice who cannot explicitly state the hypothesis under consideration in their own experiment. Identifying that hypothesis is one of the fun parts of my job but in a sense something is clearly wrong with scientific training that this is so frequently a problem. In addition scientific thinking is surely one of the most useful transferable set of skills of all and I regard it as extraordinary that so little emphasis is placed on explicitly developing these skills in so many science faculties. It may be that such skills are best taught by integrating them integrated into other courses but our current evidence is that for many topics this does not happen.

Charles Paxton
University of St Andrews
cgp2@st-andrews.ac.uk

Designing Effective Fieldwork for the Environmental and Natural Sciences



The guide provides support and ideas to academic and technical staff engaged in the design and delivery of fieldwork in the environmental and natural sciences. It draws on literature and experiences from the disciplines of environmental science, geography, Earth science and the biosciences. The guide has been prepared for higher education in the UK, with the focus predominantly, but not exclusively, at the undergraduate level.

The guide is available to download from *www.gees.ac.uk/pubs/guides/eesguides.htm* Alternatively the Centre has a limited number of printed copies to distribute *(heabioscience@leeds.ac.uk).*

6 | Using Learner Response Systems for Ecological Fieldwork

Fieldwork is generally regarded as an essential component of most bioscience degree programmes and is held in high regard by practitioners in many disciplines (Fuller *et al.*, 2006). There is a great deal of evidence that students enjoy their experiences of fieldwork, whilst learning effectively (Fuller *et al.*, 2006). Experiencing and exploring outdoor (complex) systems and processes requires learning opportunities that cannot be wholly replicated in the classroom or laboratory. In terms of the delivery, approaches that promote active, rather than passive, learning are to be encouraged as such approaches are considered more effective, particularly with small-group approaches to problem-solving (Lonergan and Anderson, 1988).

Fieldwork is not without problems and for many reasons opportunities for fieldwork within degree programmes may be limited and can be expensive. Therefore, it is preferable to maximise the learning benefits associated with field sessions. Logistically, fieldtrips can be difficult for tutors to manage and tutors often concentrate their efforts on organising students to ensure that all required tasks are completed. This can reduce time for students to experiment and reflect. In addition, students can become very task focused, working through methods and instructions without really thinking deeply about the techniques they are employing. In short, tutors can find themselves too busy organising the fieldwork activities to engage deeply with students, test their understanding and provide meaningful feedback.

Learner response systems (LRSs)

Learner response systems are a relatively new technological addition to classrooms in UK Higher Education, although they are becoming increasingly common in many educational settings (Fies and Marshall, 2006). A LRS normally comprises a set of individual hand-held or desktop keypads that transmit student votes/responses to a central device that collates, analyses and displays results to a classroom, normally via a whiteboard system. LRSs promote learning when coupled with appropriate pedagogical methodologies (Fies and Marshall, 2006) and can significantly improve interactivity in the classroom (Siau *et al.*, 2006). One of the main reasons that tutors make use of LRSs is to increase the ease with which frequent formative assessment of students can be made (Roschelle *et al.*, 2004). With LRSs such feedback is elicited from everyone in the class (rather than just from individuals who choose to put up their hands in response to questions) and allows tutors to evaluate the understanding and address the needs of a whole class. The ActivExpression LRS has the ability to receive texts of complete sentences and numerical responses in addition to the more usual selection of options from multiple choice questions.

It seemed to us that the strengths that are often attributed to LRSs (e.g. increased interaction with learning tasks, ability to elicit responses from a whole class and consequently to provide rapid feedback) might allow us to address some of the problems associated with running field courses.

Moorland Ecology fieldtrip

The Lindow Common fieldtrip introduces key ecological techniques and data collection methods used in moorland vegetation surveys for level 5 students (2nd year undergraduate n = 34; 3 staff). The fieldtrip aims to get students to engage critically with the field environment and the ecological methods that underpin the learning objectives for a written assignment. To explore the potential of LRSs to enhance fieldwork experiences we delivered six questions whist in the field to address three components of the learning experience (Table 1).

Table 1 – LRS deployment throughout the field course

Aims	Question (format)	Delivery/Location and Tutor Use
1. Testing basic knowledge and background of moorland ecology	Q1. Which three deciduous hardwood tree species are native to the UK? (Multiple choice question) A. Ash B. Beech C. Scots pine D. Oak E. Larch Q2. Name two common moorland plant species (Free text entry)	In the car park during the introductory talk. Results allow the tutors to address errors in the students' knowledge base, both in the field and in follow-up sessions.
2. Exploring problems of the data collection techniques	Q3. Estimate percentage cover of heather *Calluna vulgaris* in the quadrat. (Numerical entry) Q4. At a distance of 10m, what is the angle between the horizontal and the top of the marked tree? (Numerical entry)	During the fieldwork and data collection activities. Results will alert the students to the inherent variability between operators in making estimations and taking measurements
3. Reflecting on prior learning	Q5. What is the missing tree biomass that does not appear in the calculation of standing biomass? (Free text entry) Q6. What two statistical tests could you apply to confirm greater biomass of purple moor grass in the heathland versus woodland sites at Lindow common? (Free text entry)	On the coach before leaving on the return journey. Results will give an indication to tutors level of reflection of the methods and ability to link to relevant prior learning at level 4 (1st year undergraduate).

The LRS was installed on a lightweight tablet laptop that could be used in a hand held fashion (i.e. the screen face up) and easily carried while in the field (Figure 1). Thirty students were each issued with a LRS handset and four students shared one between two (32 handsets in total).

Evaluation

During the fieldwork it was raining heavily with a blustery wind from the time that we left the coach until the end of the three hour trip. We adopted a simple, low tech solution of putting the laptop inside a clear plastic bag which operated perfectly using the pen mouse from outside the bags even in heavy rain (Figure 1). To protect the LRS handsets from the rain they were also placed inside protective plastic bags (Figure 2). None of the students reported that this impaired the operation of the LRS handsets. The handsets transmitted without problems when tested up to a distance of 20 metres.

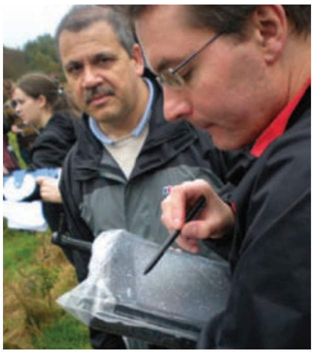


Figure 1: Tablet laptop working perfectly in heavy rainfall protected by a clear plastic bag

Figure 2: Students had no problem operating the AE pods inside protective plastic bags

We could not present the options for the multiple choice questions via a white board or other screen (as in a classroom setting) so we wrote them on A3 paper. Due to the weather, this rapidly became wet and difficult to read. For some of our simple questions this was not an issue as verbal communication was sufficient. However, presenting the options for multiple choice questions under such conditions needs further consideration.

One pleasing outcome was the enhanced reflection on operator error/variability when making basic estimations in the field. The variation in estimates of heather cover (Q3 – Table 1) for one group is shown in Figure 3. The students were genuinely surprised at the large range of estimates submitted by their peers. This generated instant discussion on approaches to standardisation for professional ecological measurements and also the nature of variation in the data used in statistical analysis. This data together with all of the data captured by the LRS was reused in follow-up session to explore these issues in more detail. When asked, the majority (85%) of the students on this field trip were in favour of LRSs being used in their teaching.

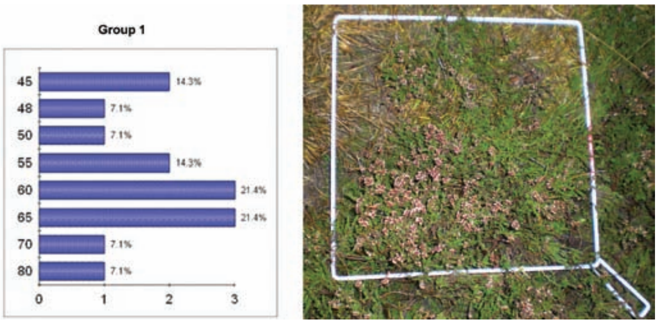


Figure 3: Output from LRS software showing the variation in students' estimations of percentage cover of heather in an example quadrat (pictured above).

We were able to deploy simple proof of principle activities that:

- tested our students' basic knowledge and background of moorland and woodland ecology. The leaders of the fieldtrip were able to respond immediately, based on the strengths and weaknesses which were identified;
- generated data sets that demonstrated, in the field, the inherent variability in making estimations and measurements (of percentage vegetation cover and angles for the calculation of tree heights respectively). This provided a relevant stimulus for discussion during the fieldtrip and in follow-up sessions; and
- encouraged students to reflect upon the methods they had used in the field and make links to prior learning and experience in statistical analysis. This allowed the tutors to respond to any misunderstandings in the follow-up sessions.

Acknowledgements

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Rod Cullen, Mark Langan and Robin Sen
Manchester Metropolitan University
r.cullen@mmu.ac.uk

8 | Practical Skills in Biology
– Engaging Your Future Market

What factors prevent young people from studying degrees in the biosciences? A lack of awareness and opportunity — did they ever meet a scientist or experience inspiring science teaching? Is it socioeconomic — one local parliamentary constituency had a participation rate in HE of only 8% in 2005 (HEFCE, 2007). Can we do more to enthuse and engage young people with the biosciences? Traditionally HE departments have focused more on sixth form students. However *"evidence suggests that decisions are taken about the attainability of HE at a much younger age than the later stages of secondary school."* (HEFCE, 2007). Instead we should be *"… providing a range of opportunities to experience positive learning situations outside the locality, raising awareness of alternative possibilities."* (HEFCE, 2007)

The Biosciences Federation recently stated

"What more can the education community do to develop scientific literacy in young people? More hands-on science and good teaching of practical skills by enthusiastic, specialist teachers are needed. … Creativity in science needs to be encouraged along with more cross curricular links to help enthuse pupils, make science relevant and encourage innovation. Sharing of resources and improved outreach work by universities would help many educational establishments further develop their work". (Biosciences Federation, 2008)

In other words, we need 'hands-on, minds-on' approaches to science outreach, with a focus on practical work.

Our approach

Taking up the challenge of attracting more young people into bioscience careers we at CELS (Centre for Effective Learning in Science) are developing a coordinated programme of bioscience activities for a range of age groups, with a strong emphasis on practical scientific enquiry. We now offer a wide portfolio of practical sessions for all key stages — from *Animal Habitats, Minibeasts and Bricks Bananas and You* (DNA) for KS1 & 2 (Primary), *Bird Flu Outbreak and Pills, Jabs and Patches* for KS3 and *Forensic Microbiology* and *The life and death of cells* (Post 16 Masterclasses). These are complemented by talks on a range of topics including Flesh Eating Bugs (microbiology and careers in biomedical science). Here are some details of three of our activities to develop field work and practical skills with school children:

- *Minibeasts* uses a simple trapping technique to demonstrate differences between a field and a woodland habitat by collecting live invertebrates and taking measurements of temperature, wind speed and humidity. It demonstrates the range of form of small invertebrates, allows participants to take field readings and encourages reflection on possible reasons for differences in the species collected in the two habitats. This "out of the classroom" outreach activity supports children studying science at KS2 (Life processes and living things) or KS4 (Living things in their environment), to encourage them to take up science courses later. It can also be used for both undergraduate level 1 teaching and trainee biology teachers as a field practical.

- *Forensic microbiology* investigates an infectious disease outbreak on a housing estate, suspected of being associated with a local school with poor toilet facilities. The students are told that various samples have been taken from patients and sent to the lab for analysis. The students try to work out the source of the outbreak using bacteriological and DNA fingerprinting techniques. An extension to the session considers what happens in the patient's blood in response to an infection. The session gives insights into a biomedical environment with specimen handling and DNA manipulation techniques. A general discussion as to how infections spread and good hygiene concludes the session.

- In *The life and death of cells* students visualise different mammalian cells growing in culture, from skin cells to brain cells and appreciate the use of cell models in bioscience. They classify and identify a number of different cell types and subsequently induce these cells to die and watch the process happen in real-time.

The CELS Bioscience Outreach Coordinator identified key staff to deliver talks in schools, and to develop and enhance practical activities for schools. Such face-to-face contact allows staff to highlight the importance of biology as a subject to pupils and improves our curriculum support through dialogue with teachers.

If you are undertaking outreach or interested in starting some outreach activities and would like advice or to use CELS resources then please get in touch, we will be happy to help.

Acknowledgements

Activities mentioned were developed by Chris Terrell-Nield, Alan McNally, Gina Manning, Luigi De Girolamo, Phil Cheetham, Alison Mealing, Jacqui Hillier, Lorraine Buckberry, Natasha Neale and Georgina Westbrook. CELS *(www.ntu.ac.uk/cels)* is funded by HEFCE as a Centre for Excellence in Teaching and Learning.

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Karen Moss and Gina Manning
CELS and Nottingham Trent University
karen.moss@ntu.ac.uk

Centre News

It is with sadness that we report the death of Professor Ed Wood. Ed was a distinguished academic, a champion of biological education and an excellent colleague. He was co-founder of the then LTSN Centre for Bioscience in 2000 and was director and subsequently co-director for the Centre until his retirement in September 2006. Following his formal retirement, Ed maintained a strong and supportive interest in our activities, and was Editor-in-Chief of *Bioscience Education* from 2007. His Full Obituary has been published by the University of Leeds *(http://campus.leeds.ac.uk/newsincludes/newsitem6194.htm)*.

He will be greatly missed by many.

In recognition of Ed's desire to develop biochemical education, particularly in the developing word, the Edward J. Wood Memorial Fund has been established to finance educational projects in ways that Ed would have approved. Details of the fund and how to donate are available from *www.iubmb.org/index.php?id=144&tx_ttnews[tt_news]=20&tx_ttnews[backPid]=1&cHash=1be5203cba*

Bioscience Resource Database

Our new Bioscience Resource Database is now available, bringing together Centre resources in a single searchable database and linking with the broader resource database JISC Intute *(www.intute.ac.uk)*, which now has improved and extended coverage of the biological sciences. Search Centre resources, such as event reports, projects and Science Learning and Teaching Conference papers. The database is still in development and more of our resources will be added over the coming months. A simple keyword search page is available and we would welcome any comments. The search page can be found at *www.bioscience.heacademy.ac.uk/resources/database/*

We would welcome contact from our community to undertake a brief evaluation exercise. Email *t.j.mcandrew@leeds.ac.uk* if you are willing to take part.

Evaluation

During 2009, the Centre for Bioscience will be gathering evidence of the effects of our work with staff, students, academic departments and other groups and organisations.

We plan to evaluate our events, project funding, services, resources and publications. In particular we are interested in the reasons for the different levels of engagement between departments. This evaluation is being done as part of a joint evaluation of the six science, technology, engineering and maths (STEM) Subject Centres — the others are Engineering, Information & Computer Sciences, Materials, Maths Stats & OR and Physical Sciences. As part of this evaluation, you may be asked about some aspect of our work. If you are asked, we hope you will be willing to contribute a few minutes and a few ideas. This collaborative evaluation is part of our ongoing appraisal and not being undertaken to provide yet another evaluation report. Rather it will help us to understand better how we can make our work with you more effective and more useful to you. It will also help each of the six STEM Subject Centres to learn from each other.

The evaluation is being carried out by Dr David Baume, an experienced academic developer and evaluator.

Student Award 2009

"Given your degree, what are you looking forward to in the future?"

Please let your students know that the 2009 Student Award is now open, giving them the opportunity to express their opinions, tell us about their experiences, add something different to their CV and win up to £100 and an iPod Touch. This year entries can be an essay, a podcast, a video or a website — whichever way students think is best to respond. Further information, including criteria and the entry form, is available from *www.bioscience.heacademy.ac.uk/funding/essay/award09.aspx*

The deadline for entries is the 15th April 2009

3rd Science Learning and Teaching Conference 2009

16th – 17th June 2009, Heriot-Watt University, Edinburgh

Registration for the Conference is now open, with an earlybird registration rate available until the 31st March. For more information please visit the Science Learning and Teaching Conference website at *www.sltc.info/registration.asp*

SLTC

Case Studies

Just to remind readers we welcome case studies on any aspect of bioscience learning and teaching. Accepted case studies will be added to the Centre website and may be printed and distributed in hard copy format by the Centre. The first author of each accepted case study will be eligible to receive a small payment of £100. Further details and a submission form are available from *www.bioscience.heacademy.ac.uk/funding/cs/index.aspx*

Steve Maw
Centre for Bioscience
heabioscience@leeds.ac.uk

Teaching Undergraduates to Write Practical Reports

Why is it that undergraduates find it so difficult to write up practical experiments in the form of a scientific report? To understand why they find it so complicated, it helps to know how students were taught to write up experiments at school; many foundation and access courses also take the school approach to practical write-ups. The school approach has some fundamental differences to the basic scientific style. However, I believe it is important not to tell students to forget what they were taught at school and start learning afresh, but to build on what they have learnt. This can avoid undermining their confidence in the whole education system, their own ability and offending any feelings of loyalty they may have to their schools. A better approach is to understand the skills they have learnt at school and then develop these skills into an ability to write reports in a scientific style.

At school students will have been taught to write up an experiment as something they will do. Their experiment is often preceded by a pre-test, which suggests to pupils how they might carry out the main experiment. Students list the equipment they will need and write bullet point instructions about what they will do. I believe it is important to let students see the value of this experience. They can be told that they have learnt skills valuable to a scientist and that the school-style method is similar to instructions written, for example, in practical schedules which they follow in practical classes. They have learnt about the planning process, so they can now move on to the reporting process. Because they are so used to writing in the future tense, in bullet points and listing apparatus, it is extremely hard for many students to adapt, removing technical details such as how they labelled tubes or started a stopwatch.

A school-style results section is a table displaying raw data. This helps students learn how to arrange their own data in a logical manner but students find it extremely difficult to describe data directly from a table. At A-level what we call a results section is split into two halves. Their table of raw data, the results section, is followed by an analysis section, which comprises a graph and a description of the patterns in the graph. The graph will have a title which begins 'A graph to show that...'. The idea behind this is that they would otherwise put a title such as 'My Graph'; it forces them to write something useful. However, it is extremely difficult at university to get them out of this habit, and without constant reminders they will quickly slip back into it. Students need to be told that what they used to call a results section, is now what they might put in their lab book, and should not be included in a practical report. The school analysis section is actually the results section, but they also need to learn that it can include a graph or a table. Getting them to do something with their data, expressing their results once, and learning why they should use either a graph or a table, can be very difficult for them, as can making reference to the graph or table in some text which describes the data.

School children are not taught to write discussions of any sort. The final sections of a school experimental write up comprise evaluations such as why data points did not appear exactly where they were expected to, the anomalous results, and also comment on health and safety issues. There are also conclusions which prove or disprove expectations. I ban all mention of conclusions, proofs, health and safety and evaluation. Any relaxation of this ban results in paragraphs of writing about their expectations, anomalous results and things they might do differently next time, at the expense of any discussion at all. Students are left having to fill paper with a style of writing that is completely new to them. Some excel at an early stage while others struggle to develop the necessary skills. I find it helps to tell them that I am confident they have the ability to tackle a critical discussion; they are, after all, university undergraduates. I really do believe they should all be capable of doing this and many rise to the challenge. Good students will produce critical discussions using primary literature and link the discussion to the approach they took in the introduction, giving a very good overall structure to the report.

Students find referencing unbelievably difficult. They struggle to find relevant non-web-based material, incorporate it in their report in their own words, refer to it correctly in the text, and list all references at the end. It is essentially a series of instructions they must learn to follow and they are not used to following instructions that are so precise. With referencing, as with the rest of the practical write-up, taking an approach that incorporates an understanding of the school experimental write up, and letting students appreciate this understanding, can enable the majority of students to make a good attempt at a scientific-style experimental report by the end of their first semester.

Harriet Jones
University of East Anglia
harriet.jones@uea.ac.uk

Priority Themes

Over the next couple of months the Centre will be developing its operational plan for 2009/2010. As always we are keen to hear from the bioscience community and value your thoughts and suggestions.

Should you have any suggestions as to what ought to be a priority activity or theme for bioscience education then please email your comments to *heabioscience@leeds.ac.uk*, marking your email 'priority themes'.

Virtual Analytical Laboratory (VAL)

Annually around a third of students enter bioscience programmes at De Montfort University having had no laboratory experience at school or college. I am unaware of whether this reflects a national trend, but a previous *Bulletin* article highlighted the need to recognise the magnitude of the transition between science at school and university (Hughes, 2008). In recent feedback, our first years requested the need for more laboratory support early on in their academic careers.

In response, we have developed a number of multimedia resources to help undergraduate students build a foundation of practical skills and knowledge before they enter the bioscience laboratory. We have produced a website entitled "Virtual Analytical Laboratory" (VAL) containing video, animations, audio and screen-capture resources on microscopy, haemocytometry, spectrophotometry, pipetting and serial dilutions. In October 2008 we piloted the resource with undergraduate Biomedical Science and Medical Science first years who used it in computer sessions prior to attending practical classes later in the semester.

Results

In response to a questionnaire (n=82 respondents), 84% of students (agreed or strongly agreed) that they were "satisfied with VAL overall". Students were positive of it being a beneficial educational tool to use before entering the laboratory, and they thought the various multimedia components of it were good quality (which considering one or two of the videos did surprise us a bit!).

"I found it really useful because I know what I'm going to expect exactly in the lab sessions."

"VAL is very useful for someone who has not been in the lab before."

"VAL has been very useful in easing my nerves before lab sessions."

Other feedback identified the need to introduce a study guide and clarify which resources should be used first. (More detailed findings of this intiial evaluation will be issued in a forthcoming Bioscience case study).

Did VAL improve laboratory knowledge?

In my experience, students are nearly always "satisfied" with online learning when they are questioned, and more important is whether resources actually improve understanding. In the questionnaire students were given a short laboratory test which asked basic questions such as how to label equipment. It was interesting to observe that those students with absolutely no laboratory experience (n=28) produced similar test scores to those students with claimed previous experience (n=54); this suggests that the resource shows potential in helping students build a foundation of basic knowledge before entering the laboratory environment.

Next development steps?

The Virtual Analytical Laboratory *(http://hlsweb.dmu.ac.uk/ahs/elearning/RITA/Index.html)* is freely available to academic users under a Creative Commons 2.0 licence. We aim to develop more resources including laboratory safety, and collaborators are welcome! Our research will continue to improve the educational impact of the resource, and we aim to include a study guide, a diagnostic 'pre-test' and progress 'post-test'. Next year as VAL is rolled out, we will evaluate whether it has improved performance in the laboratory itself.

Survey Monkey and Google Analytics

Feedback from users is invited through the completion of short surveys that are hosted on Survey Monkey (available at: *www.surveymonkey.com/*); this provides a choice of designs and questions in a very easy to use format. A free service is available for short duration surveys, although we have opted to pay to lengthen the timeframe for gathering responses.

Further user information is harvested through Google Analytics. The data require careful interpretation but provide a useful semi-quantitative indicator of activity. Measures include visitor details (how many visits, time on site); traffic sources (search engine, key words) and content (popularity of pages). For example, VAL has been viewed by 141 unique visitors from the UK and around the world since Analytics was established (December 2008). Peaks of activity coincide with events such as submitting an abstract to a conference. The most popular page has been a haemocytometer animation, and the longest average time spent on any page was nearly 6 minutes for a serial dilution animation. This data can provide a useful indication of pages that work well, and also highlight unfortunate pages that are perhaps less well designed or less informative.

Summary

The Virtual Analytical Laboratory been piloted with first year undergraduate bioscience students and has fulfilled its initial objective of helping students gain confidence and a grounding in knowledge before entering the laboratory. From the perspective of the academic staff involved in the project, we anticipate that the time invested this year will be far outweighed by of not having to repeat basic instructions to many groups, across many modules and for many years to come. We hope VAL will support both the student and staff experience!

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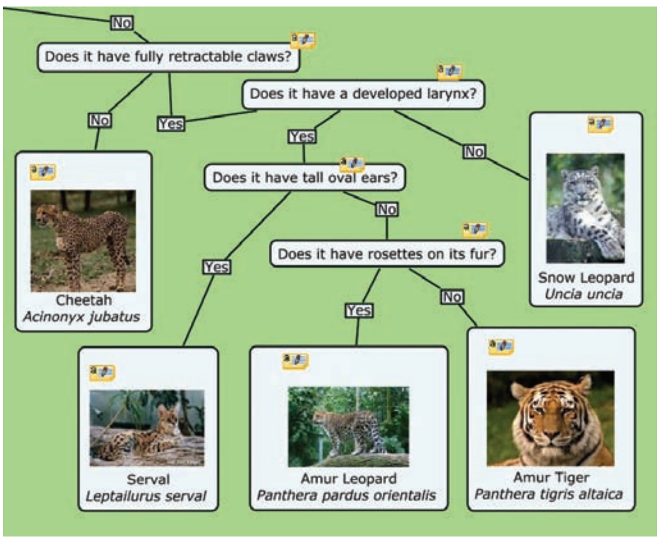
Vivien Rolfe
De Montfort University
vrolfe@dmu.ac.uk

12 | Going to the Zoo!

Many of us can remember a primary school visit to the zoo. One of my more vivid memories is of eating a peanut butter and jelly sandwich in the indoor elephant viewing area of the Portland Zoo, Oregon USA, not Dorset UK — the unmistakable smell of elephant dung hung heavy in the air. For most people, zoos are the only place to experience large animals from other parts of the world, but can a zoo be used as an educational resource for a large university class field trip? It has been attempted, but visits tend to become a walk around whilst students fill in a question sheet. At the School of Biological Sciences in the University of Southampton, we have gone beyond this and created a problem-based, authentic practical exercise to take advantage of our outstanding local zoo, Marwell Zoo.

The practical was created for Patterns of Life and their Evolution, a first year general biology course that focuses on how evolution has shaped the major groups of living organisms. The task is presented as essentially the same problem Darwin faced as he sailed around the world on the Beagle. Although we go to Marwell Zoo instead of the Galapagos Islands, our explorers are faced with determining the best way to organise the animals they observe. Hopefully, like Darwin, they will come to see that evolution can be the organising principle.

The assignment asked them to collect (through notes and pictures) at least 40 animals and then create a dichotomous key reflecting what is known about their evolutionary relationships. On the day, the students are given passports with a Zoo map showing the four areas of the zoo where they must obtain stamps. Demonstrators are positioned at the four locations to stamp the passports to ensure that the students are moving around the zoo. We assigned the students to small random groups of four. This arrangement is suitable for extremely large class sizes (>100) because the students disperse as soon as they find their groups. They can visit the four pre-assigned stamping areas in any order. The trip is run on an afternoon which gives the students plenty of time (~3 hours). Students are encouraged to take digital photos with their mobile phones.



After the trip, the groups have two weeks to research and organise their collection into a key. Students have to find online and library resources to complete their keys because many of the essential characteristics such as teeth and bone structure are not directly observable. Additionally, mammalian relationships are not intuitive, so require additional use of outside sources. The first time we ran this practical, keys were submitted either in paper form or on Blackboard using wiki with hyperlinks between questions and animals. Although many of the wiki submissions were outstanding and we received good student feedback, assessment of the wiki submissions was impractical due to the need to follow hyperlinks laboriously. After consultation with Adam Warren from our university Learning and Teaching Enhancement Unit, this year we switched to Concept Maps (Cmaps). Cmaps *(http://cmap.ihmc.us/)* is a free program that allows the students to work in a controlled external file stored over the internet. With Cmaps we could view an entire key and quickly follow the groupings, making it easy to assess a large number of keys. The program also allows students to hyperlink to websites, add comments and references, and upload digital images. Several students could work on a key at the same time so groups could collaborate and work from different computers.

Student feedback was extremely positive in the first year and this October's field trip seemed to go well. The quality of the keys varied, with bats and birds being grouped together incorrectly in a few keys, to near perfect groupings with detailed definitions of the criteria as well as pictures with links for each animal. The large range and high quality evident in some students work clearly demonstrates that this problem based learning exercise has gone beyond the school field trips I remember. The student handout is available at my website *(www.sbs.soton.ac.uk/staff/jdp/jdp.php)* and the instructor's version with a passport is available by contacting me.

My only regret is that there are no elephants at Marwell and thus no elephant house. But they do have a giraffe house; so perhaps I will try a Marmite sandwich next year!

Joel Parker
University of Southampton
j.d.parker@soton.ac.uk

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