Data-driven EBL: Embedding Research in Life Sciences and Tutorials

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Abstract

The three-year Faculty of Life Sciences (FLS) CEEBL project aimed to generate enquiry-based e-learning resources using Final Level project students, who, themselves, used an enquiry-based approach in their project work. These resources focused mainly on supporting practical classes and employed a data-driven approach, where appropriate, in order to enhance research skills in students, *i.e.*, analysis, evaluation and critical review skills. In addition, the FLS Final Level tutorial programme was revised to provide a consistent student experience and incorporate novel EBL activities.

In 2006-7, 32 students opted for e-learning projects (ELPs), with 33 in 2007-8, and 30 in 2008-9. These students attended a dedicated course, BIOL30300 ELP, to train them in project skills and promote creative and critical thinking. They developed a range of e-learning resources to supplement FLS practicals, tutorials and other FLS course units. A variety of software and additional technologies were used to create a range of learning designs, such as scenario-based resources and problem-solving activities that students evaluated on their chosen target group. Although students produced individual projects, they worked in project groups in a blended fashion (*i.e.*, online and face-to-face) to support each other and critically review their project materials. Contribution to online discussions was used by supervisors to help assess Project Performance (20% of the project mark). Project scores were comparable with those obtained by laboratory project students. High quality e-learning resources were compiled and hosted on Blackboard and were made fully searchable.

Introduction

Background

FLS has an international reputation for research and is keen to exploit this in its teaching and learning activities. This project aimed to further bridge the teaching/research interface by embedding research-driven EBL activities in bioscience practicals and tutorials. The CEEBL project had two parts:

1. to develop online data-based EBL activities to support Faculty practical classes, and to provide a genuine learning experience for students by embedding the principles of enquiry within the e-learning resources;

2. to provide a consistent and enquiry-based tutorial programme for Final Level students across the whole range of FLS degree programmes by developing a generic Final Level tutorial programme and introducing novel EBL tutorial activities.

The target groups of the Faculty Project were principally Second and Final Level students across all degree programmes. There are approximately 500 students per year group in FLS, and all are involved in Level 1 and 2 practical classes and tutorials as they progress through their degree courses. Some resources developed in the project were also aimed at Level 1 students, pupils in local schools and staff at Manchester Royal Infirmary (MRI).

Project work, by its nature, is enquiry-based, so EBL resources were developed *for* students *by* students using an EBL approach.

1. Phase I of the FLS project in 2006-7 audited current EBL practice, piloted a project to generate e-EBL resources to support Second Level practical classes (Laboratory Skills Modules (LSMs) and Research Skills Modules (RSMs) and identified potential EBL opportunities to enhance the Final Level tutorial programme.

2. Phase II in 2007-8 expanded the range of e-resources developed by ELP students following implementation of a modified training course designed to enhance creativity in student output. In addition, a tutorial programme for Final Level students was piloted via Blackboard.

3. The final phase in 2008-9 focussed on generating and consolidating e-learning resources and on evaluation.

Rationale

The connection between teaching and research goes beyond the mere transfer of knowledge; it involves the acquisition of research skills by students, such as the ability to ask appropriate questions, investigate ideas and analyse and evaluate the outcomes of these investigations. Practical, experimental work is key to facilitating the development of these skills and, ideally, is based on enquiry (Jenkins *et al.* 2007). The skills involved in learning by enquiry correspond to the higher cognitive skills identified by Bloom (1956) in his taxonomy of educational objectives, and those integrated into the Kolb (1984) learning cycle. Therefore, it is necessary to provide the opportunity for students to ask questions; undertake research; and identify key points and/or concepts in order to acquire and understand knowledge. Students need to be given the opportunity to think about and process information or data and integrate it with prior knowledge. They can then construct new knowledge which can be applied to different situations or problems. This project aimed to consolidate the links between teaching and research by enhancing enquiry in laboratory and tutorial activities.

Current tutorial provision for the Final Level is somewhat inconsistent regarding the contact hours and availability of resources to tutors across the different degree programmes. We aimed to address this issue by integrating Course Materials into the Blackboard VLE under a new Tutorial Course Code banner (BIOL30000), ensuring that all tutors had access to course materials and activities; guidelines on delivery (*e.g.*, suggested timetable, additional activities and past examination papers); and a selection of model answers to facilitate feedback to students.

Development of e-EBL Resources

Approach

Selection of project students and supervisors

Final Level students opted for an ELP by filling in the appropriate project selection form on the Faculty intranet and selecting their specific topic in discussion with their allotted supervisor. Although these students attended a training course, BIOL30300 ELP, they were supervised individually by an academic. Some supervisors were involved in the design and delivery of Second Level practicals and these were ideally placed therefore to develop supplementary e-EBL materials. Tutors who were *not* involved in Level 2 practicals (but who opted for an e-learning project student) were encouraged to focus on the development of tutorial materials. As it was not always possible to match student topic preferences with practical coordinators, not all projects were aimed at practical units. We felt it important to retain the element of choice for students in the selection of both the type of project and the topic.

Meetings and communication

Meetings were held for project supervisors to explain the rationale for the EBL project, request their cooperation and support, give details of the training programme, present ideas for projects and field questions. Supervisors were reassured that they did not need expertise in technology, e-learning or EBL, but a general enthusiasm would be helpful! Guidelines for e-learning projects were provided for both staff and students on the Faculty intranet, as well as for external examiners.

Recruited supervisors were emailed during the year if their students did not attend the training course for e-learning projects, which was only necessary a couple of times as most students had excellent attendance. Monitoring attendance was essential to ensure that all students are able to produce a usable e-resource by the Easter vacation deadline. Supervisors were also emailed throughout the year to remind them of deadlines and procedures relating to projects (such as assessment criteria). They were also contacted in July 2008 and April 2009 to elicit feedback on the training programme and ask whether they intended to use their student's resource in their teaching activities. Weekly contact was maintained between students and the e-learning team, particularly in Semester 6, when students needed more technical support.

BIOL30300 ELP Training Course

All ELP students attended the compulsory training course (BIOL30300 ELP e-Learning Projects) facilitated by CW and supported by Ian Miller and his e-learning team. The course aimed to equip students with appropriate project skills (such as project planning and instructional design, copyright, statistics and the use of a variety of software applications, see Table1). Students were encouraged to use both logical and creative approaches to resource design. Logical approaches followed traditional instructional design strategies such as ADDIE (Strickland 2009), and creativity was encouraged using a variety of tools, see Table 1 (Bransford and Stein 1984).

The course was also available online in Blackboard. It ran over the latter six weeks of Semester 5 and up to the Easter break in Semester 6 (12 weeks in total), and took place in a computer cluster in a dedicated project lab. Face-to-face workshops were accompanied by online goal-orientated tasks within a 'virtual laboratory' environment, where students developed their skills and project materials, collaborated and supported each other in groups. Students were allocated to project groups on the basis of the type of resource they were developing, so that they would be better able to help each other. This blended delivery gave students the opportunity to communicate and support each other away from the formal classroom setting. We wanted ELP students to have a similar experience of working in groups to their laboratory counterparts, who are supported by other members of the research group to which they are assigned (Ginty and Wakeford 2006). Project supervisors provided face-to-face, discipline-based expertise in the traditional manner.

Activity	**Outcome**
Brainstorming (groups)	Generate new ideas
Mind-mapping (individual)	Lateral thinking to explore ideas that have been generated
Group discussion (real time and online)	Consolidate and critique ideas (focus) and carry them forward
Focused Questioning - SCAMPER	Examine different aspects of e-materials
Peer evaluation and review (online)	Reflect, critically review, modify and improve

Table 1. Creative and critical thinking activities.

An enquiry-driven approach (which is evident in laboratory projects) was used in both the training programme and the design of e-learning resources (Wakeford and Miller 2008). Project students selected and researched a topic of interest with advice from their academic supervisor and produced a 10-credit literature review in line with Faculty guidelines. After an examination of the particular needs of their target group, ELP Students then selected one aspect of their topic to carry forward as the focus of their e-learning resource. Students were encouraged to use a scenario- or data-driven problem-based strategy to produce an interactive EBL resource on their particular topic of interest (Juwah 2002). They used a variety of software packages and design formats to generate these resources, in addition to other technologies such as audio, video and assessment tools.

Students formed an hypothesis to test the effectiveness of their resource in enhancing learning. They also evaluated their resources by testing the knowledge and problem-solving skills of their target group using online assessments. This mode of active learning should facilitate understanding and research, as well as encourage problem solving and critical analysis. Moreover, feedback to the assessment questions provided an opportunity for the user to reflect on his/her learning. In addition, students used discussion forums to peer review project materials developed by other members of their online group. It was hoped that this approach would promote critical thinking and enable troubleshooting of design and usability issues. Hence, EBL materials (scenario or problem-solving) were developed using a process of EBL (*e.g.*, students choose their topic, worked in groups as well as individually and participated in critical evaluation during peer review).

SESSION	LEARNING OUTCOMES	TASK
1. Literature review	Initial briefing with project supervisor to identify an area of interest	Explore and research the literature. E-mail project title to CW. Write literature review
2. ELP: What is e-learning and what are E-Learning Projects?	Understand the pedagogy of e-learning, and learning styles and the stages of project development.	Ask a question: look at the FAQs Identify your learning style online. Begin reflective diary.
3. Look and Learn: research and review online resources	Appreciate the attributes of a good e-learning resource	Review attributes of e-resources, evaluate and post comments. Creativity activities – lateral thinking (groups).
4. Do you need an audience?	Formulate project aims, outcomes and hypothesis	Identify target audience Formulate SMART objectives & hypothesis. Begin Needs/SWOT Analysis
5. Ask a silly question: questionnaire design	Formulate appropriate questions for analysis and evaluation of target group	Design analysis questionnaire
6. Have you got a problem? Enquiry-Based Learning and problem solving	Design a resource to promote active learning	Create a learning design to promote enquiry and/or problem solving. Construct flowchart/decision tree for a scenario (Groups)
7. Plan ahead: project planning ADDIE principles	Understand instructional design features	Complete a skills audit & plan your skills development programme; generate a project plan, construct a timeline & produce a storyboard.
8. Home sweet Home	Manipulate standard web authoring software	Construct a homepage using Dreamweaver. Upload project materials to Group Discussions for peer review.
9. Software toolkit	Understand attributes of web authoring tools.	Explore the software tools; select software for resource development Post your decision to discussion board. Meet e-learning team for feedback – SCAMPER questions
10. A picture paints a thousand words: graphics for the web	Manipulate images and produce a simple animation	Engage your audience: design interactive features. (groups)
11. Know your rights: copyright issues	Comply with copyright regulations	Complete copyright declaration & check images etc comply. Reflect: post a notice outlining your progress.
12. Testing, testing: quizzes and assessment tools	Design assessments	Assess your audience using appropriate activities, *e.g.* online quiz.
13. Evaluation: online and in time	Evaluate learning outcomes	Peer review project materials (groups) Modify according to feedback. Plan evaluation.
14. Analyse your data: quiz and questionnaires scores	Select appropriate statistical test(s) and tools.	Analyse and evaluate project data.
15. Final Report	Plan and write a project report	Submit report. Liaise with your supervisor.

Table 2. BIOL30300 ELP Course Overview.

Assessment of ELPs

All projects in FLS are equivalent to 30 credits. A further 10-credit Literature Review, on the fundamental science underpinning the project, was submitted in Semester 5 in advance of the project. In Semester 6, students reviewed project materials for each other in online groups. Contributions to online discussions were available to supervisors to help them assess their student's performance. The intention was that constructive alignment of course content with assessment of discussion contributions, which contributed towards 20% of the final project score, provided an incentive to participate in the online process (Dalgano 2001). In addition, the e-learning resources produced by the students carried a further 20% of the overall project mark, with the remaining 60% allocated for the project report. Written guidelines and assessment criteria were provided to both supervisors and external examiners.

A pilot study using NVivo software to access, manage and analyse text from discussion forums was carried out in order to facilitate qualitative analysis and interpretation of student contributions, and move beyond the basic classification and sorting of contributions by student name and topic (possible within the VLE) (Wakeford and Ginty 2007). The analysis was based on the Community of Inquiry Model by Garrison *et al.* (2001), which demonstrates that learning takes place when there is overlap in the online environment between social interaction, cognitive processing and teaching presence. There was evidence that peer review did, indeed, lead to the modification of project materials, and that critical thinking was employed in the exploration of these materials and in giving feedback. However, there was no statistical correlation between project performance mark and the number of references relating to critical thinking, nor was there any evidence for overall improvement in project scores in students that engaged most in critical thinking online.

Although feedback from supervisors on the usefulness of discussion contributions in assessing project performance was relatively limited, all of those that responded to an evaluation questionnaire found the exercise helpful.

Outcomes: e-Learning resources

The learning designs formulated by students were analysed and matched to the style of problems that students developed to encourage the skills of enquiry in their target group and in relation to the type of web authoring software used for the resource. We identified, broadly speaking, ten categories of learning design (Wakeford 2009a). A key skill in enquiry and problem solving is the ability to ask appropriate questions to stimulate investigation, and the approaches adopted by students were matched to a range of questions that they addressed, as shown in Table 3. The problems were either 'closed', with a clearly defined answer or solution, such as mathematical calculations, or 'open' with no clearly defined 'right' answer but rather a range of possible solutions, such as the explanations for case histories. Jonasson (2000) refers to these as 'well-structured' or 'ill-structured' problems.

Learning design	**Content or problem**	**Question or enquiry**	**Example**
Content-assessment Or 'Assessment sandwich'	Information-based	What do you know about....? What does this mean?	Topic, concept or mechanism Comprehension problems
Linear; content-question-content-question	Step-by-step problems or calculations with a single solution to analyse	What is the answer?	Identify the gene. Find the value of..MCQs, EMQs
Group-based: use group discussions	Data (numerical or text-based) analysis	What are your results? How do they compare with the group?	Group analysis and evaluation
Choices based on decision trees. Branched routes through content.	Select appropriate path at key decision points.	What is the best way of doing...? Shall I do this or that? Why doesn't this work? What is this?	Design problems Dilemmas Troubleshooting problems Identification key
Multiple starting points	Select one of a number of initial optional routes	What happens in this case?	Testing hypotheses; exploring patient scenarios
Stories; context-based; usually linear	Contextualised information unfolds	How can you explain....?	Case histories, scenarios to set-the-scene
Role play	Multiple perspectives	What does this look like from this perspective? What is the evidence?	Analysis of evidence Ethical issues
Simulations	Virtual reality	What happens if.....?	Experiments, Research problems
Virtual tour	Instructional	How do I........?	How to use software or equipment or perform a methodology
Assessment activites	Questions; Interactive activites	What is the best answer/option?	MCQs, EMQs Games (cross- word, word-search, drag-and-drop)

Table 3. Problems and learning designs.

Around 40% of resources were based on a simple linear *content-assessment* format, where the user reads and explores the content (*e.g.* that might comprise text, figures, animations and video) and tests their understanding using assessment questions, which are either integrated into the resource at intervals and/or are found at the end. Many students used an 'assessment sandwich' by presenting users with a pre-test and a post-test for formative or summative assessment. A variety of alternative designs, or combinations of designs, were used by the remaining students. Some used linear designs in a *content-question* format, where content is presented in the form of a problem and the correct answer to each sub-section permits the user to progress to the next stage of the problem in a linear sequence. Other resources were *group-based* and constructed for use within the VLE as part of wider activities.

More imaginative designs were based on *decision trees*, where the user progresses down a particular path based on their responses at key decision points in the problem, such as the selection of an experimental technique appropriate for a particular application. One resource, for example, required the user to select one from a range of hypotheses to account for field observations, and the user was then presented with experimental data to analyse in order to be able to accept or refute the hypothesis. Other *contextualised* resources were based around scenarios where the information unfolds in a story as the user progresses through a real-world problem. For example, one student used film clips to provide context to particular neurological conditions and another used cartoons to portray an 'invasion' of micro-organisms against the body's defence mechanisms. Others used patient case histories and data. Some students designed resources using *multiple roles* to provide different perspectives on ethical issues, such as the use of stem cells in research and human cloning. Others constructed simple *simulations* of experiments and experimental data for data-driven EBL.

A range of software applications was used to develop these learning resources, depending on the design requirements. Wimba Create, Dreamweaver and Opus were used most frequently for basic web authoring. Opus is particularly useful for interactive activities such as 'drag and drop', 'mouse-overs' and quizzes. Classapps was used by many students for assessments and evaluation, since data can be automatically compiled and analysed. Most basic web authoring software can be used to create different roles (routes) that the user can adopt, similar to those available in Webquest. Novel's Scenario-Based Learning interactive (SBLi) is designed for branched and multi-path problems; and significantly, it permits the path followed by the user to be tracked as they explore the resource.

Evaluation

e-Resources

Resources were evaluated by supervisors according to scientific content; planning and learning design; functionality and presentation/appeal; and the appropriate use of technologies, and were found to contain a variety of enquiry-based elements. Evaluation of the effectiveness of individual resources in enhancing student learning in the target group was undertaken by project students and included in their project reports. Almost all students reported an enhancement in the learning of their target group following intervention with their e-learning resource. Some improvement in problem solving was evident from responses to more probing assessment questions (presented 'before' and 'after' completing the resource). These data should be interpreted with caution, however, because it was generally not possible for students to test their 'experimental' target group against a matched control group. Moreover, variations in problem solving skills are difficult to ascertain; changes may be subtle and depend on many factors, including the complexity and type of problem. Different strategies may be used to tackle different types of problem, so it was difficult to measure short-term changes in the skills of the target group (Isaksen *et al.* 2000).

Training course

Evaluation of the training course by staff and students was by questionnaire. Feedback was positive overall from both students and supervisors. Around 80% of students liked being a member of a project group and found that working in project groups was helpful or very helpful. They valued the support of their peers and staff via online discussions and appreciated the opportunity to share ideas and obtain feedback on their work. Group members discussed project work face to face (in workshop sessions) and online. In addition, most students could identify the features of EBL and had included elements of enquiry in their projects.

Project scores

Evaluation of the parity of marks between e-learning and laboratory projects was made by comparing project scores. Encouragingly, the distribution of project scores was the same for ELP projects as for laboratory projects. We were encouraged by students' achievements, since the majority of students gained project scores that were higher than their unit average score in their Final Year examinations, suggesting that the quality of projects is being maintained. In addition, an ELP project was one of two projects successfully nominated by the Faculty for publication in the student-authored journal, *Bioscience Horizons* (Samani 2009).

Challenges, benefits and developments

Engagement

One of the main challenges in the FLS CEEBL project related to engagement of staff and students in the programme, which was not particularly surprising. We anticipated some opposition to changes in the tutorial programme, for example. It was disappointing that fewer students than we would have liked opted for e-learning projects that focussed on practicals, but we are confident that the e-learning resources will gradually develop into a useful repository of supporting course materials over the next few years.

Training course

The training course was based on pedagogy to facilitate enquiry (Justice *et al*. 2002), particularly in the online environment (Boud and Prosser 2002). We aimed to encourage deep learning, critical thinking and reflection, by challenging and engaging students in self-directed, active learning demonstrated through clear communication of their ideas, both on the web and in their project reports. However, we found that additional elements were essential in order for the students to develop their projects in a more imaginative manner. Hence, we would suggest modifications to Justice's 'Grammar of Inquiry' model and Boud and Prosser's framework for online learning to include activities to promote creative thinking (Isaksen *et al.* 2000) in order to move students away from using the online environment in a largely text- and information-based way.

Creativity in the design of e-resources

One of the most difficult aspects for students has been in the design of EBL materials. Students tended to research their chosen topic and write as much as they could about it in the online environment. However, we wanted students to focus on an enquiry-based approach. To encourage this, they worked face to face in groups and brainstormed ideas about the type of learning design and content they might use in their e-resource. They then worked individually to refine and focus feasible ideas using mind-mapping, for example, before posting their designs in the form of plans and/or storyboards to online group discussion forums. This period of individual work allows ideas to incubate and mature and become more clearly defined (De Bono 1970; Isaksen *et al.* 2000). Peer review of project plans created further opportunities for reflection, modification and improvement. Finally, each student met with a member of the e-learning team and was subject to focused questioning and discussion using the SCAMPER tool (Isaksen *et al.* 2000), which generated the opportunity for further creative modifications in their final learning design. Plans were fractionated into component parts and each aspect examined, in turn, with reference to the triggers represented by the acronym, SCAMPER:

1. Substitute (what else could we do/use?)
2. Combine (how about a blend/combination?)
3. Adapt (what could I copy?)
4. Modify (what could I change?)
5. Put to other uses (can this part serve another purpose?)
6. Eliminate ('less is more' – what can be left out?)
7. Rearrange or reverse (what items can be interchanged or transposed?)

This type of questioning is designed to provoke students into lateral thinking and move potentially useful ideas forward.

It appeared that incorporating into the training course in 2008-9 specific tasks to promote the generation, expansion and review of ideas did, indeed, lead to more innovative products than previously. Although, this was a relatively small pilot with 33 participants in 2008-9, and it was not possible to use a concurrent control group that was not subject to the creative toolkit (Wakeford 2008). It is possible to measure the creativity of individuals by psychometric means, such as word association testing or using checklists for the skills involved in creative thinking (Talbot 2002). In an educational setting it is more feasible to assess creative output – as with a painting or a piece of literature – as an e-resource product. Assessment criteria did not specifically mention creativity or innovation, but credit was given for incorporation of elements of enquiry into the learning design.

Discussion

Three questions have arisen out of this work. First, what types of problems or enquiry might be encountered (in biology); second, what problem-solving strategies are used (by students); and third, how can these be facilitated in the online environment? In a wider sense, how do we perform enquiry and might it be exploited in the online environment?

Different types of problems that might be encountered in biology have already been highlighted (Table 3). Cooper *et al.* (2008) point out that while we know a great deal about the problem-solving process in an abstract environment, we have less insight into how students solve many types of scientific problems. She has found that most students' problem-solving strategies and abilities can be improved by working in groups, and believes this is because students must explain to their group why they think an action should be taken and what the result might mean for their particular problem. Should we try then to mimic the traditional classroom setting by using, for example, online group discussions? Although this has some advantages over the face-to-face situation (*e.g.* postings can be made synchronously or asynchronously, discussions can be held in the classroom or remotely and participants have more opportunity to consider responses), Savin-Baden (2007) points to the necessity for effective facilitation and emphasises the importance of learning design over content, in order to promote participation in the PBL process. It is important here to make the distinction between Problem-Based Learning (PBL) and problem-solving. In PBL, the problem acts as a stimulus for the learners to define their own learning outcomes in open-ended investigations. In practice, problems are formulated around the curriculum and provide a framework in which the learner explores the required content. Problem-solving, on the other hand, relies on the manipulation of knowledge and data in response to a particular question in order to arrive at a solution or answer (Belt *et al*. 2002). Alternatively, stand-alone e-learning materials or RLOs (reusable learning objects) can act as resources or information repositories to support other activities that might themselves be enquiry-based; or better still, the RLO can stimulate research by the target group, and hence facilitate enquiry and problem solving.

Although 'pure' enquiry is student-led and open ended, the online environment can, nonetheless, be exploited to provide e-learning experiences that take advantage of the differences in the way students learn electronically and the benefits offered by technology. We have shown in this project, in agreement with Belt *et al.* (2002), that effective use of animations, simulations, audio and video technology, and interactive activities can provide rich and varied opportunities for students to visualise both problems and potential solutions, and provide 'real life' context to the problem to help engage and motivate students. However, caution should be exercised when designing contextualised resources, since peripheral content can be distracting for some students and prevent them from focussing on the problem at hand. Overton and Potter (2008) have shown that both working memory and cognitive overload influence problem solving ability. However, in the online environment additional information can be 'layered' into the resource and accessed via links, rather than be presented together with so called 'essential' information. Inevitably, both content and tasks must be structured in the online environment, but can nevertheless enhance the skills of enquiry with effective learning designs. These may be created using various software tools, or within templates like the SBLi interface. The choice will depend on many factors, such as whether the learning materials are required for the entire curriculum, a single course unit or an individual resource; whether presentation will be entirely online or blended; whether the materials are aimed at individuals or groups of students working collaboratively; and how learning will be supported and assessed. The technology should facilitate EBL.

Conclusions

We have generated a bank of searchable and reusable online Enquiry-Based Learning resources using a variety of software tools and emerging technologies to implement effective learning designs. Supervisors were asked to validate the content of student resources for accuracy. The e-EBL materials, thus generated, will benefit the Faculty (both staff and students) by providing e-resources to support teaching and learning, in the form of additional background material; pre-laboratory activities; assessment activities; virtual experiments for absent or failed students; and extension activities for the most able or highly motivated students. Although there is a plethora of excellent online resources available, and it is not our intention to 'reinvent the wheel'; this programme provides valuable transferable skills for our project students whilst at the same time generating customised e-learning materials.

Final-Year Tutorials

Rationale

Final Level tutorials are currently delivered in Degree Programme-specific groups (6 to 8 students per group). The format and content of tutorials is governed by the Programme Directors, but the universal aim is to prepare students for their final programme-specific examinations (a general essay paper and a problem paper which tests largely data-handling and comprehension skills). Final Level tutorials do not include assessed assignments and attendance, although compulsory, does not impact on students' progression (in contrast to 1st and 2nd Level tutorials where successful completion may confer compensation for substandard performance in exams). There is no generic timetable for tutors to follow, and previously no tutorial handbook for guidance. As a result, some students perceived that they received less academic support and advice than others – this is largely dictated by their degree programme. Activities are delivered on an ad hoc basis, with tutors accountable to their programme directors.

Our project was set up to provide a more consistent experience by addressing the inconsistencies arising from current practice, and also to provide guidance to students not only in preparing for exams, but also for future employment or postgraduate study. Furthermore, we hoped that providing a generic 'handbook' would make the planning and organisation of tutorials easier for Final Year tutors.

Approach

Generic online handbook

Programme directors were consulted about the possibility of producing a generic handbook and the idea was also presented to the two FLS Teaching Boards that oversee teaching and learning in the Faculty. There was a large amount of support but some apprehension that tutors might be expected to do more work! Programme directors were also asked to provide examples of past examination papers, which could be posted on the Blackboard VLE alongside the generic handbook for use by tutors. Many programme directors were happy to supply this information, provided that the answers were not made available to students. The idea was that programme-specific problem papers would only be available to tutors from relevant programmes. However, essay papers often cut across more than one programme, and therefore were made available to tutors from different programmes.

In order to develop a generic online handbook, it was necessary to create a new course unit code, BIOL30000. The advantage of this was that all Final Level tutorial material could be posted in one place, making it more easily accessible to both tutors and students. The handbook was produced using the same format as the 1st and 2nd Level handbooks and included suggestions for activities and a provisional timetable for tutors. These activities included: working through degree-specific problem papers; constructing essay plans under exam conditions; group-based learning activities focused on a scientific paper or recent scientific media article; and oral presentations of students' literature review research or project data. The latter provides useful preparation not only for writing up literature reviews and projects, but also for interviews and vivas.

Across the Faculty of Life Sciences, there were 450 Final Level students and over 50 tutors. Tutors were expected to meet with students for at least 12 hours during the academic year, averaging one hour every two weeks.

Careers exercise

Recent graduates from the Faculty of Life Sciences have entered employment in a diverse range of different fields, from forensic scientists to medical writers. It has long been an objective of the tutorial programme to provide 'careers advice', as outlined in the Final Level Handbook. This is in line with a recent study by Sue Cranmer (2006) at the Institute of Education who suggested that '*all* academic courses should include employability enhancing content'). In the same year, Yorke (2006) suggested that employers were not entirely happy with the level of graduates' generic skills, such as communication, team-working and time management. Many students enter their final year with little idea about what they will do after graduation, despite the fact that the University of Manchester Careers Service is highly acclaimed. This apparent ignorance about career opportunities probably stems either from student apathy or from difficulty in finding specialist, FLS-specific information. For this reason, it is important for students to be able to emphasize the generic skills that have been developed largely in tutorial sessions. In order to prepare some material for developing careers activities, we contacted the University Careers Service and the Alumni Association. The Careers Service prepared a CV-writing exercise tailored to Life Sciences students and the Alumni association posted a request to recent graduates for biographies that highlighted their chosen careers. This resulted in a single FLS alumnus contributing a case study about his job. In addition, a job application exercise was posted, with the aim of highlighting actual jobs which are particularly relevant to Life Sciences graduates and focussing on the application process. A link to the Careers Service was provided, together with a calendar of local careers events, and deadlines for applications and funding opportunities.

The following suggested timetable for the 1st Semester was included:

Week	Activity
1 - 2	Careers information – students encouraged to access careers exercise Introduction to exam essay writing exercise
3 - 4	Go through problem paper
5 - 6	Essay paper under exam conditions
7 - 8	**Presentation of literature review**
9 - 10	Discussion on programme-specific scientific topics
11 - 12	Go through problem paper

Table 4. Suggested timetable for 1st Semester. N.B. Students are expected to prepare their answers to problem papers/ essay plans in advance of tutorials in order to discuss these.

Assessment

Final Level tutorials have no formal assessment component and students are not penalised (formally) for non-attendance. However, an incentive to students is that, unless they attempt the assigned work, they will not be able to benefit from feedback (Dochy and McDowell, 1997). It is traditionally difficult to get students engaged in activities (*e.g.*, careers) that are not assessed, even if, by completing them, they will benefit in terms of finding a job or a postgraduate training post (Ramsden 1992).

Evaluation

It is difficult to evaluate the implementation of a structured Final Level tutorial programme in a quantitative manner because the aim is not for students to achieve higher exam marks, rather that they improve their transferable-skills base and increase their chances of employment or obtaining a place on a postgraduate course. Furthermore, we hoped that tutors would find it easier to structure their tutorial programmes. At the end of the year, we posted a questionnaire to obtain feedback from both tutors and students about the accessibility and relevance of information on the site. Eleven (out of 17) tutors and only 7 (out of 180) students responded. The consensus was that it was easy to navigate around the site to find the required information and that the resources provided (especially the examples of problem papers and essay) were useful. However, students requested more examples of these and wanted access to model answers. It was a deliberate ploy not to provide model answers to students because the aim was to go through the answers in tutorials with the tutors. Furthermore, there is a danger that model answers could be passed on to students from lower years. One tutor suggested that an exercise could be developed which would encourage students to critique the scientific content of press articles related to specific degree programmes. 113 students booked appointments with the Careers Service (this does not include students who made informal visits), which is on par with previous years. It was hoped that student appointments would increase as a result of our intervention, but unfortunately, this was not the case.

Dissemination

Before constructing the online handbook, we met with programme directors to find out what types of resources they used and what they would like included in the resource section. In order to publicise the new BIOL30000 unit, we emailed programme directors and asked for the names of tutors who would be interested in accessing the online handbook. Once tutors were signed up, their students were given access to the student handbook. In all, 17 tutors and 180 students used the online resources.

The idea of a structured Final Level tutorial programme, available to both students and staff, is easily transferable into other disciplines. Now that tutors and students have access to basic information, programme directors have been emailed to invite them to submit generic exercises for use by tutors from other degree programmes. Some of these exercises may be adaptable for use in other Faculties.

Challenges and Limitations

We wanted to include more EBL activities in the Final Level tutorial programme, including some careers activities which would involve students selecting and then applying for fictitious jobs. This would give students the opportunity to tailor their CVs and could lead to interview experience, with other students playing the role of interviewers, armed with notes about the job. This idea was presented to the two Education Boards, but was met with resistance– it was argued that tutorials should focus entirely on preparing students for exams and that tutors would be ill-equipped to run these activities (they missed the point that activities would be developed in conjunction with the Careers Service and that adequate information would be provided to tutors without the need for them to do further research). As a result, we decided to cut these activities from the programme and instead provide a link to already established careers activities that students could access in their own time (University of Manchester Careers Service, 2009).

In order to ensure that tutorials were as enquiry-based as possible, the suggested format for tutorials was to get students to access the papers in advance of tutorial sessions. They would then be expected to discuss their answers with other students before discussing them with the tutor. In the case of essay papers, students could write plans ahead of the tutorial and then swap these with other students to learn about alternative ways of addressing the question.

Further Developments

In order to address the issue of enhancing the EBL experience of students in tutorials, we developed some activities for use in 1st and 2nd Level tutorials. These activities are based on the themes of 'Sustainability' and 'Global Health'. Whilst they are particularly applicable to Life Sciences students, they could be adapted for use in other Faculties (see Appendix 1).

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Appendix 1

Examples of new tutorial activities

1. Sustainability tutorial

Aims:

- To encourage students to think about sustainability and how this relates to careers in the Life Sciences.
- To get students to consider the effects that developments in Life Sciences might have on communities and the environment.

Intended Learning Outcomes:

- Students will be able to define sustainability in terms of how it relates to the Life Sciences.
- Students will be able to cite examples of where bioscience has had both positive and negative impacts on a community/environment.
- Students will be able to formulate arguments for and against scientific developments.

Rationale: why consider sustainability issues?

> *There is mounting evidence and media coverage that students want to work for ethical employers who are environmentally and socially responsible.*
>
> *[Employers] considered the social/environmental ethics, values and experience of university students as part of their graduate recruitment [and] said universities should do more to prepare students for working with employers who are socially and environmentally responsible.*

Quotes from a research briefing by Higher Education Academy Education for Sustainable Development Project (2008)*

Resources:

(see http://www.bioscience.heacademy.ac.uk/resources/esd/index.aspx)

What does this term mean, and how does it relate to life sciences?

There are many definitions (see http://www.ecifm.rdg.ac.uk/definitions.htm)

e.g., in the drug development process:

- What is the environmental impact of the development and manufacture process?
- What happens to breakdown products from the drug? (*i.e.* these may have toxic effects on the environment – examples?)
- Is it possible to test the drug ethically on animal and human subjects?
- Loss of plant species necessary for development of drugs.

Other issues to consider:

- bio-control of pest species;
- genetic modification of crops for disease resistance or salt tolerance;
- impact of pollutants on cellular processes;
- species adaptation to environmental change.

Case studies:
Control of malaria (http://www.scidev.net/en/health/malaria/)
Consider the options for this:

- A vaccine;
- Prophylactic drugs;
- Insecticide-treated bed nets;
- Widespread spraying of insecticides (*e.g.* DDT).

Limitations of each (*e.g.* effectiveness, access to treatment, side-effects of drugs, resistance to drugs, storage of vaccines, uptake, toxicity of DDT, etc).

HIV/AIDS (http://www.scidev.net/en/health/hiv-aids/)

- Treatment v prevention;
- Scarcity of ARVs (Anti-Retroviral Drugs) – who should receive treatment?
- Cost of treatment;
- Issues of pregnancy/ breastfeeding;
- Complicating factors (*e.g.*, malaria/ TB).

Biodiversity + Biotechnology (http://www.scidev.net/en/agriculture-and-environment/)

- GM crops – can lead to increased yields/ less need for pesticides, etc; cost to farmers;
- Deforestation;
- Biofuels – sugar cane grown at expense of other crops;
- Overfishing of rivers/ oceans;

Interest in 'Ethical Scientific careers'? see http://www.sgr.org.uk/ethics.html

*http://www.heacademy.ac.uk/assets/York/documents/ourwork/tla/sustainability/employable_briefing2008.pdf

2. Global health tutorial

This is a topic which has great potential for discussion amongst 1st and 2nd year Life Science students. I was inspired to develop a tutorial activity after attending a talk by Thomas Pogge at the EPhar meeting in July 2008 (see http://www.yale.edu/macmillan/igh/).

Aims:

- To encourage students to think about the ethical issues associated with the global availability of drugs.
- To introduce the concept of sustainability.
- To promote a basic understanding of the patenting law and why there is a need for patenting.
- To raise awareness of the most common diseases worldwide, and the drugs available to treat them.

Intended Learning Outcomes:
Students should be able to:

- Debate the relative merits of drug patenting and the availability of generic drugs to the Developed/ Developing countries.
- Discuss possible strategies for making drugs available to those who need them and whether such strategies are sustainable.

N.B. Pharmacology students might also be expected to discuss the mechanisms of action of the biggest-selling drugs worldwide.

Tutorial activities

The questions raised below are designed to stimulate **debate** (*e.g.*, 'Should drugs be made available free to Developing Countries?') Students would be expected to research the questions and find material with which to support both sides of the argument. Students could be divided into groups representing the affected parties (*e.g.* CEO of a large pharmaceutical firm, HIV patient in Africa, son/daughter of Alzheimer's disease sufferer in UK, graduate in Life Sciences considering a research career).

N.B. Students might be able to suggest strategies for financing this initiative (similar to that proposed by Pogge). Alternatively, students could use their research findings to produce a **poster**, or could write an **essay** discussing the pros and cons of the proposal.

Roles

CEO of Pharmaceutical Company

> *As a result of the current economic gloom, the company is undergoing some serious restructuring. Our current top-selling drug will be out of patent in 2 years and a number of promising leads have fallen at the last hurdle. In order to satisfy our shareholders we will need to concentrate our research efforts on one or two key areas, at the expense of others.*

HIV patient, Zambia

> *I was recently diagnosed with HIV and have been told that the local health centre have run out of ARV drugs. I have heard that drugs are still available but that I must travel to the capital, Lusaka, for treatment. This will mean raising the transport money and leaving my pregnant wife and six children behind in the village. My hope is that drugs will become available soon so that I can begin treatment.*

Son/daughter of Alzheimer's disease sufferer in UK

> *My mother was recently diagnosed with Alzheimer's Disease. The Primary Care Trust has assessed her condition and her GP has prescribed a wonderful drug which has enabled her (so far) to maintain a good quality of life.*

Pharmacology Graduate

> *I graduated in the summer, following a year out at Astra Zeneca. I have decided that I would like to pursue a career in research. I recently travelled to Malawi and saw the devastating effects which malaria and other diseases have on the people there. Many people are too poor to get access to the drugs which they need to live and for some the drugs available are not even effective. I would like to be able to help these people to a better quality of life.*

In addition to the above, **Pharmacology** students could choose one of the drugs listed below and present details of mechanisms of action/side-effects, etc. to the rest of the group.

Questions for students to consider:

Drugs – to patent or not to patent?

- What are the laws governing the right to produce drugs? What is a generic drug?
- What is the World Trade Organisation (WTO)? Who are the member states?
- What are the consequences of patenting drugs for rich nations/ poor nations?
- Should pharmaceutical companies be allowed to charge what they like for drugs?
- Should pharmaceutical companies be allowed to make copies of patented drugs?
- What do you understand by the term sustainability? How is this related to drug development and availability?
- Which drugs are the biggest sellers and who benefits from them?

Resources for tutors

These notes are structured around the questions for students:

WTO's Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) – 1993/4

- '20-year patent protection to be available for all inventions, whether of products or processes, in almost all fields of technology' (however, patents are applied for before clinical trials commence so the shelf life of the drug under patent tends to be between 7 and 12 years).
- 'Trade secrets and know-how which have commercial value must be protected…'
- 'Test data submitted to governments in order to obtain marketing approval for pharmaceutical or agricultural chemicals must also be protected against unfair commercial use'.
- Creators can be given the right to prevent others from using their inventions, designs or other creations — and to use that right to negotiate payment in return for others using them. These are 'intellectual property rights'.
- Effectively, this means that once a drug have been approved for use, the pharmaceutical company that produced it can set the price for that drug, in the knowledge that other companies are not allowed to copy it and sell it cheaper.

A generic drug is one which is produced and sold without patent protection. It should be as effective as a patented drug because it contains the same active ingredients. Usually these drugs will only become available once the patent on the original formulation has expired.

The WTO has 150 members (of which, two-thirds are developing countries)

- The WTO supports developing countries by giving them "special and differential treatment" *e.g.* by giving them extra time to fulfil commitments.
- Countries such as India and Thailand took advantage of this (*e.g.* to provide generic ARV drugs to other developing countries at a fraction of the cost of patented drugs).

Rich nations have to pay increased costs while a drug is under patent, but at least benefit from the fact that drugs are produced for their market. Poor nations cannot afford the drugs, and therefore pharmaceutical companies concentrate their research efforts on providing drugs for richer nations. Once the patent has expired, both rich and poor nations benefit from greatly reduced costs. Problems with the TRIPS agreement include:

- High prices of drugs;
- Neglected diseases – diseases which affect most people (*e.g.* malaria) tend to be prevalent in regions where the poorest people live;
- Bias towards symptom relief – it is more profitable for pharmaceutical companies to focus on these drugs as people become dependent on them (*e.g.*, anti-ulcer drugs; anti-depressants); drugs which are curative are only used for a relatively short period of time and may even eradicate the disease;
- Waste – ensuring that patents are issued in all WTO-member states is an expensive process and protecting the patent involves expensive legal battles;
- Counterfeiting – because patent drugs are so expensive, many small pharmaceutical companies produce illegal copies;
- Accessibility – in developing countries, drugs do not always reach the people who really need them, and even if they do, instructions are not provided in the local language and the expertise might not be available to dispense them correctly;
- Inappropriate marketing – may target the wrong people (*i.e.* drugs may not always be the most suitable for the patient).

Yes - Pharmaceutical companies need to recoup the costs of developing their drugs ($1-2 billion/ successful drug).

No – The large pharmaceutical companies make huge profits (http://www.guardian.co.uk/uk/2008/aug/17/pharmaceuticals.nhs) and therefore could afford to reduce their prices for people who can't afford them. Private funding (*e.g.* Gates Foundation (http://www.gatesfoundation.org/GlobalHealth/)) finances research into new drugs and vaccines.

- In May 2000, five pharmaceutical companies signed up to the Accelerating Access Initiative (AAI) with a view to provide cheaper and more accessible drugs to HIV/AIDS-related care and treatment in developing countries. This agreement also involved UNICEF, UNAIDS, WHO, the governments of the countries participating and NGOs. In return for providing much cheaper drugs, governments promised to waive import taxes and to improve distribution of drugs to those who really needed them. As a result, more people have access to ARV drugs, and at a fraction of the price pre-2000.

  Pros – Countries such as India have a booming drugs industry, with the facilities to make good quality drugs. They are able to sell the drugs to other developing nations at a fraction of the cost of drugs under patent, and therefore they are accessible to a much larger market.

  Cons – This undermines TRIPS and could, therefore, mean that the pharmaceutical company which produced the patented drug is unable to recoup the cost of development (see BBC Health article). It would therefore have less money to spend on the development of new drugs. While drugs are under patent, there are strict quality controls over their production. There is a possibility that the quality of cheap 'copies' may be inferior or that these may be harmful to patients.

- Sustainability - http://www.ecifm.rdg.ac.uk/definitions.htm discusses the relative merits of various definitions. Students should think of examples of initiatives to help developing nations and discuss how sustainable they are (*e.g.* providing 50,000 doses of ARV drugs to a hospital in Zambia is not a sustainable initiative because HIV patients require treatment for life). In contrast, effective treatment of TB could increase the lifespan of HIV patients.

- Biggest selling drugs in the world (2006):
    - Lipitor (Atorvastatin) – a cholesterol-lowering drug - US$12.9 billion;
    - Plavix or Iscover (Clopidogrel) – inhibits platelet aggregation (used to treat CHD) - US$5.9 billion (under patent until 2011);
    - Nexium (Esomeprazole) – proton pump inhibitor used to treat ulcers/ gastro-oesophageal reflux - US$5.7 billion (2005);
    - Seretide/Advair (Fluticasone/Salmeterol) – corticosteroid/ beta-agonist inhaler used to treat asthma/ COPD - US$5.6 billion;
    - Zocor (Simvastatin) - a cholesterol-lowering drug - US$5.3 billion (patent expired 06);
    - Norvasc/ Istin (amlodipine) – calcium channel blocker used to treat hypertension/ angina - US$5.0 billion (patent expired 2007);
    - Zyprexa (Olanzapine) – benzodiazepine – an antipsychotic used in the treatment of schizophrenia - US$4.2 billion (2007) (patent until 2011);
    - Risperdal (Risperidone) – dopamine antagonist - antipsychotic used in treatment of schizophrenia (inc children) - US$4.0 billion (patent expired end 2007);
    - Prevacid/ Zoton (lansoprazole) - – proton pump inhibitor used to treat ulcers/ gastro-oesophageal reflux - US$4.0 billion;
    - Effexor (Venlafaxine) – serotonin-noradrenaline reuptake inhibitor used to treat depression/ anxiety - US$3.8 billion;

Source (Forbes.com)
It should be clear from this list that pharmaceutical companies make most of their money from drugs used to treat cardiovascular disease/ stroke, gastric ulcers and mental illness. This correlates well with the leading causes of death worldwide, but not in developing countries. With better healthcare (especially in developed countries), more people are presenting with mental health issues and aging populations are at greater risk of dementia.