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Proceedings of The Science Learning and Teaching Conference 2007

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Keele University
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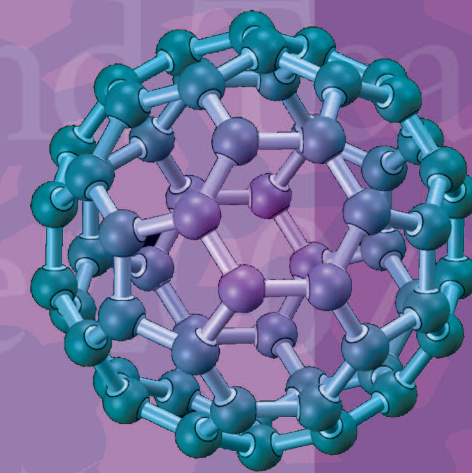

towards excellent science teaching in university based education

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Preface

The Science Learning and Teaching Conference 2007 is the second in a series designed to bring together higher education teachers engaged with science disciplines. During the first conference, in Warwick UK, more than 50 presentations covered a huge range of topics ranging from assessment to virtual experiments (via andragogy, the Midwich Cuckoos and plagiarism). In 2005 CETLs (Centres for Excellence in Teaching and Learning) had only just been established and we heard some early reports of their activities. In 2007 we expect to hear much more.

This conference has proved to be just as popular and even more intriguing, taking us from the crime scene to the writing on the wall, from parrots to professionals and from physics in .mp3 to rousing the dead. I have seen the papers and I look forward to hearing them presented!

A conference like this does not just happen and I want to pay tribute to the team of people, principally from the three subject centres, who have contributed to the organisation of the meeting and the publication of these proceedings. Equally important are the contributions of the organising committee and referees who selected such a strong set of papers. Finally I must thank the most important people of all – the delegates – for the contributions they make on the day. Without them, there would be no discussion, no coffee-break buzz, no networking – and no progress!

Peter Goodhew, April 2007

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Posters

[K1] Post-secondary science education and the scholarship of teaching and learning: three key cases from the US experience

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Keywords: scholarship, evidence, pedagogy

Abstract

Post-secondary faculty members in the US have tended to ignore even strong evidence on the effects of different pedagogical strategies.

The scholarship of teaching and learning (SOTL) movement invites faculty to see effective pedagogy as a valid and interesting area of research, one that should inform their efforts and, perhaps, one that they might want to advance. I will review three contrasting SOTL approaches as illustrated by three studies, one in calculus, one in physics and one that was multidisciplinary. One produced massive improvements in student success (from 60% below C to only 4% with no dilution of standards), one allows the comparison of the effectiveness of very different pedagogical approaches across a range of institutions and the third defined important barriers to the development of higher level critical thinking.

[O1] A study of the impact of blended learning on bioscience students

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This paper was not submitted in time for inclusion in the Proceedings.

[O2] Reflection as a component of a blended learning approach: encouraging engagement and re-engagement

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Keywords: reflection, blended learning

Abstract

Human Physiology is a level one undergraduate core module that is taught using a blended learning approach. Students are encouraged to direct their own learning using 'land-mark' lectures hosted on-line, linked to references to key resource material in textbooks, on web-sites and in computer software programmes. These elements constitute the base of a learning triangle, whose apex is class contact in the guise of dedicated workshops that enable staff to work alongside individual students or student groups. Reflection is viewed as both an approach and method for enhancing the quality and depth of student learning. To encourage a cycle of engagement and re-engagement, students complete a reflective diary. This is a vehicle for encouraging individual learners to think about their learning and to understand better what, how and why they learn. Reflective narratives provide an experiential window that offers an understanding of how and why students choose and use materials and resources. To determine the level of reflection, reflective statements were coded using the framework proposed by Kember *et al*. (1999). Students' diaries exhibited a progression from what is little more than a description to deep reflection. Engagement and re-engagement with learning as facilitated by reflective diaries has a positive influence on assessment performance, with a significant positive correlation noted. The outcomes from this project indicate the important role played by reflection in encouraging engagement and re-engagement in a blended learning model and the positive influence that reflection can have, in terms of, the process of good quality learning, the development of appropriate learning behaviour and student performance during assessment tasks.

Introduction

Blended learning can be accomplished through combination of technology-based materials, face-to-face sessions and print materials. To foster this approach through the medium of the University online learning framework, the traditional format of the module comprising a weekly programme of 2 lectures and one tutorial, was replaced by converting lectures into an on-line form and hosting them on the University's virtual learning environment (Wolverhampton Online Learning Framework, WOLF), linking these to key texts, online resources and computer software packages – comprising the two points of the base of the students' learning triangle (**Figure 1**). The apex point is one of 9 3-hour interactive workshops covering the key areas of physiology – the face-to-face 'class contact' element.

In learning and gaining new insights into human physiology, students need to be reflective and put what they have learned into perspective. An extensive review of the literature on reflection and experiential learning (Moon, 1999a; Moon, 1999b), provides a particular focus on the application of reflective writing via the vehicle of learning journals. Reflection

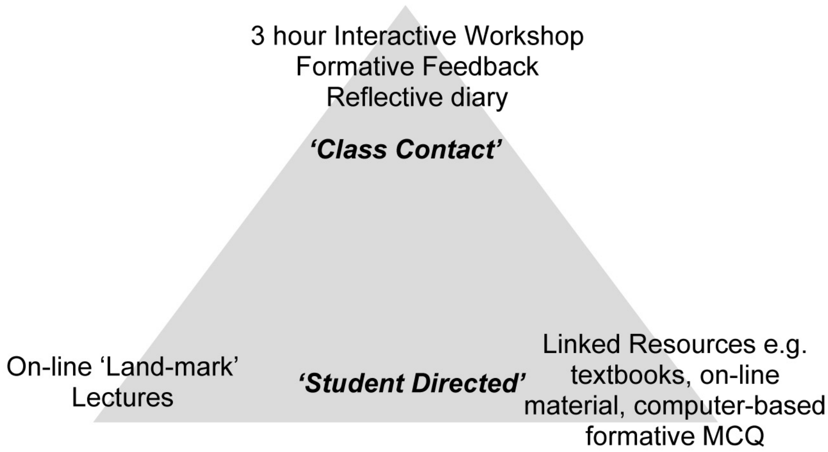

Figure 1: The students' learning triangle

can be viewed as both an approach and method for improving the quality and depth of student learning. In view of this linked into the 'class contact' element, a weekly student diary sheet designed to encourage and facilitate students to reflect on their learning and accomplishment during the week must be completed. Race (2002) captures the intentions of the reflective diary when he comments that 'the act of reflecting is one which causes us to make sense of what we've learned, why we learned it, and how that particular increment of learning took place. Moreover, reflection is about linking one increment of learning to the wider perspective of learning - heading towards seeing the bigger picture.' Reflection is therefore a way of thinking about learning and helping individual learners to understand what, how and why they learn. The reflective diary is the 'vehicle' for reflection and makes use of structured entries with simple prompt questions to provide scaffolding for the individual learner to make sense of their experience and make connections.

One dimension of reflection of interest in this study was depth, with an aim to better understanding the relationship between depth of reflection and effective learning behaviour and by implication performance. Frameworks to assess the 'level of reflection' tend to involve application of hierarchical models of reflective activity (Hatton and Smith, 1995; Kember *et al*., 1999; Kember *et al*., 2000), with progressive sophistication from description to deep reflection, the latter associated with perspective transformation (Mezirow, 1991). Predicated on Mezirow's (1991) work Kember *et al*. (1999) provide a substantiated model for estimating the depth of reflective thinking, from 'non-reflection' to 'premise reflection'. The seven levels define the coding system (**Figure 2**) for students' reflective diaries. The 'level of reflection' increases from 1 to 7, with parallel categories representing equivalent 'levels' and shaded boxes representing 'non-reflective' action.

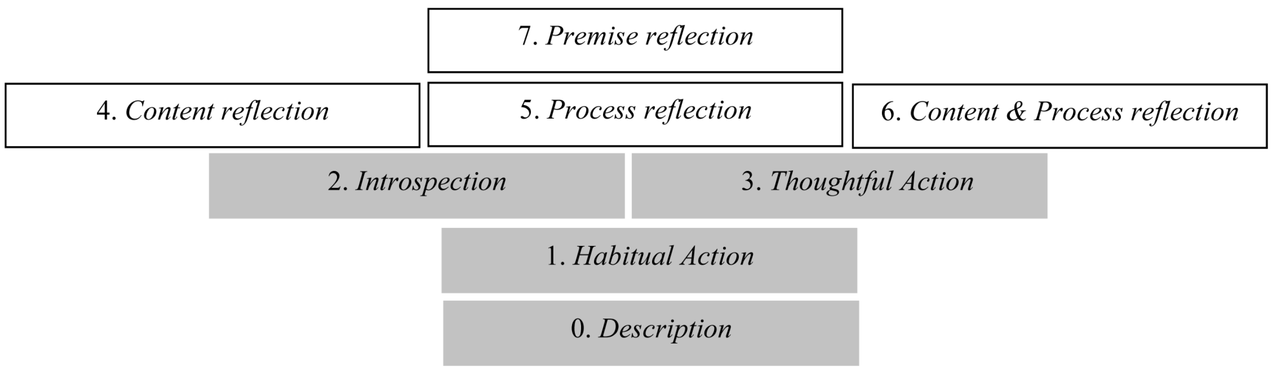

Figure 2: Coding categories for reflective thinking (reproduced from Kember *et al*., 1999)

Habitual Action is activity performed automatically or with little conscious thought, often not a feature of journal narratives (Mezirow, 1991 p106). *Thoughtful Action* involves higher-order cognitive processes with a focus on ongoing action. It draws on existing knowledge and prior learning to make selective review rather than deliberate appraisal and reappraisal (Mezirow, 1991 p107). *Introspection* involves thinking about thoughts and feelings and therefore lies in the affective domain (Mezirow, 1999). '*Reflection* involves the critique of assumptions about the content or process of problem solving. *The critique of premises* . . . pertains to problem posing as distinct from problem solving' (Mezirow, 1991 p105). Premise reflection is considered to be at a higher level and involves transforming of meaning, being aware of why we perceive, think, feel or act in the way we do (Mezirow, 1991 p105).

Methodology

During the module, students were expected to engage with the process outlined in **Figure 3**.

Figure 3: Expectations of engagement required of the students

Students' reflective diaries were coded according to the framework developed by Kember *et al*. (1999). Statistical analysis was performed using SPSS (v 11.5). The correlation between completing the reflective diary and student performance was explored using a Spearman Rank test and multiple comparisons between 'level of reflection' and student performance were made using a one-way ANOVA.

Results

A strong positive correlation is evident from **Figure 4**, $r = 0.96$ ($p<0.05$). Analysis using a one-way ANOVA shows that a significant difference exists between different 'levels' [$F(4,103) = 10.727$, $p = 0.000$]. The pair-wise comparisons (**Table 1**) locate these differences. Significant improvements in assessment performance are noted when *Descriptive narratives* are compared to those exhibiting *Introspection* and *Content & Process Reflection*. Assessment performance for students' diaries coded as demonstrating *Content & Process Reflection* also show significantly improved module grade when compared to *Habitual Action* and *Thoughtful Action*.

Discussion

Reflection is acknowledged as being both involved in and enhancing the quality of learning (Moon, 1999; Moon, 2001) and building on the experience of a pilot study, a weekly reflective diary was introduced in the module BM1119 Human Physiology. The foremost intention of the reflective diary was to integrate a reflective opportunity into the

Pair	Mean difference	p-value
D – HA	-1.29	0.972
D – TA	-3.83	0.140
D – IN	-5.18	0.015
D – CP	-8.23	0.000
HA – TA	-2.54	0.482
HA – IN	-3.89	0.093
HA – CP	-6.95	0.000
TA – IN	-1.35	0.597
TA – CP	-4.41	0.001
IN – CP	-3.06	0.054

Table 1: Pair-wise comparisons for mean module grade for the fives levels of reflection

Note: D = Description; HA = Habitual Action; TA = Thoughtful Action; IN = Introspection; CP = Content & Process Reflection. Shaded areas represent mean difference is significant at the 0.05 level.

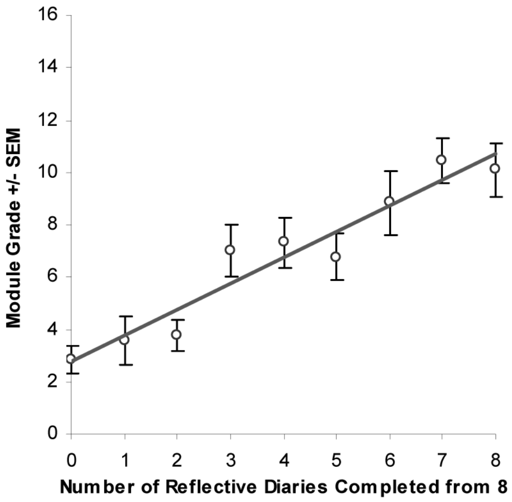

Figure 4: Relationship between module grade achieved and level of engagement as defined by number of reflective diaries completed (n=110)

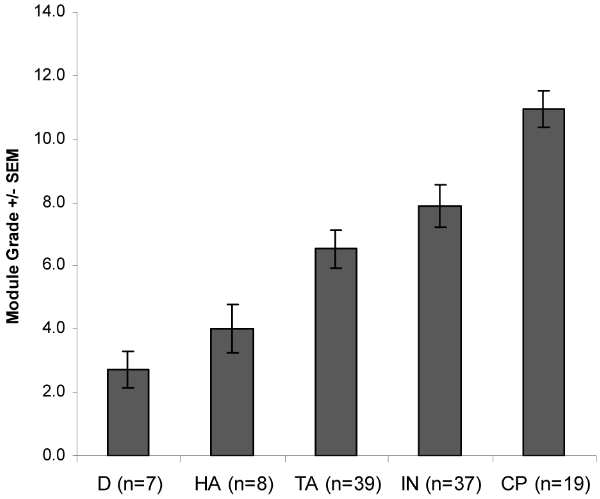

Figure 5: Sample means and SEM for the five levels of reflection (n=110). *Note*: D = Description; HA = Habitual Action; TA = Thoughtful Action; IN = Introspection; CP = Content & Process Reflection

curriculum. A 'scaffolding' document with questions to promote and support reflective writing was provided, and the learning intentions were discussed with the students, this provided a clear rationale for the process.

Student engagement with the process of completing the weekly reflective diary was positive, with a strong positive correlation (r = 0.96; $p<0.05$) (**Figure 4**). Completing the reflective diary encourages a cycle of engagement and re-engagement. Results suggest that improved assessment performance is associated with higher levels of engagement with this cycle. Many accounts are characterised by candour; however the majority of diaries (91 from 110) are characterised by descriptive writing or 'non reflective' actions as defined by Mezirow (1991).

- 'the workshop this week was quite difficult. This maybe because I didn't do any reading about the topic beforehand'
- 'the work was quite difficult, there was so much you needed to understand'
- 'the workshop was very challenging and too many calculations involved. I need to do so much more reading in order to be able to complete workshop questions in the phase test'

- 'work was a little challenging maybe due to not reading before attending'

Despite 'scaffolding' the approach, many students tend to be mechanistic and uniform rather than critical, an approach consistent with the findings of Hatton and Smith (1995). Reflective diaries were successful in developing the students' awareness of the value of formative feedback; with the majority of students acknowledging the value of the formative feedback opportunity:

- 'very useful'
- 'useful, it gives sense of direction that I have to follow'
- 'Yes, useful but much information to be retained'
- 'It was very good, good explanations of the issues'
- 'Very useful explained in detail'

There is an increasing awareness that the superficial or 'non reflection' noted above may not be effective as a means of learning (Mezirow, 1998; Kember *et al*., 1999; Kember *et al*., 2000). Some students' diaries (n=19) developed a deeper level of reflection, with content and process reflection coupled with acknowledgement of the value and potential application of formative feedback:

- 'Feedback useful, helped me to understand my weaker areas'
- 'Key points on cue cards, extra reading on relevant theory on questions that were incorrect'
- 'Made extra notes and corrected those things where I went wrong. Useful as it tells and explains where went wrong. If proper notes aren't made, can't revise properly'
- 'The feedback session at the end of the workshop was very useful. The use of the feedback made me understand in more depth about the subject'
- 'Feedback session was useful. Used session to take notes on additional points'
- 'I used the feedback to correct and amend my answers to the workshop Qs [questions] and realise what I need to revise and make more notes on'

Of particular interest is the comparison between 'levels of reflection' and performance on the module assessment. **Table 1** and **Figure 5** compares the mean module grades of students for each of the five 'levels of reflective thinking', *Description* through to *Content & Process Reflection*. From the analysis, significant difference exists between different 'levels' of reflection [$F(4,103) = 10.727$, $p = 0.000$]. The pair-wise comparisons (**Table 1**) locate these differences. Students engaging in reflective activity as represented by CP (*Content & Process Reflection*) coding for their reflective diaries, demonstrate significantly improved assessment performance when compared to their peers who engage in 'non-reflective' activity as characterised by *Descriptive, Habitual Action* or *Thoughtful Action*. Progressive levels of sophistication of reflective thinking are associated with improved assessment performance. Those students with reflective diaries characterised by *Description* and *Habitual Action* exhibit significantly poorer levels of assessment performance when compared to those who engage in *Thoughtful Action*, drawing on their existing knowledge and prior learning or *Introspection* by integrating thoughts and feelings in their reflective narratives.

Conclusion

Reflective diary writing is a process that accentuates favourable conditions for learning. A significant improvement in assessment performance is associated with increasing 'levels of reflection' in students' reflective narratives. The outcomes of this project indicate the important role played by reflection in encouraging engagement and re-engagement in a blended learning model and the positive influence that reflection can have, in terms of, the process of good quality learning, the development of appropriate learning behaviour and student performance during assessment tasks.

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[O3] The use of reflective practice to support a final year team research project in biosciences

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Keywords: reflection, evaluation, personal development, feedback

Background

All final year students in the Faculty of Life Sciences complete a research project module worth 40 credits. In September 2006 the Faculty of Life Sciences (FLS) in partnership with the Manchester Science and Enterprise Centre (MSEC), launched the Life Sciences Enterprise Project (LSEP) as an alternative option to either the traditional laboratory-based, bioinformatics or computer-aided learning/education research projects. Based on a course model by Stefan Przyborski at the University of Durham and existing modules run by MSEC in other Faculties, the end product of this research project is a business plan for either a product or service. In developing the business plan, students are using research knowledge outputs from the field of life sciences, e.g. potential drug targets for the treatment of Alzheimer's disease. This project is therefore designed to develop both the students' deep understanding of a specific field of science and to also help them understand the processes involved in recognising the potential of university-based research to solve commercially valuable problems in the market place.

The business plan is only part of the range of assessments this project adopts; we also aim to help the students developing their transferable skills as they apply their knowledge on a real task. The intended learning outcomes relating to the transferable skills are summarised in **Table 1**.

As tutors, we have come to recognise that students do not always identify their advances in skills development or their personal development. We therefore felt that one of the most effective ways to assist students in appreciating their personal and skills development would be to incorporate regular opportunities for reflection on their progress throughout the module. This communication will describe the approach taken to introduce reflective practice into the course and to also share our and the students' experiences of reflective practice.

At the end of the course the student will be able to:	
ILO1	Develop critical thinking
ILO2	Develop, structure and communicate ideas effectively
ILO3	Develop and utilise creative problem solving skills
ILO4	Plan and prioritise work load and work effectively in both teams and as an individual
ILO5	Reflect on individual and team performance as a basis for personal development
ILO6	Reflect upon personal and team strengths and weaknesses in the context of project work and be aware of how this information can be used
ILO7	Develop useful networks

Table 1: Intended learning outcomes (ILOs) of transferable skills and personal qualities

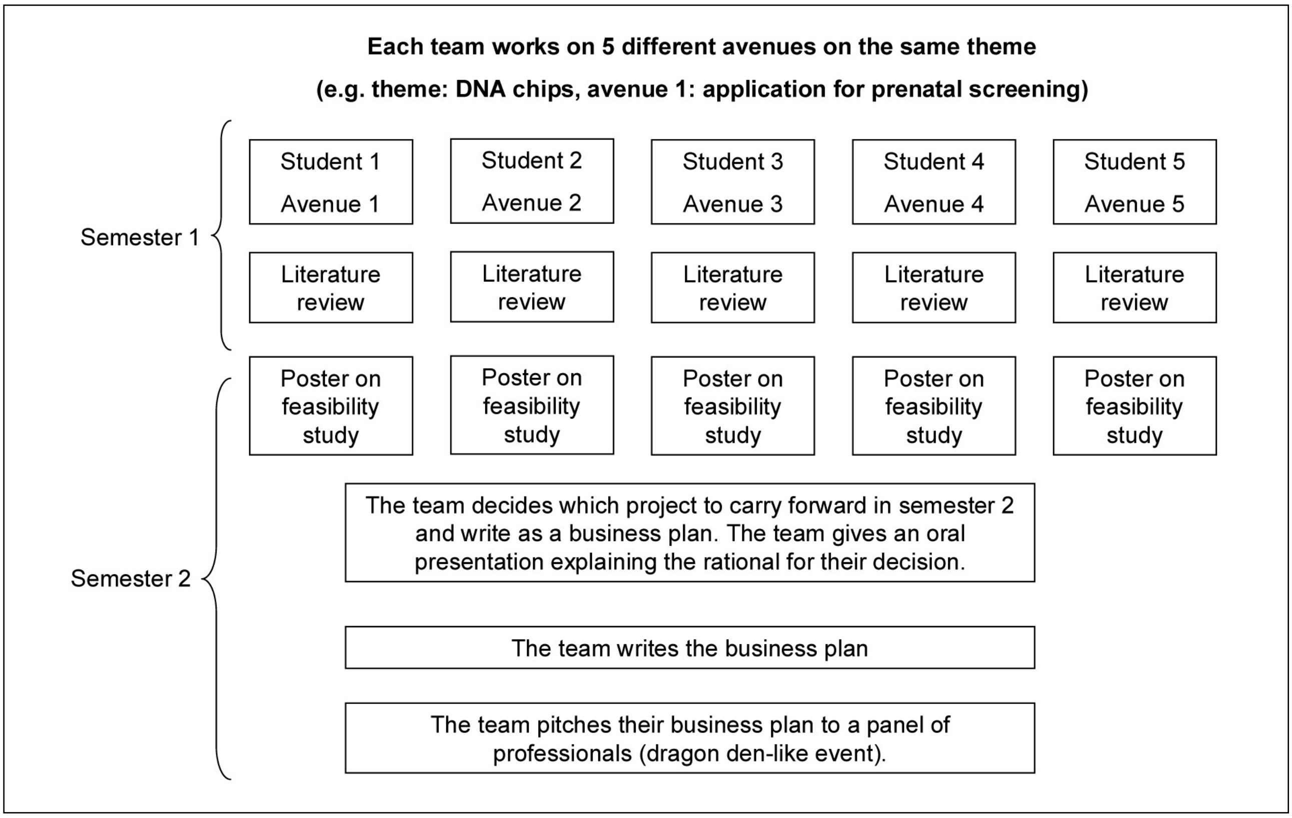

Figure 1 summarises the course individual and group assessment components

Course Design and Structure (see **Figure 1**)

The thirty students registered for this course were divided into six teams of five students (**Figure 1**). Each team was assigned a research 'theme', e.g. gene therapy, biostatistics and an academic supervisor within the Faculty of Life Sciences. Within that theme, the team were asked to consider potential avenues to explore. These avenues may have lead to the development of a service, e.g. consultancy, technical; or a product, e.g. therapeutics, diagnostics, medical device, educational package, etc. In weeks 1-6 of Semester 1, a series of workshops and tutorials were held to provide an overview of the processes underpinning the entrepreneurial journey from having an initial idea to the development of a successful venture. At the end of the semester, each student submitted a literature review focusing on their chosen avenue. The review included the scientific background of the product/service plus a feasibility study for its potential exploitation.

The key points of the feasibility study were communicated in a poster format to the other team members. Prior to the poster presentation, each team established evaluation criteria against which each individual idea was screened and ranked. The idea with the strongest potential for successful commercialisation was presented to a panel of staff and formed the basis of the team project work in the following semester.

The objective of the team work in Semester 2 was to develop a written business plan. In this semester there was no formal taught input and teams were expected and encouraged to establish their own action plan. During development of the business plan, the team met with their supervisor and Martin Henery from MSEC on a weekly basis to report their progress in the previous week and aims for the following week. After submission of the business plan, each team presented their plans in the form of an 'elevator pitch' to a panel of staff including enterprise professionals.

This course therefore comprised both individual and team components. To ensure that students were prepared for the team aspects, a series of tutorials were delivered during the first semester, focussing on problem-solving and creative thinking, developing team working skills and managing conflict within the team, and providing guidance on reflective practice.

Introducing Reflective Practice

There are different types of reflective practice as discussed by Schön in Baume (2003) and Cowan (2006). One of our intentions for the reflective practice component of the module is that it would support the team-working elements of the course by enabling students to reflect upon their individual and team performance – how successful was I/we in the activity and why? Did I achieve what I wanted to? Schön describes this form of reflective practice as 'reflection on action'. We wanted our students to take their critical reflective skills a stage further by reflecting on and learning from their previous experiences and using this as a basis for personal development and to improve their own individual/team performance in the future. To achieve this, students had to consider strategies for overcoming weaknesses. This form of reflection is described as 'reflection for action' by Cowan (2006).

The Reflective Portfolio

By the end of the module, students produced a reflective portfolio of five reflective pieces which constitutes 25% of the final module mark (each piece contributes 5%). As described by Mutlow in Baume (2003), we wanted to use the reflective portfolio for two purposes: as part of (i) a 'process portfolio' where the student shares his/her experiences as they are happening and from these experiences reflects upon what s/he has learnt and considers how s/he can build on this understanding by setting goals and action plans; and (ii) a 'completion portfolio' where the student provides evidence that the learning outcomes have been met.

The Process Portfolio

For the process portfolio students were required to submit short reflective pieces on a weekly basis. The aim here was to push the students to reflect regularly on the new knowledge, skills or experience that they had acquired or developed during LSEP and consider how this new knowledge could be utilised in the future, to the advantage of the individual, team or both. Students were also asked to consider their experiences outside of the module and how these could be beneficial to their progress on this module. With this aspect of the reflective portfolio, we wanted to emphasise to students the importance of considering how they performed in a particular situation and what changes they would make if the same situation arose again in order to improve their performance ('reflection for action').

At the end of the course, students selected four of the weekly pieces which most accurately reflected their personal development over the duration of the course. We were aware that the majority of students were unfamiliar with what constitutes reflective writing and therefore up to week 6 of the course, the reflective pieces submitted were used as formative assessment. Staff provided personalised feedback to assist with production of the summative pieces.

In addition to the weekly reflective log, students produced two extended pieces focussing on the avenue selected by the team and the presentation of the choice rational. Students were asked to consider the processes and activities the team underwent during the planning stages of the selection and presentation (**Table 2**, 'Planning the Presentation').

	Content	Word count
Ongoing reflective log	What has happened during the last week? What have I learnt from this? What goals can I set myself in the future?	200-400
SWOT analysis I	Benchmark for the start of the course. What are my strengths and weaknesses? What are the opportunities and threats to me at this point in the course? What strategies can I use to overcome these weaknesses and threats?	500
Planning the presentation	Reflect upon the process of producing the team plan of action and criteria for selection, e.g. how did we plan and prioritise the task? What experiences was I able to bring to the task? How did the team manage the process? Did the team work effectively? How would we do this differently if we had to repeat the process again?	1000-1500
Reflecting upon the presentation	Reflect upon (i) the plan of action used in the run up to the presentation and (ii) the presentation – did we adhere to our schedule? If not, why not? What were the team's strengths and/or weaknesses? How did I perform within the team during this process? What could I do differently during the next team activity? What lessons have I/we learnt?	1000-1500
SWOT analysis II	Having completed the course, students must consider their level of personal development by returning to the SWOT activity – what are my strengths and weaknesses at this stage? Are they the same or different? What experiences can I take from this course and use in my future career? What evidence have I got to confirm that the learning outcomes have been met?	2000-2500

Table 2: The five components of the reflective portfolio

Following the presentation students were asked to reflect upon how effective their planning stages were and also the presentation itself. Further details of the individual components are described in **Table 2**. Both these assignments were designed to help student reflect for what the groups tasks that were awaiting them in semester 2.

The Completion Portfolio

Here the students were asked to provide evidence for the learning outcomes listed in **Table 1**. When providing evidence, students had to reflect upon their personal development since the start of the course. The SWOT (Strengths, Weaknesses, Opportunities, Threats) analyses completed at the start of the year as a benchmark were compared against a further SWOT analysis at the end of the course. To provide evidence for ILOs 5 and 6 in **Table 1**; students were asked to respond to an advertisement for a job. In the application procedure, students could reflect upon the skills they had developed over the course and consider how these might be of benefit or relevance to the job in question.

Benefits to the students

As evidenced by the weekly reflective logs, we have found that the introduction of reflective practice has achieved our aim to assist the team-working elements of the course by enabling these students to reflect upon both their individual and team performance. In the first excerpt this student is considering the team's preparation for the presentation:

> *'We spent so long debating about which market to go for that we didn't leave much time for creating and sending the presentation. I think we also ran out of time because we did not stick to our plan over the Christmas holidays. If we had stuck to our plan we would have decided on the market during the holidays and we would have had a week at least to prepare and send the presentation.'*

In the second excerpt, this student has considered their individual performance in the poster presentation:

> *'I feel that I let myself down during the poster presentation. My poster did not meet the requirements that it should have. I realised that when I designed the poster, I did not think of **why** I was designing it. **What** was its purpose? **Who** was I designing it for and **what** were they going to use it for?'*

In both excerpts, the students have clearly reflected upon the event itself and the reasons why their performance had not met the standard the students had set. We wanted students to not only recognise their strengths and weakness, but to also consider strategies for overcoming weaknesses, to improve their future performance. These students would then need to progress by considering appropriate strategies to avoid finding themselves in the same situation. In this third excerpt, the student has recognised a weakness and subsequently proposed a strategy for overcoming this weakness:

> *'I think that part of the problem is my style of writing. I tend to be quite descriptive and I waffle, which isn't very good for scientific writing. When reading scientific papers I much prefer the short and pithy articles as I find that they get the point across in a direct but comprehensive fashion. I need to learn to mimic this style to be more concise and succinct. I have found reading my work aloud helps with this, and I've also printed off my first draft and attacked it with red pen as I found it much easier to be ruthless on paper.'*

This was the first course in the Faculty of Life Sciences where reflective writing had been incorporated and therefore it is important to determine how the students have received this component of the module. In our evaluation questionnaire completed by the students halfway through the module, students were asked to note which comment listed in **Table 3** most accurately reflected their current opinion of the reflective portfolio. Although the majority of respondents stated that they 'had to force themselves to do it', all 12 respondents could appreciate how reflective writing can be of benefit and this is confirmed by an excerpt from one of the weekly reflective logs:

> *'As a side note, I am continuing to gain so much more from this course than just knowledge. . . . The self development and understanding that I have gained, and continue to gain, from the course materials and these personal reflective logs is what I now feel are going to be the true rewards of this course and not just the mark contribution to my final degree.'*

Benefits to the tutors

Asking students to submit a reflective log on a weekly basis has given the course tutors a clear insight into the progress of this new module and real time feedback on the activities proposed in the workshops and tutorials. We have been able to closely monitor any

Comment	Number of respondents agreeing with comment
Do it because I have to, but do not see any point in doing it	0/12
Have to force myself to do it, but I can see a point in doing it	7/12
Can see myself becoming better at it and I am getting more and more from it	2/12
Feel quite confident that I am good at it and get what I am supposed to out of it	1/12
Have done it for a long time now and recognise how useful this activity is	2/12

Table 3: Results from course evaluation questionnaire.

concerns of the students regarding the content and if necessary, quickly provided additional course materials or direction.

Many reflective logs have also discussed the progress of the team and team dynamics. Where conflict has arisen we have observed the team's progress in subsequent weeks and if unsuccessful in managing the conflict, we have organised additional meetings with teams to discuss issues and strategies.

Finally, although this is difficult to evaluate at this stage, it is likely that the relationship established between the students and the tutors through this course, is partly the result of the supplementary means of communication that are the weekly logs.

Conclusions

The introduction of reflective practice into this new course has benefited both tutors and students. As tutors, we have received real-time feedback on the progress of our module, of particular importance and benefit when introducing a new module. Students have successfully developed critical reflective skills over the duration of the course. These skills have been used to identify the strengths and weaknesses of both individual students and teams. Students have progressed to use this knowledge to set personal and team goals and realistic strategies for achieving these goals.

Acknowledgements

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[O4] E for effective? e-portfolios, self reflection and personal development planning

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[O5] Renovating laboratory teaching: keeping the students' interest

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Keywords: laboratory teaching, physics, experiments, tutorials

Abstract

In recent years the Physics and Astronomy Department at the University of Glasgow has become aware of a growing dissatisfaction with the teaching of our laboratory classes, particularly at level one. Students found the work a 'chore', tackling the work as something that had to be done, rather than something they actually wanted to do. This attitude was having a detrimental affect on the students' views of Physics, and indeed on their performance. The Department concluded that this issue had to be addressed. This paper details the renovations carried out to the level one practical Physics class and reports on the improvements this brought about for the experience of the undergraduate students. The improvements focussed on the introduction of 'experimental tutorials' – a series of connected tutorials and experiments designed to clearly connect the theoretical and practical sides of Physics. The end result was a more intensive laboratory course which was well received by the students.

Introduction

For several years now, the teaching staff in the Physics and Astronomy Department at the University of Glasgow have been aware of a growing dissatisfaction with the level one Physics course. In particular, students appeared to dislike the practical classes. To address this apparent growing dissatisfaction it was decided to renovate the level one practical class. The course is split over two semesters, and it was decided to concentrate, initially, on reworking the first semester course. This paper reports on the renovations which were carried out and how well they succeeded.

Student preferences

Before renovation of the laboratory course could begin, a survey was carried out in November 2005 of the then current level one class, as well as students in higher years. The purpose of this survey was to determine what the students were looking for from the level one laboratory classes.

The students were first asked whether they felt the laboratories were a place to learn new, practical skills, or to help illustrate the coursework they were taught in their lectures. 65% of level one students, over 90% of level two students and 70% of level three students favoured the latter.

When asked about the structure of the experiments, 55% of level one students expressed a preference for having a clearly detailed list of tasks as opposed to using their own initiative when approaching the work. The students from later years were more split on this topic – only 35% of level two students agreed to a preference for a clearly detailed list of tasks, whilst the level three students were split evenly between the two views. This is perhaps to be expected given that these older students have an obvious preference for the subject in the first place, having chosen to continue their Physics studies beyond level one. The level one students also did not want to be offered a choice of experiments to pick from – over 60% wanted the decisions made for them. Again the older students differed in their view regarding this (60% of level two students and 70% of level three students wanting the option to choose their own experiments). This result was not unreasonable – the majority of level one students do not have enough experience to pick their experiments.

The final two questions related to whether the students would rather work alone or in groups, and whether they would prefer more use of computer simulations. The clear majority at all levels was for pair or group working (over 90% in favour in every year group), whilst they did not want to see greater use of computer simulations. Instead they wanted to see more use of tutorials. Again, over 90% would prefer tutorials to simulations.

Aims of the renovations

Analysing the responses to the student survey allowed a new structure to be devised for the level one laboratory class.

Before the renovations took place, students attempted three five-hour experiments, accompanied by one hour tutorials every other week. This gave the students eighteen hours of laboratory time. Whilst the experiments which the students undertook had merit in terms of the Physics and practical skills they taught, they had not been updated in many years and were no longer seen as being in synch with the taught lecture courses. Since the students clearly indicated a preference for the experiments to highlight areas of the course covered in their lectures, it was felt that a wholesale recreation was needed for the laboratory course. This became one of the key aims of the renovations. The full aims were:

- to create direct illustration of lecture material – the laboratory course should be an integrated part of their lecture course, not separate to it.
- to encourage more free-thinking on the part of the students, within clear guidelines – tasks were phrased in ways which required students to use some initiative (e.g. a student might be told to plot a graph to confirm a theory, but not told explicitly what that graph should be).
- to bring in more research-style methodology. (e.g. greater emphasis on computer-handling of experimental data – previous experiments had used a lot of hand-drawn graphs).
- to create a faster paced working environment to avoid student boredom.
- to replace outmoded equipment.

Experimental tutorials

To insure that the students clearly saw the connection between the practical work and their lectures, it was decided to replace the traditional experiment structure with experimental tutorials. These would consist of a theoretical Physics question, such as might be presented in a tutorial. This would be based on work recently covered in the Physics lecture course. The theory covered in the question(s) would then be directly mirrored in the experiment the students attempted. It was hoped that the students would be familiar with this approach, as it was in someway similar to that which they were familiar with from school where practical and theoretical Physics are taught hand in hand.

An example of one such experimental tutorial follows.

- *Course topic covered*: Hooke's law and simple harmonic motion (SHM)

- *Tutorial question*: the students were presented with the hypothetical situation of a mass oscillating on the end of a vertical spring under SHM. They were given the equation of motion for the mass and asked to sketch this motion. They were then given an equation for the force on the mass and asked to sketch how this varied. They were then given a final equation, detailing the period of oscillation, and asked to calculate a value for a given set of variables.

- *Experiment*: the students were presented with a practical duplicate of the hypothetical situation described in the tutorial question. The motion of the mass on its spring and the force exerted by it were monitored by sensors connected to a PC. The students carried out a series of measurements to monitor motion and force, and then calculate the period of the oscillations. If the students carried out the experiment correctly, then the computer would produce graphs similar to the ones they had sketched from the theory. They would then use the same data to calculate the period of oscillation and compare this to the value from theory.

By carrying out this experimental tutorial, the students came at the idea of Hooke's law and SHM from both a theoretical and a practical direction.

This particular experiment also met one of the other aims of the renovations – specifically the updating of experimental equipment. An earlier incarnation of this experiment had had the students manually counting and timing bounces of an oscillating mass. The use of a computer to do these calculations considerably improved this experiment. The experiment also required the students to carry out data analysis and manipulation within the Microsoft Excel package, meeting another of the broad renovation aims.

Before the students began the series of experimental tutorials, they carried out an intensive IT exercise. A large proportion of this was designed to introduce the students to the many uses Microsoft Word and Excel have for the modern physicist. The exercise saw the students creating scientific diagrams, tabulating data and then manipulating that data in Excel. These Excel skills were further developed as the term progressed. A subset of the experimental tutorials, including the one detailed above, had an element of data analysis as a key component.

To match up the experimental tutorials with as many of the topics in the lecture courses as possible it was decided to shorten each individual experiment to one hour in length, with each student attempting three such experiments in every three-hour laboratory session. To accommodate the number of students, each group of students was divided into three, with each group progressing through the three experimental tutorials as the laboratory session went on. The level one lecture course is divided into three separate topics, so wherever possible each laboratory session had one experiment from each topic.

This structure was adopted for the first five weeks of the laboratories, making a total of fifteen new experiments. The final three-hour session was different. Here, two ninety minutes exercises were designed to promote team-working skills. One of these was a theoretical exercise, testing the students' knowledge of special relativity. The second was a practical exercise where the teams (of typically four or five students) were given a set of tracks and supports and asked to design a roller coaster which would illustrate certain aspects of dynamics; which aspects were chosen was left up to the students. In both of these exercises, assessment was based on a short presentation given by the group at the end of the ninety minutes.

To create the seventeen new experiments, the lecturers from the level one course were asked to select a series of topics from their course components and devise the basics of an experiment which would illustrate each of these topics. An Honours level undergraduate student in the Department was then employed over the summer of 2006 to work through these basic plans and flesh them out with the help of the members of staff. The end result was a diverse collection of relatively straightforward experiments which covered a wide range of topics covered in the lecture course components.

Results

These new experiments were first deployed between October and December 2006. After the first week it was decided that it was not practical to have the students attempt three experiments in each three hour session. The time allocated to each experiment was instead increased to ninety minutes and each student expected to attempt two out of the three available each week. The students were assigned to the experiments each week, as the information we had received from the original questionnaires suggested that they did not wish to have to make the choice themselves.

Whilst this reduction in experiments attempted meant that the students covered less material than had originally been planned, the extra time allocated to each experiment meant that the standard of the work carried out improved. It also made the job of the demonstrators considerably easier. They could now actually provide useful guidance to students, something which was felt to be essential to the students' laboratory experience.

To assess how well these new experimental tutorials were received, a new questionnaire was given out at the end of the semester. Even before this was given out, however, it was apparent that the level of activity in the laboratories had improved. When previous cohorts had attempted the older, longer experiments, there were often periods where the students were clearly losing interest in the work. Under the new structure their attentions remained focussed on the work at hand. This was perhaps in part due to the more hands-on approach of demonstrators who were also 'refreshed' by the new work.

In the survey the students were asked to rate the standard of the level one laboratory class as 'Excellent, Good, Fair, Poor or Very Poor'. 60% ranked the laboratories as good or excellent, with another 37% ranking them as fair. The students were also asked to rank the standard of the demonstrators on the same scale. Here 77% of the students considered the demonstrators excellent or good, 17% as fair.

This feedback was, in itself, very encouraging. Whilst they were not the same cohort as those polled in the first questionnaire – clearly not possible as those former students did not undertake the new structure – they clearly felt that the experimental tutorials were a useful exercise.

The students were also asked to compare their experiences in the Physics level one laboratory with other laboratory courses they were taking, if appropriate. Specifically, they were asked how the Physics labs compared to those of the Astronomy and Chemistry courses.

The results were mixed. In comparison to Astronomy, the students' views on the Physics laboratory were encouraging. There was a three-way split of opinion in regard to the Astronomy laboratories. One third of the students thought the Physics laboratories were better, one third thought they were worse and one third thought they were just the same as the Astronomy laboratories. This may not, at first glance, seem like an encouraging result. However in previous years, the Physics laboratories had always been considered much poorer than their Astronomy counterparts. The fact that opinion is more divided, therefore, suggests that progress is being made.

When compared to Chemistry, though, Physics did not fare so well. Over three quarters of students taking both courses felt that the Chemistry laboratories were better than the Physics ones. When asked to give more details on why the Chemistry laboratories were viewed more highly, the responses fell broadly into two categories. Either students felt that the Chemistry laboratories were less rushed/better organised, or they felt that they were easier. The former problem is not too surprising since this was the first year which the new Physics laboratory structure was being used, and this inevitably meant occasional mistakes cropped up. The latter problem is what might be called a 'classic' – students will often prefer courses which appear, to them at least, to be easier.

Conclusions and future work

Discussions with undergraduate students in the Physics and Astronomy Department had highlighted a growing dissatisfaction with the practical side of the teaching of the course. Students felt it was disconnected from the taught work and of little purpose. A subsequent survey of level one students past and present provided guidance on what the students were looking for. This enabled a renovation of the practical class to better meet the expectations of the students, whilst retaining the educational merit desired by those teaching the course. Lengthy experiments were removed and more focussed experimental tutorials brought in. These directly linked the taught course work with the laboratory class, drawing out key aspects of the course to further strengthen the students' learning.

Student reaction to these changes has been broadly favourable and the initial aims of the renovations have been met:

- *to create direct illustration of lecture material* – each experimental tutorial specifically tied into an aspect(s) of preceding lectures.
- *to encourage more free-thinking on the parts of the students* – students had to work out what to do with data, which equations to use and so on.
- *to bring in more research-style methodology* – many of the experiments used modern data acquisition computer packages to analyse results efficiently.
- *to create a faster paced working environment* – students undertook two experiments per three-hour session instead of one over five hours. This reduced time forced students to concentrate on the tasks set them and kept them working.

- *to replace outmoded equipment* – a wide range of new equipment was purchased, including PC-based data acquisition systems and digital oscilloscopes.

The introduction of these experimental tutorials was always intended as just the first stage of an on-going improvement in the practical teaching. As well as further adapting these tutorials in light of the experiences running them, more renovations will be needed to insure that the students' experience continues to improve as they progress into the second semester of level one and then into higher years of the degree course. Already the semester two level one labs have been altered to somewhat match the experimental tutorial structure. In place of three, five-hour experiments, students attempt six, three-hour experimental tutorials. These experiments will focus more on developing laboratory skills than on following up lecture material as these are important skills for the students to develop. There will also be a greater emphasis on error analysis and on writing scientific reports. The aim is that by the end of the full year the students will have well-rounded, high quality skills in a wide range of practical Physics.

The overall intention of these renovations was to improve the level one practical Physics teaching. This improvement had to not only be from an academic's point of view, but also apparent to the students. The information presented here shows that this overall intention was successfully achieved. What is particularly encouraging is that the students' views of the laboratory are positive despite the fact that more is now expected of them. There is often a view that 'better = less work'; the results here suggest that if the correct changes are made, this is not necessarily the case.

[O6] The Oxford integrated laboratory course in chemistry

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Introduction

The chemistry undergraduate degree program at Oxford is well regarded internationally, academically challenging, and seen as an attractive option by large numbers of students, yet in some respects, particularly in the syllabus that it follows, it could be considered too traditional in nature. Nowhere is this more evident than in the practical course, in which the emphasis is largely on illustrating the principles of chemistry and its logical foundations. This concentration on core chemistry is a reflection of a correlation of the practical course with lectures, but such a linkage carries with it the danger that other more modern – and perhaps more exciting – aspects of experimental chemistry might be sidelined or shunted out of the course altogether.

The entire undergraduate chemistry course at Oxford is currently under review and we have taken the opportunity to commit to a radical change in direction in experimental chemistry, whilst maintaining the emphasis on an academically challenging syllabus. This paper and the associated talk outline our plans to completely restructure and revitalize the practical course. We discuss the limitations of the current course and sketch out the directions in which we wish to take the new course. There are cogent reasons why a new approach to practical chemistry is worth considering; this paper outlines the approach we are taking and the challenges any new course faces.

Limitations of the current practical course

The undergraduate practical course at Oxford is fragmented, both physically and academically. It is housed in six separate laboratories, which are divided among three buildings, together with a dedicated computing laboratory housed in a fourth building. The laboratories themselves vary in the degree to which they are suited to undergraduate work, and their physical separation effectively prevents interaction between the different parts of the course, for example ruling out experiments in which students synthesize a sample in one laboratory and analyze it in another.

In a seven million pound refurbishment program now underway, Oxford University is relocating these six laboratories into one large area in a separate building, currently occupied by another science department. The new space will be flexibly divided into several contiguous laboratories, all of which will have ready access to separate dedicated computing and instrument areas.

In designing the physical layout of this new area, and taking into account the current review of chemistry, we have considered whether it is best to retain the present traditional division of the course along inorganic, organic and physical (IOP) lines, or whether alternatives are worth exploring, since a move away from an IOP course would have implications for the design of the refurbished laboratory space. Any reorganization of the practical course must take account of the review of the lecture course, which is likely to largely remove the main IOP boundaries. We have therefore decided to mirror the anticipated changes in the lecture course, and develop a highly integrated experimental course in which the IOP boundaries will be blurred, or even completely removed.

Why change?

The common model for the chemistry degree in western Universities, both in lecture courses and practical work, is to divide topics into discrete IOP segments. This is the model that has been in place for many years at Oxford. However, widespread adoption does not indicate that this is the only possible model; indeed, this approach suffers from a number of disadvantages.

A practical course divided along IOP lines does little to demonstrate to students the interdisciplinary nature of science. The boundaries between scientific disciplines are increasingly fuzzy and the most fertile areas of scientific research often lie at these boundaries. It is academically valuable to reflect this in the practical course and in addition students often find experiments that lie just outside the mainstream areas of chemistry particularly intriguing. Lecture courses in many Universities now implicitly recognize that the barriers between different areas of chemistry are to some degree artificial. If the role of the practical course is to illustrate and amplify lecture material, dissolving barriers in the lecture course should prompt similar action in the practical course.

Science education is expensive, so we are hoping that an integrated course will also be more cost-effective. Different courses use similar equipment; the same spectrometer that is used to assess the quality of organic products could also play a part in the analytical or physical chemistry courses, but at present, our division of experimental work across multiple sites means that sharing of equipment is difficult to timetable and there is pressure on courses to meet their own needs by duplicating equipment held in other laboratories. By bringing the teaching of five hundred students into a single laboratory complex, sharing of equipment is far more straightforward.

Finally, and perhaps most importantly, student motivation is a key factor in the redesign. Increasing both the variety in the course and introducing a more open-ended approach to experimental work will provide students with a sense of investigative freedom. We believe this will vividly contrast with the disinterested attitude that students may have when they are required to repeat experiments whose outcome is known or can be predicted before the experiment even begins.

What are the plans?

The planning process for the new practical course has the following goals:

1. *Bring together the labs physically so that sharing of equipment is simple and routine.*

2. *Divide the course into theme-based segments such as synthesis and experimental methods rather than topic areas such as organic and physical.*

3. *Create an introductory course to run alongside the lecture course in the first half-term of the first year*. In the first year lecture course, early lectures will focus on

chemical principles and will help to bridge the knowledge gap between school and University. The new practical course will have the same goals and will illustrate and reinforce this lecture course, simultaneously filling in some of the practical skills gaps remaining from A-level.

4. *Offer realistic opportunities for every student to engage in open-ended project work, as a taster for the year of research to come in the fourth year*. Students spend the entire fourth year at Oxford as a member of a research group. Many groups work on cross-disciplinary topics and we wish to give students a taster of the types of work they will be able to engage in during that final year.

5. *Integrate experimental chemistry with computer methods*. Although Oxford has particular strengths in computational chemistry, students commonly view computer methods as a subject set apart from the rest of the practical course. The deep integration of computers into chemistry at the research level is not necessarily apparent to undergraduates, so we aim to thoroughly integrate computer use into the practical course. The key here will be to encourage the perception of computers as tools, like spectrometers or rotary evaporators, to be regarded as objects that slot naturally into practical work whenever they might be of value. Instructions for experiments will of course be available to students online, together with safety information, details of experimental technique, video clips and similar material, but we aim to embed computers much more thoroughly. For example, experiments in photoelectron spectroscopy probe molecular orbital energies directly; we would expect students to follow experimental work with an investigation of computational MO methods without being specifically required to do so, in fact without this option even being suggested in the experiment instructions. Column chromatography is well suited to illustration through computer simulation, but a deeper understanding of the process can be gained through computer investigations into solids, surfaces, adsorption, the structures of zeolites and resins. We aim to develop an expectation amongst students that this sort of computational investigation is the natural way to proceed, not something that is done because the instructions for the experiment require it.

What has been done so far?

An informal survey some years ago confirmed that substantial overlap exists between the practical courses in different UK universities, an observation that will surprise few chemistry faculty. That experiments on the gas phase infrared spectrum of hydrogen chloride, or the visible spectrum of iodine vapour, appear in many courses reflects a collective judgment of those in charge on the value of such experiments. As we have concluded that an integrated course is an attractive option, we were hopeful that some universities would already have integrated courses in operation.

The reality is very different. Three Oxford summer students contacted chemistry departments in universities in the USA, Canada, the UK, Europe, Australia and elsewhere, gathering information on course content and approach. Many universities commented how attractive they felt the integrated approach to be and would be interested in the final outcome, but few had much to offer. We are therefore starting with the aim not of modifying what is already in operation at other Universities, but with the development of a fresh course essentially from scratch, while taking advantage of the experiences of others where possible.

Implementation

The final course will be some two years in construction, but its elements are becoming clear:

1. 1st year introductory course. The first part of the Introductory practical course will be closely linked to the lecture course which provides an integrated view of the chemistry to come. There will be no division into IOP sections in either lectures or laboratories, and there will be substantial use of group teaching in practical work with pre-labs and post-labs

2. The remainder of the 1st year practical course will focus on experimental techniques, particularly in areas such as vacuum methods or error analysis which are widely applicable. The reduction in the quantity of practical work at A-level has created difficulties for University chemistry departments; students now arrive at university less well prepared, so we feel that a course in techniques is an appropriate first step in the main section of the practical course. It is a little ambitious to consider project work at this stage, but we nevertheless are planning to include open-ended experiments, since one of our key aims is to encourage students to think in a scientific and enquiring fashion. For example, in the first year experiment on errors students will at times not be told what measurements to take, how to take them, or what the errors might be due to.

These techniques experiments will cover experimental error and the preparation of solutions and standards, vacuum methods, the principles of optics, separation methods and other topics. Though illustrated with examples from specific parts of chemistry, these will be taught as applications of chemistry, rather than the means to purify an organic sample, or carry out a specific vacuum-line synthesis. Even at this early stage there will be a focus on group work, on experiment design, and on exercises that depart substantially from traditional recipe-type experiments.

3. The 2nd year course will combine more advanced techniques with experiments that cross traditional boundaries. Experiments that focus on one area of chemistry will not be banned – it would be unproductive to ignore experiments such as the gas phase high resolution IR spectrum of small molecules just because such an experiment is clearly physical chemistry - but these will be included only where they can justify their inclusion in an integrated course.

4. The 3rd year course will consist of a mix of pre-planned experiments, and a range of projects.

5. Computing will be integrated into the course from the earliest stage, not just by providing students with ready access to computing facilities, but by encouraging them to regard computing as an essential part of practical chemistry.

The advantages

We would not be planning such a course without having been persuaded that the advantages that it can offer are worth the time and effort (and finance) required for development. These advantages include:

1. Providing students with a clear view of chemistry as a single coherent subject rather than as discrete areas.

2. Linking the practical experience of students more securely into the integrated lecture course.

3. Providing more opportunity for project work by encouraging students to widen their sights when devising experiments and giving them early experience working on open-ended experiments.

4. Using instrumentation more effectively by making all major items of equipment available to all parts of the course.

5. Extending the variety and depth of techniques experiments.

6. Fully integrating computer methods into the practical course.

7. Simplifying the addition of experiments in areas such as biochemistry which might fit only with difficulty in a traditional IOP course.

8. Developing experiments that may be of interest to students in related disciplines, such as physics or biochemistry, so facilities and expertise can be shared with other departments.

The Disadvantages

In setting out to develop this course we recognized that there might also be disadvantages in the new arrangements. Some problems doubtless will become apparent only when the course is fully operational; some, however, we can already foresee:

1. Experiments that cross the traditional IOP boundaries may not always fit neatly into a practical course, and those that involve links to areas such as physics or material sciences, though they may be of special interest, may require that students understand areas of science that have been covered only briefly in lectures.

2. Our plan is that the finished course will comprise a large pool of experiments. Even before this stage is reached, laboratory demonstrators will need a knowledge of a greater range of techniques, since they may be required to be familiar with methods well outside their field of research expertise. A greater degree of demonstrator training will therefore be required.

3. Our research suggests that the number of experiments currently available at other universities which might be included in an integrated course is surprisingly small. Hence a considerable amount of development work is required.

4. Devising new integrated experiments from scratch is in general more challenging than devising an experiment in a single area, since it may require input from, and collaboration among, several people.

Spreading the word

We hope that the developments underway at Oxford will be of widespread interest to those running chemistry programs elsewhere. We are enthusiastic about integration to form a single, coherent, unified course and believe that the course will, in time, form a valuable resource for the wider academic community. We intend to make available the outcomes of the work in a variety of ways.

We expect to develop, and publish, a number of new integrated experiments. All of the course material will be on the web, and we expect that most of this will be freely available outside Oxford. Some experiments may be located in other departments and run remotely; we expect in due course to develop links with other Universities to enable sharing of this type of experiment. We already have a substantial database of safety data for undergraduate use and will develop this further. When not required for the undergraduate course, the new facilities will be used to host summer students and to enthuse school students about chemistry, an initiative from which we hope all University chemistry departments will eventually benefit.

Perhaps most significantly, we hope to change student perceptions that the practical course is often the dullest part of a chemistry degree course. We would like students to come to regard the practical course as one of the highlights of their degree, mirroring the enthusiasm that they already feel for their final year projects. Much needs to be done, but we believe an integrated course offers a promising way to combine academic excellence with entertaining science.

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[O7] To assess or not to assess: what's in a question?

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Keywords: e-assessment, feedback, adaptive assessment, synthesised tutoring

Abstract

That modern students are over-assessed is not really in doubt so why, then, are people like myself working hard at apparently introducing more assessment in the guise of e-assessment. The answer lies partly in nomenclature - can any learning be achieved without questions being asked? - and partly in intent - are we asking questions to show how clever we are, to find out how little the students know, to provide a portfolio of achievement, or to provoke the students into thinking about their subject? This paper will explore two of the ways in which, so called, e-assessment techniques can be applied to improve students' learning experiences without adding to the assessment burden.

In the sciences we want our students to be able to apply themselves to problems that require several steps to get from question to solution. This type of problem can be very time consuming and demoralising for those students who cannot 'see' the whole solution, and who, therefore, do not know what it is that they need to know to be able to solve it. One approach to overcoming this problem is to give students practice at a variety of such problems within an environment that will guide them if they need it. One such environment is a tutorial, but these are expensive. Another such environment can be created electronically, and is described in this paper. Items are expensive to develop but the costs can be ameliorated by collaboration, so that each item is used by many students.

One feature of electronic assessment systems that is probably not used to best effect is the immediacy of the feedback that is possible. The design, application and implementation of this immediate feedback to best support learners and their learning will also be discussed.

Introduction

The work patterns of science students have undergone considerable change over the last few decades, with an ever increasing accent on the assessment of components of courses rather than of the whole course. One consequence is the reduction in use of the relatively benign coursework assignments that used to be an integral part of courses, providing opportunity for consolidation of new material acquired in lectures and its assimilation into the framework of the subject. Students' difficulties with such coursework could be handled in tutorials or problem classes, where feedback could be provided at the time it was needed, i.e. when the problem was being addressed.

With the increased pressures on academic staff time and the decrease in use of such coursework, the opportunities for students to receive timely feedback on misconceptions and misunderstandings are becoming fewer. When feedback on submitted coursework is provided, it is usually after a significant delay, and is thus of considerably reduced value to the student. To be of maximum use, constructive feedback needs to be immediate, and the student needs to be in an environment in which they are encouraged to use the feedback immediately to update their concepts and to apply them, probably in the solution to the problem that revealed the misconception.

One way of resurrecting this sort of environment is to use carefully designed questions that provide graded and constructive feedback, and then to present these to students in an electronic assessment system that provides opportunities for the students to apply the feedback immediately, either by re-trying the original question or by moving to the next step in the development of a more complex problem. The technology to create such learning aides has been available for some years, but the investment in academic time to develop such resources can be very large. There are two areas of recent development, however, that can help spread the cost of such work. One is the development of new international standards for the interchange of electronic questions between assessment systems. The other is the development of software tools for the development of such learning materials through the use of assessment systems.

In the past, tutoring systems were based around presentation systems that were able to ask simple questions. What is needed in the sciences is the ability to ask more sophisticated questions and to have more sophisticated analytical tools for the responses. New systems being developed are able to support such features, and there is promise that in the near future there will be a variety of such systems on which the materials will be able to be implemented with little change.

Enabling developments

There have been a number of developments over the last few years that have improved the prospects of new uses of assessment systems along the lines described in this paper.

New specifications have been developed for the interoperability of learning materials (or Learning Objects) between various presentation systems. These include aspects such as accessibility issues, the metadata used to describe the materials and therefore the means of searching, content management, learner information, questions and tests. This last specification, for questions and tests, is now in its second version, and has already provided a stimulus for a number of commercial systems to support the export and import of questions and assessments in a common format. Interestingly, it has had the effect of provoking some academic developments that have been direct implementations of the specification. The specification, or course, had to be sufficiently flexible to allow most of the commercial systems' question types to be represented. The academic systems, however, tend not only to match the flexibility of the specification so that they are able to render the exported questions, but are also relatively easy to extend to support new features.

The two examples below are both based upon such an assessment system that has been extended beyond the provisions of the Question Test Interoperability (QTI) specification that it implemented, which was QTI version 1.2. This specification has, however, has been superseded by a new version (QTI v2.1) that in fact supports some of the new features described, so that much of the functionality necessary to achieve the sort of learning resources being described here will be accessible as new assessment systems based upon the most recent specification become available.

The new version of the Question Test Interoperability specification provides the means for the randomisation of numeric and textual values, for creating adaptive questions that change according to the users' responses, and for retrieving values from user responses and using them to create alternative answers for later parts of a question (error propagation). These offer exciting opportunities for the development of a new class of interactive materials that create dynamic learning opportunities for students. These materials may also come to provide a means of low profile assessment of individual student progress that more closely matches that of the subjective assessment of each student carried out by a tutor during a tutorial.

There is no doubt that the development of these sorts of materials is a demanding and time consuming task, and only justified on a large scale if the resulting materials can be used widely. The interoperability specifications are, of course, of crucial importance here because the task is too large for individual departments, and collaboration between departments depends upon the ability to move the materials into the local assessment system without re-implementation. It also provides the means to retain the same materials during the evolution of assessment systems within a department.

Another maturing technology that is important to this materials-sharing scenario is the electronic repository or item bank, where these assessment items can be shared between the contributing sites. The searching of item banks requires consistent and high quality metadata, and if the items are to be shared in more than one repository then the metadata must also comply with a suitable specification, of which a number exist. Each item within an item bank can require more than one file, of course (e.g. a question file and an image), and so there is another specification dealing with the aggregation of these files into one container (called packaging, with the container being a .zip file). These specifications (learning object metadata, packaging, QTI) are all fairly recent, being developed internationally with contributions from UK HE via the JISC CETIS activity.

Example 1 - problem tutor

This resource is aimed at the type of numerical problem in which a student is given data from which a final answer must be obtained by selecting, possibly deriving, and applying appropriate formulae. This sort of problem occurs frequently in scientists' professional life, and they make good exercises for students. The selection of the appropriate formulae helps remind the student of the meaning and significance of the terms and what they represent, and the merging of different formulae into a desired form for a particular problem can help resolve misconceptions about the concepts to which they relate.

When a new topic has been introduced, it is conventional to show students one or two examples of such problems being solved before giving them their own to solve. In some cases students need tutorial or peer help to enable them to understand the concepts sufficiently to solve such a new problem at all. An adaptive assessment system can be used to synthesise a tutor's contribution to this learning activity. The problem needs to be broken down into steps, and then at each step a number of options given to the user - some appropriate and some inappropriate. The inappropriate options should be good 'distracters', i.e. should not be able to be logically deduced as 'wrong' without understanding the problem, and should include popular misconceptions so that users can be disabused of these.

Another task for the author is to decide how far to follow options that are not 'wrong' but merely 'inappropriate' or just 'inefficient'. If two vector forces are to be combined, for example, the student might be offered the options of taking moments or resolving the forces into components. Whilst the preferred method is to resolve the forces into components, taking moments (with care) turns out to be equivalent. The decision that has to be made by the author is whether to just explain that it is equivalent, to demonstrate that it is equivalent, or to provide the additional materials to let the student work through the alternative method and find out for themselves. This latter approach can lead to confusion if the alternative method is much more complex than the preferred method.

Example 2 - rich feedback

The tutoring scheme described above can be very useful in helping students develop their approach to problems, and in giving them confidence in their ability to solve them. The nature of the tutor is such, however, that a student will always eventually be able to solve each problem, even if they take a lot of false turnings in doing so. There is therefore a requirement for assessments in which the student has to solve the whole problem without help, and then submit an answer for marking.

A dissatisfaction that the students have expressed with such assessments is that having solved a problem, worked out and entered an answer (or whatever action is required for the user to indicate the answer) that the impersonality of the lack of immediate feedback about the correctness or otherwise of the answer is somehow more distressing than simply handing in the equivalent answer on paper. From the tutor's perspective, of course, feedback at the submission stage is inappropriate for non-invigilated coursework assessments where students may be working together. This leads to a situation where students spend far too long worrying about whether a particular answer is correct or not before submitting. They also dislike the inability to submit textual working, and what they therefore see as the all-or-nothing marking used. Students prefer to be able to submit working along with a final answer, knowing that they will get marks for correct working, even if the final answer is incorrect.

The submission and marking of such working by an electronic assessment systems is a difficult problem, even the automated marking of essay-type free text entry questions is not yet routinely available. Trying to understand the rationale behind an incorrect argument based on symbolic and numeric expressions is sometimes beyond the ability of the tutor, let alone an e-assessment system. This problem would become much simpler, of course, if a structure was introduced into each problem, but that would preclude the testing of the very skill that the students are being required to develop.

In an attempt to improve this situation, three numerical questions within an assessment involving several question types were modified to allow more than one attempt each. The numerical questions were selected for this use because the numerical values were randomised so that each student (probably) received a different version of the question. Therefore, giving feedback about a result would not directly help a second student without their understanding how the first student had undertaken the problem. The scheme allowed up to four tries at each question with reduced marks available for each subsequent try, and with more detailed hints being provided at each stage. This information was given to the student in an introduction to the whole assessment, and in an explanatory paragraph in the feedback when each further try was about to be given. The assessment system being used (the SToMP system) supplies feedback as each question is submitted (as opposed to at the end of the whole assessment).

Two advantages were anticipated, 1) the submission of the answer would no longer be seen as such a final action, and 2) the feedback could be applied to the problem immediately, whilst the problem was still fresh in the mind of the user.

It is clearly important that the feedback given to the student should be as pertinent to their error as possible, and not just a generic description of how to solve the problem. The feedback needs to be based as closely as possible upon the evidence the student has supplied in their response, and therefore a number of new test schemes were implemented.

- The user's response was checked against alternative answers based upon popular errors for each problem. For example, where the probability of the success of a trial was to be calculated, the probability of failure (its complement) was checked.

- The user's response was checked to see if it was in error by a simple power of ten. This can be the result of a scaling error in putting the final value into the required units.

- Where the final value was calculated from one or more summative terms involving values to be scaled, then a scheme was devised where errors in these scalings could be detected.

- Users were additionally invited to enter a numerical expression involving the original values given in the question, scaling values and physical constants. If the nature of any error in the final value could not be determined, then this expression was analysed for

    - its value (compared to the entered value)

    - the presence of the original question values

    - the use of the original question values and other constants in the required form (e.g. A = B / C)

Each of the three numerical questions remodelled in this way ended up with ten or more recognisable ways of getting the answer wrong, and during the ensuing trial of the system with 36 students there were a total of 177 attempts at these questions, with only 33 responses not being recognised by one the above schemes.

Outcomes

The problem tutor has the capability of recording all student actions and the time at which they were taken. This produces a large amount of data that, for any one tutored problem, is interesting but of limited use. For example, the rate at which a student progresses successfully through the problem can be deduced, but this merely shows that one student's working habits are different from another's. Parameters such as the ratio of correct to incorrect (inappropriate, etc.) responses, the rate of responding, the number of alternative answers chosen per unit time (can indicate guessing) and others can be extracted easily, but comparisons between students reveals little that was not already known. The real use of this information, it is conjectured, would be to log the change in some of these parameters for the same student with similar examples over an extended time scale. This information is not yet available, but could perhaps be used to create metrics of a student's academic progress.

The problem tutor has been used with a short pre and post exposure on-line questionnaire that was last year improved by the addition of a comment facility. The comments obtained so far have all been positive, one such being:

> 'This system is very, very good. I think I really enjoy in the process of learning the stuff that I thought it was quite boring, when I was using the computer based tutoring system. I hope we can use it as often as possible!!!'

The aim of the 'multiple-try with improved specificity of feedback' scheme was to turn what was purely an assessment into a learning experience. In its original form, in 2003, the most difficult of the three questions involved had 2/38 users get full marks, 9/38 obtained a reduced mark (e.g. an inaccurate value) and the rest got no marks at all. In 2004 students were invited to enter an expression, but it was only evaluated rather than analysed. In practice no student gained from entering the expression and in fact only one student obtained any mark at all. The system described above was implemented for the 2005 cohort of 25 students. For this question 21 were offered more than one try and of these, nine got it right on the second try, two on the third try and one on the last try. Only three students failed to get any mark.

In the comments of the survey of this assessment, instead of 89% of students disliking the lack of marks for working (as in 2003), only 19% cited this but 30% made some positive comment about the expression entry and multiple try scheme. With this clear recognition of the change by students, and the difference in the number of students being able to complete the question, it is difficult to avoid the conclusion that some learning had taken place, and that the resulting mark was a better indication of each student's understanding and ability for this question than in previous years.

[O8] Learning via online mechanics tests: update and extension

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Keywords: objective questions, mechanics, error taxonomy, evaluation

Abstract

This paper describes the use and extension of online mechanics tests written as part of the PPLATO (2005) project and described at the last S.L.T.C. by Gill and Greenhow (2005). By using random parameters within questions, millions of question realisations will be seen by students, each with fully-worked feedback, including run-time-generated diagrams if required. An implication of the randomisation is that students' answers (numbers or choices) recorded in the answer files need to have associated metadata that tags their meaning. This meaning requires an overarching *taxonomy of errors* to identify the class of error being made by the student (procedural, conceptual etc). We will describe the specification of this taxonomy and the relative frequency of errors being made by the last five years mechanics classes. We show how this data can be used to inform edits and updates of the questions by enhancing the (hidden or displayed) distracters using evidence-based *mal-rules* as well as those arising from *break points* in the question's solution. In turn, this informs the contents of the feedback so that we are able to suggest *where* the student went wrong, rather than just that they were wrong.

We report on a continuation of our FAST (2005) experiment designed to study the efficacy of the feedback. The use of *indicators* in subsequent exam scripts supports the view that students' retention period of the techniques given in the feedback and their ability to answer unseen exam questions correctly is linked to their engagement with and performance on (generally repeated) tests.

Background

The Mathletics system currently comprises some 1600 *question styles* (see below) that exploit the use of random parameters within highly-structured questions that test the mathematical and statistical skills of GCSE students to second level undergraduates. In particular A-level content in algebra and calculus (C1-C4 modules), statistics (S1) and mechanics (M1 and some of M2) is now quite mature and in heavy use at Brunel University with our Foundations of IT and first-year mathematics students. Although based on A-level syllabuses, the material overlaps significantly with that taught at university in a range of disciplines that require mechanics (e.g. engineering, physics, sports science). That some Brunel students find this material difficult is almost certainly due to the changes in the A-level curricula, whereby they have had less exposure to the application of mathematics, rarely going beyond the M1 syllabus, and often not even that, preferring to take their two applications modules form statistics and/or decision mathematics. The inexorable slide in numbers taking A-level physics has further compounded this situation. We believe this situation is not unique to Brunel University, but commonplace across most of the HE sector. We are left with a significant need to diagnose and cover elementary material again during the first half of a typical level one undergraduate mechanics module, before progressing to more advanced material. We present evidence that the Mathletics question database, used for formative assessment with rich feedback, is very helpful in this task. Our experience over the last 5 years of trials with many hundreds of students indicates that they value the extensive feedback as a learning resource, as well as for the marks awarded. Thus student engagement and time-on-task is generally assured, which builds confidence, having a beneficial effect on other learning tasks within the module. The pedagogy of building tests into a module is quite well established, and various trials of the mechanics material (described and updated below) have indicated that students move, at least partially, to a deeper approach to study (Gill and Greenhow, 2005).

The underpinning technology, whereby many thousands or millions of question *realisations* are generated by a single question *style* that encodes the algebraic and pedagogic structure of the question, is extremely helpful in moving students away from simple memorisation towards understanding the question's content and solution. The random parameters, possibly constrained according to the question's content (realism of the question and reverse engineering from a desirable solution form), are carried through to all parts of the question so that it realises with:

- dynamic MathML, giving equations in the question and in the (often extensive) solution and other content given as feedback.

- dynamic SVG, giving accurate diagrams, charts and graphs.

- dynamic wording, giving different scenarios, expressed in gender- and ethnically-balanced language.

- dynamic question functionality, such as algorithms that, when run to completion, generate, for example, HTML tables of variable length.

Other technical issues, described in Ellis *et al* (2005), include:

- Accessibility. This has been a key feature of all elements of the questions. Student preferences are stored and used to resize/recolour all text, equations, diagrams and tables.

- Functions. A great deal of technical effort has also gone into the writing of functions to underpin the questions. These split into two basic types: functions that return the result of a calculation and functions that return display strings e.g. a MathML string to display a curl in determinant form or an SVG string to display a force diagram or a speed/time graph.

- Exportability. All of the above generic issues concerning the display of mathematical content on a web page may be exported to other web-based CAA or CAL systems.

A taxonomy of errors

Whilst the overwhelming utility of using random parameters within questions is clear, there are a number of consequences for question design. We elaborate here on how (displayed or hidden) distracters within questions can be attributed sensible metadata to be recorded in the answer files. Our approach to the design of distracters is based on the belief that

Error Type	Classification
Generic errors that may occur in most/all areas of mathematics	
Assumption	Students assume certain things that are not true, for example, in projectile questions, that vertical velocity is equal to initial velocity.
Calculation	Method correct but calculation errors are made.
Copying Errors	Copying values incorrectly.
Definition	Not knowing the definition of terms given in question text, e.g. magnitude.
Formulas	Incorrectly stating/recalling formulas.
Incorrect Values Used	Using incorrect values in method, for example, when substituting values into formulas.
Knowledge	Knowledge students are lacking that would enable them to answer questions.
Methodology	Students attempt to use an incorrect method to answer a question.
Modelling	Generic definition, e.g. ignoring forces acting on particles for example, gravity.
Procedural	Method student attempts to use is correct but can only do initial/certain stages of the method. They stop halfway through when they do not know the stages that follow or when they are unable to interpret initial results.
Reading	Reading the question text incorrectly and confusing the value of variables.
Trigonometry errors	Basic definitions of cosine, sine and tan incorrect. This is most apparent in questions where students are required to resolve forces.
Resolving Forces	Resolving forces incorrectly (specific to mechanics)

Table 1: List of errors and their categorisation

most wrong answers (from students who are trying rather than guessing just to study the resulting feedback) in either CAA or paper-based tests are not arbitrary, but result from logically-structured but incorrect methods of solution. We have therefore spent much time identifying such *mal-rules* from past examination scripts and encoding them in questions. Mathletics then is able to recognise selected answers/input numbers thereby offering students targeted feedback that tells the student not just that they are wrong, but *why*.

This is, of course, very beneficial for the student; for staff, the answer files need to record metadata for student choices (outcomes) that reflect more generally and usefully how students are making errors. For example, the three-parameter question style with descriptor ‘ax+b when x = c’ might realise as ‘What is the value of -5x-6 when x = -2?’. Recording an answer of -16 is less useful that recording how that answer might arise; the outcome metadata must therefore somehow encode the information that the student

Error Type \ Topic	Vectors	Kinematics	Dynamics	Statics	Overall Weighted Mean
	Weighted Mean				
Calculation	2.86%			3.62%	**2.203%**
Copying	0.58%	1.27%		0.27%	**0.365%**
Formula	5.18%			0.73%	**1.861%**
Incorrect Value	0.29%			1.67%	**0.699%**
Knowledge	6.32%	16.50%	2.03%	14.11%	**8.764%**
Methodology	1.13%		6.53%	2.20%	**2.836%**
Modelling			0.34%	0.73%	**0.353%**
Procedural	1.46%	12.65%	6.22%	7.24%	**5.578%**
Reading				0.23%	**0.084%**
Trigonometry			2.75%		**0.709%**
Correct	70.73%	63.18%	42.60%	49.81%	**55.210%**
Unable to Answer	11.44%	6.38%	39.50%	19.38%	**21.210%**

Table 2: Table showing the weighted mean for each error type that occurred across the four subtopics and the overall weighted mean for errors that occurred at level one

cannot handle double negatives. The same outcome metadata might pertain to other questions too, meaning that the student genuinely doesn't understand, rather than that (s)he simply made a slip (also serious!). For simple algebra, strictly formulaic mal-rules appear to be useful; for the mechanics questions described here, value judgements need to be made, especially on what can be assumed about the student's elementary algebra and calculus skills that are needed as small parts of a larger calculation. This means that a more abstract categorisation of error type is needed in order to understand individual students' or whole-cohort profiles, as given in **table 1**. These error types arose naturally from the analysis of five years' worth of examination scripts (126 in total) and are used to:

- summarise the relative frequency of errors in the four main mechanics areas for which CAA questions were set and run, see **table 2**.

- design those questions, especially the mal-rules and their associated metadata, see **figure 1**.

Efficacy of feedback

Anecdotal and questionnaire evidence strongly indicates that students engaged with, and even enjoyed, a programme of structured and staffed lab sessions during the 2004/05 and 2005/06 academic years. Although these sessions did not count towards the overall module mark, they were explicitly built-in to the module timetable and highlighted by the lecturer. It is natural to ask how one might measure the learning effects of the feedback, for how long do such effects last and are they applied out of context, even in other unrelated modules? To attempt to answer the first two questions, we looked at (rather mundane but easily identifiable) *indicators* in their lab workings and, as shown in **figure 2**, their end-of-module exam scripts. The indicators reflect features of the feedback and we seek to see if students mimic them by: using properly-constructed diagrams (early) in their solutions; laying out their methodology in a clear way; quoting units in their final answers; underlining vectors. **Figure 2** shows a clear increase in the use of diagrams in the period

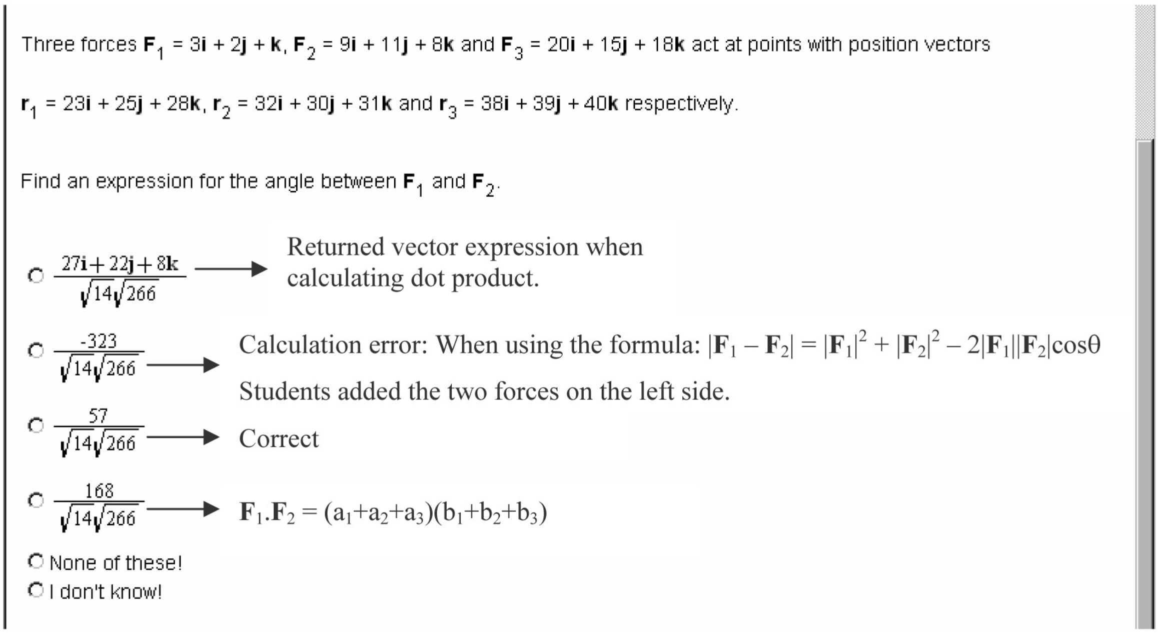

Figure 1: A typical multi-choice question. The encoded mal-rules (in blue) arise from the analysis of break points in students' working (i.e. points where students' working commonly goes wrong) and their metadata is recorded according to the error categories of **table 1**

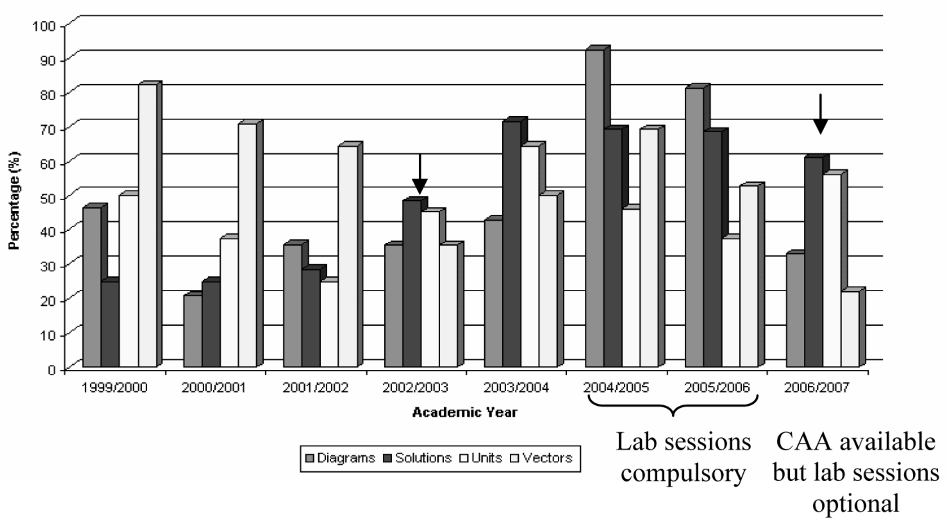

Figure 2: Indicators showing the effect of CAA on students' behaviour in subsequent exams. Vertical arrows indicate a new lecturer taught the module

of ‘compulsory’ CAA, some improvement in solution layout and identification of vectors, but students still seem impervious to efforts to get them to use units. What is new to this figure compared with Gill and Greenhow (2005), is this years’ worth of data (exams took place in January 2007). **Figure 2** reflects the fact that very few students tried the (now optional) CAA tests, none significantly, which means that CAA of this type needs to be built-in (possibly for marks) rather than added-on to an already busy timetable. The results, however, do act as a benchmark of the existing situation, see the remarks in the introduction, and suggest that the use of compulsory use of CAA for two years buoyed up the slowly-sinking performance of the student cohort.

Conclusions

The design of objective questions for mechanics problems that typically require 5-10 lines of equations, is facilitated by understanding content-specific mal-rules by which students make errors at break points within their solutions. It is possible to categorise these mal-rules by an overarching taxonomy of errors that may pervade mathematics and other related disciplines. We can then inform and understand what information is recorded in the answer files of any CAA system, especially if the questions fully utilise the potential of random parameters. The method has recently been extended to more advanced topics, such as vector calculus and examples will be presented at this conference.

Much of the effort involved in authoring is spent on writing extensive feedback screens. Students use these as a primary learning resource which they perceive to be of value. We extend the indicator-based evidence presented by Gill and Greenhow (2005) which suggests that students' competence with the mechanics subject material is enhanced, providing that they actually engage with the questions. In practice this may mean that a small percentage of marks needs to be awarded for the CAA tests.

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[O9] Culturally neutral assessment questions in science and engineering

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Keywords: assessment, language, vocabulary, cultural differences

Abstract

Assessment problems can arise in classes containing students from a variety of cultures with different experiences, attitudes and expectations of education, and often a very different range of relevant technical or social experiences. It is possible inadvertently to set assessment questions or tasks which require responses of a type which are unfamiliar or antipathetic to the student, which use vocabulary that is not understood in a sufficiently sophisticated way or which implicitly require a set of experiences or knowledge which not every student possesses. There is little literature on this topic relating to science or engineering students. In this paper several examples of culturally loaded questions are given and the suggestion is made that all science and engineering assessments should be scrutinised from the cultural perspective.

Introduction

> *'Some academics . . . write exams in which part of the challenge is to work out what the question means before answering it. Too often academics applaud this approach for being 'clever', claiming that assessment is to sort out the sheep from the goats, and understanding the question's true meaning is part of that. 'Nice one', their colleagues say, 'the clever ones will work it out'. But we do not include 'cleverness' among the intended learning outcomes. . . .'*

Phil Race, The Higher, December 23rd 2005.

We may not intend to write 'clever' exam questions but without sensitive scrutiny some difficult-to-decode questions may slip through the assessment process.

It is self-evident that all students are different. It is equally clear that, in the vast majority of cases, for every student in a cohort the assessment associated with that module is the same. This is usually true for both the method(s) of assessment and for what is assessed. If, as is now regarded as good practice, the assessment is intended to verify the achievement of the intended learning outcomes, then it seems obvious that it must be the same for every student. This is surely required to ensure equity of treatment among students and between groups of students, and to establish confidence in the evidence provided by the assessment outcome (e.g. exam mark).

On the other hand, there is plenty of evidence (both academic and derived from common sense), for the difficulty of devising assessments which are totally free from bias towards or against one or more groups of students. There is a substantial literature relating to unintentional bias in assessment. Researchers have identified the potential for bias arising from cultural differences, gender difference, disability and other factors (Baumgart and Halse, 1999; de Vita, 2002; Martin, 2003; McCullough, 2004).

Bias in the Engineering assessment

Let us define a 'neutral' assessment item (exam question or any other type of assessment) as one in which every student has an equal opportunity to demonstrate the extent to which they have met the intended learning outcome (ILO) which is being tested. The item must therefore relate to an ILO which has been published to the students in advance, and it must be phrased so that the way in which the ILO should be demonstrated is clear to the student at the time of the assessment. In less pompous words, the question should be clearly understandable and relate to the appropriate curricular content. This is easier to specify than to achieve.

There are a number of features of science and engineering education, at least in the UK, which either increase the difficulty of devising neutral assessment exercises or tend to disguise the presence of bias. Among these are:

- A high percentage of students for whom English is not their first language. This can be as high as 50% in many classes. In many UK universities the Engineering Faculty contains the highest proportion of overseas students in the university.

- Many classes contain students from several quite different cultural backgrounds. For these purposes there are significant cultural differences between students within Europe (Northern Europe vs Eastern Europe vs Mediterranean Europe for instance) as well as between the continents and sub-continents of Asia, America and Africa. Not least among the differences is the understanding of what an engineer is and does – the very word has no universality of meaning. This is less of a problem for a scientist.

- A significant content of practical work, in laboratories and on field trips.

- A large mathematical content, which can often mean that connected prose writing is not required in order to meet many of the ILOs, but on the other hand;

- A professional milieu which demands clear reporting, both written and spoken, and a proportion of professional (as opposed to technical) material such as project management and business skills.

- The high cost of provision of a good science or engineering education, because of the need for laboratory space, equipment, materials costs and high staffing levels to ensure safety and practical skills training.

The net effect of these factors on patterns of assessment is that the student will probably encounter items which are essentially numerical, mathematical, practical, oral and essay-based, but that no one of these forms dominates. These items will be attempted by students who have different English language skills, different understanding of 'graduateness' or 'engineering' and different expectations of higher education, for which they may be paying an apparently high price. It is therefore quite easy for biased items to be hidden within this welter of assessment styles.

Types of Bias

Level of ILO. In higher education we expect to be assessing ILOs at all six levels of Bloom's taxonomy – simply expressed as knowledge, comprehension, application, analysis, synthesis, evaluation (Bloom, 1956). However these are merely the levels of cognitive skills, based around knowledge. In a professional science or engineering education we also expect to develop (and therefore must test) the affective and psychomotor domains, that is attitudes and practical skills. We nowadays test practical skills less frequently than in the past, although our students are often exposed to practical experiences, and we almost never assess attitudes. As Elton (2003) rather resignedly reports 'The difficulty with designing attitude assessments is that in traditional forms of assessment, e.g. essays, it is almost impossible to distinguish a genuine attitude from a pretended report.' However, he offers no alternative!

In the domain of cognitive assessment, which is in practice where most science and engineering assessment items remain, the first two levels of Bloom's taxonomy present relative few problems (but not none – see below). We can assess knowledge (level 1) by demanding the recall of information and comprehension (level 2) by asking for an explanation in the student's own words. Even at this level we meet a cultural issue – it is deeply embedded in many (predominantly Eastern) cultures that there is no point in re-writing the words of a great master, because s/he has already expressed the ideas to perfection and it would be discourteous to paraphrase. Although many academics would have difficulty describing themselves as a great master, nonetheless this is how they may be viewed by some students. This issue can only be addressed by attempts to change attitudes prior to assessment, and is often tackled in the (unfortunately pejorative) context of plagiarism.

At level 3 and above (application, analysis, synthesis, evaluation) potential problems of bias abound. Words which might be used in assessment items could include analyze, categorize, compare, compose, contrast, create, criticize, critique, deconstruct, defend, demonstrate, design, devise, discriminate, distinguish, evaluate, generate, interpret, illustrate, justify, manipulate, modify, plan, predict, relate, reconstruct, relate and show. Each of these requires a sophisticated grasp of language as well as the required cognitive understanding. At levels 5 and 6 (synthesis and evaluation) a critical approach is essential and it would be impossible to demonstrate ILOs at these levels without using words and phrases which had come neither from lecturer nor book.

The above paragraphs have focused on 'answering the question'. This is predicated on the writing of a clear question, which has two elements – the use of a vocabulary which is understood and the use of contextual examples which can be interpreted on the basis of the student's prior experience. An extreme example illustrates this latter point. Many universities in South Africa are now teaching engineering to a cohort of students some of whom have grown up in townships without electricity. Following a course on materials selection it would not be helpful to base an assessment on the reverse engineering of a 13 amp plug (which is an example used in many UK universities).

More subtle examples can be found when teaching management or business studies to engineers. A module on Project Management at Liverpool is given to a large class drawn from every engineering discipline, computer studies and some pure sciences. To assess at level 3 (application of knowledge in a new situation) it is necessary to select a number of 'new situations' but to choose them in such a way that they are equally accessible to all the students. This rules out using excellent project scenarios based on dam-building (familiar to the Civil Engineers but to no-one else), or software engineering, or car manufacture, or banking or in fact almost anything! A level 3 question such as 'devise a work breakdown structure for (some familiar process)' is very difficult to write in a neutral manner. What process is familiar enough to all students? No industrial process, certainly. One cannot assume that every student has, and has taken apart, a car, or even a bicycle. The unfortunate result is that the remaining scenarios are mundane, unexciting and tend to lack complexity – which is the key aspect which makes a task worth undertaking as a project. Domestic scenarios like 'preparing a meal', as well as being seen as trivial, are in fact not universal. Quite a number of students have never prepared a meal from raw ingredients, as becomes evident on reading their answers.

Similar issues arise from a question designed to allow students to be creative in the context of a SWOT analysis. The obvious question is 'Analyse the Strengths, Weaknesses, Opportunities and Threats of the following proposition, and then make a recommendation whether it should be adopted.' It is very difficult to then identify a neutral proposition. Consider the proposition 'let us build a fourth tunnel under the River Mersey for the use of pedestrians and cyclists.' However, many Liverpool students, although aware of the existence of the road and rail tunnels, have never been through any of the existing tunnels and do not understand how they were and are funded, so a proper analysis is not available to all students. In an attempt to use only concepts known to everyone, I used the real proposition (reported in The Times) 'An advertising company should rent advertising space on students' foreheads.' This appears to be totally neutral: surely every student understands advertising and certainly every one has a forehead. However on reading 220 answers (some very imaginative) it became clear that a small minority (2 or 3%) of students did not understand the word 'forehead'. This was clearly a failure of general (not technical) vocabulary, but it arose from the most thoughtful and well-meaning intentions.

Vocabulary. The vocabulary available to students is worthy of separate consideration. There have been many studies of the vocabulary skills of school students; one of the most relevant is by Farrell and Ventura (1998), who looked at the technical and non-technical vocabularies available to 300 17 year old A-level physics students. These are the students from whom Science and Engineering undergraduates are drawn one or two years later. Farrell and Ventura measured both the claimed understanding and the actual understanding of 50 non-technical and 25 technical words, all taken from A-level exam papers. Their results revealed some astonishing disparities, even among non-technical words. 96% of the surveyed students claimed to understand 'transmitted' whereas only 30% could explain or define it. The equivalent results for 'qualitative' were 66 and 29%; for 'marked' they were 82 and 12% and for 'significant' 91 and 46%. The situation was similar for technical words. For example 'couple' scored 97 and 24%. The conclusion must be that we cannot assume that the vocabulary used in assessment items can be universally understood, even when questions are couched in 'ordinary' English. Particular misconceptions revealed by Farrell and Ventura included 'qualitative' meaning 'of fine quality' and 'yield point' defined as 'the amount given out'.

My own experiences recently revealed first year engineering students who did not understand 'opaque' or 'inflammable'. The vocabulary used in the last three years' exam papers on Project Management in Liverpool included the following words which were not defined in classes:

Assembly, auditor, balanced, batch, blizzard, chromium, client, construction industry, deadline, deliverable, finishing, functional, generalist, Human Resources Department, machining, morale, particulate, polishing, process, rapid prototyping, resource, revenue, review, sandwich, script, shooting (of film), stamping, standards, stock, trollies.

It is not clear whether all of these were understood by all students, although their inclusion was intended to give appropriate contextual colour to otherwise dry questions. One recent email from a student, just before the 2006 examination, gives a clear indication that this might be a problem:

> *‘dear professor:*
>
> *While i was reviewing the past exams papers ,i found i didn’t know the meaning of some words, which are not about the knowledge of this module but comes from the problem of my English level. Such as the ‘refurbishing your bathroom’, i lost the meaning of it. to be honestly, my English is not good enough.*
>
> *in these cases, what can i do? can i ask the monitor teachers in the room for explaination?*
>
> *I hope it won’t going to be considered cheatting or what’s your suggestion?’*

There are also cultural and contextual differences of meaning for identical words. This section of the paper started with a discussion of the vocabulary skills of ‘school students’. In a recent question it became clear that some students interpreted this to mean undergraduates at university, while others took the intended meaning of secondary school students. Farrell and Ventura (1998) give a similar example with the word ‘primary’. This is readily understood by A-level students in the context ‘primary school’ but not in the intended context ‘of primary importance’.

Conclusions

Under UK quality assurance procedures examination papers, but not always other assessment items, are usually checked both by the setter and by a moderator. If the assessment is not supposed to be a test of language skills, then it should be checked for technical accuracy, for alignment to the ILOs and for grammatical accuracy. This review indicates that moderators should also be asked to check for unintentional bias. It would not be easy to produce a comprehensive check list for this purpose but the issues and vocabulary discussed in this paper could form a starting point.

Recent trends in engineering education may also help to mitigate the problem of cultural bias. Movements such as CDIO (2006) and ALE (2006) promote active learning which makes it less likely that any student can remain culturally isolated. Students who are regularly working in teams, making products and considering the engineering context of their studies will have a better chance of absorbing the local technical (and wider societal) culture.

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[O10] Computer-assisted and peer assessment: a combined approach to assessing first year laboratory practical classes for large numbers of students

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Keywords: computer-assisted assessment; peer assessment; laboratory practical class assessment

Abstract

Providing fair assessment with timely and useful feedback for students is a difficult task for science laboratory practical classes containing a large number of students. Throughout our Faculty, such classes are assessed by short-answer questions (SAQs) centred on principles encountered in the laboratory. We have recently shown that computer-assisted assessment (CAA), using dedicated software, reduces staff administrative time and is well received by the students. The software allows questions to be posed, answers entered and marks allocated by staff via a computer interface. However, student evaluation has shown this system does not currently allow satisfactory feedback. We have thus introduced peer assessment (PA) as a complementary assessment procedure whereby a student marks the work of one of their peers following specific marking guidelines, in order to improve the learning experience for the students.

In October 2006, 465 students registered for the 'Introduction to Laboratory Science' 10-credit unit in the Faculty of Life Sciences, University of Manchester, UK. This first-year unit consists of ten compulsory practical classes covering a range of biology subjects. The first four practicals taken in weeks 2-5 were assessed using PA; the remaining six practicals were assessed by CAA by academic staff or postgraduate student demonstrators. All students attempted the SAQs for all ten practicals.

Student, academic and administrative staff opinions about the assessment procedures were sought via questionnaires (pre- and post- assessment) and focus groups. The student focus groups were led by trained PASS ('peer assisted study support') leaders in order to get the 'real' student views.

We will present the evaluation of the combined assessment approach for such large student numbers at the conference.

This study has been supported by a grant from the HEA Centre for Bioscience Departmental Teaching Enhancement Scheme 2006.

Introduction

Practical competence of individual students in the laboratory can be hard to assess directly in large classes where students generally work in pairs or in groups; assessing practical skills under exam conditions can be expensive, time-consuming and may not provide the best conditions for students to demonstrate their ability. For these reasons, the formal, summative assessment for laboratory practical classes in the Faculty of Life Sciences at The University of Manchester focuses on other important learning outcomes. These include the ability to analyse and manipulate data using appropriate statistical methods and the ability to relate knowledge acquired in the laboratory to theoretical material covered in lecture units.

Assessment thus utilises data-handling exercises and short answer questions (SAQs) based on principles encountered in the laboratory. The questions are accessed and marked via computer (computer-assisted assessment, CAA) using dedicated software developed by the School of Computer Sciences, The University of Manchester (ABC, Assessment By Computer, Sargeant *et al*., 2004). The software allows questions to be posed, answers entered and marks allocated by staff via a computer interface. CAA for SAQs has been used with some success (Bull and Collins, 2002; Pain and Le Heron, 2003; Wang *et al*., 2004) and has been found to compare favourably with traditional paper-based assessment in our own Faculty (Sheader *et al*., 2006), especially with regards to ease of implementation, ability to spot plagiarism and reducing variability between markers (by having one member of staff mark one question for all students).

However, evaluation has shown that CAA scores poorly on student satisfaction surveys, particularly with regards to providing timely and satisfactory feedback. Recent student evaluation also revealed that many students were unfamiliar with this style of assessment and were uncomfortable with their lack of certainty in knowing what is expected of them in completing the assessment, especially as all other assessments in the first year were by multiple choice questions alone.

PA is a distinct method of assessment that actively engages students in the process (Ellery and Sutherland, 2004; Orsmond, 2004). In doing so, students are given an insight into how assessment ‘works’ at University and a chance to see directly the attainment level of another member of their year group. This gives students the valuable opportunity to judge how they are performing compared to their peers and help in how to tackle assessment in the future; important criteria defining effective feedback to students (Falchikov, 1995; Gibbs, 1999; Race, 2001; Rust, 2002). For these reasons PA was introduced as a complementary assessment to CAA for BIOL 10401 in 2006.

This study will present the evaluation of the combined assessment approach for such large student numbers. We aim to provide evidence to show that the assessments are accepted by staff and students as fair, academically rigorous, easy to administer and that the quality of feedback to students is enhanced.

Methods

Assessment of the unit

In October 2006, 465 students registered for the Introduction to Laboratory Science 10-credit unit (BIOL 10401) in the Faculty of Life Sciences, University of Manchester, UK. This unit has ten associated practicals covering a range of biology subjects, which in previous years had been assessed by SAQs based on work covered in the laboratory classes. The SAQs were marked by staff via computer using specialised software (Sargeant *et al*., 2004). For this year, the first four practicals (taken in weeks 2-5 of the semester) were assessed by SAQs completed on paper, but marked by fellow students (peer assessment). The remaining six practicals (taken in weeks 7-11) were assessed by SAQs, which were submitted by the students via computer and marked via computer by academic staff or postgraduate students. Questions were assigned different marks ranging from 1, for questions requiring one-word answers, up to 10 marks for questions requiring longer, more detailed responses.

All students attempted the SAQs for all ten practicals. The formative mark for the unit comprised 20% for attending and completing the practicals and 80% for the SAQs.

Completion of SAQs and administration of PA practicals
SAQs covering material from practicals 1-4 were distributed and completed on paper. Scripts were submitted to the Undergraduate Office by the deadline date. Administrative staff recorded the submission from each student and then covered the student names to allow anonymous marking.

Completion of SAQs and administration of CAA practicals
The ABC software allows inputted questions to be accessed via an external URL website, with a separate URL for each practical. All students were given a unique identifier (student registration number) and password so they could access the URLs from any internet-linked computer. The students could enter the websites and attempt the questions in their own time by entering text-based answers. Answers could be saved and edited prior to submission by the deadline. Only one submission was allowed and submissions were not possible after the deadline had lapsed. An email receipt was sent to students to confirm answer submission. Submitted answers were saved on file and could be accessed by the administrator as required.

Questions were set by several staff, although only one member of staff was required to enter the questions into the ABC system. One computer technician was then required to oversee the process. This involved registering the students' registration numbers to use the system and monitoring any problems the students had in accessing the websites.

PA of practicals 1-4
Two days after submitting their answers, the students attended the peer-marking sessions held in a lecture theatre (session length 50 minutes). Attendance at the marking session was compulsory; non-attendance was penalised with the student losing 50% of their own marks for practicals 1-4. Half of the student cohort attended either one of two sessions. Each student was given a script to mark and signed the coversheet claiming that they had marked the work to the best of their ability. Five scripts were duplicated, to allow different students ($n = 4$) and a member of staff ($n = 1$) to mark the same script. No student marked more than one script. One member of staff revealed the expected answers to the SAQs using a presentation, allowing enough time for students to allocate marks for each question. Scripts were collected and the marks collated by administrative staff. A selection of scripts ($n=50$) was moderated by staff, with particular emphasis given to high and low scoring scripts.

Marks were released 10 days after the PA sessions. Students were given 1 week to challenge their mark, and were given the opportunity to have their script remarked by staff if they were unhappy with how another student had marked it.

CAA of practicals 5-10
For CAA, answers saved on file were passed to tutors for marking, with scripts made anonymous automatically. To mark the assessment questions via computer, tutors could access the student answers on-screen, and depending on length of answer, could visualise several scripts at a time. The student responses could be compared with a pre-inputted 'model answer' and marks allocated manually, as appropriate. Final marks were totalled automatically and presented in a spreadsheet for analysis.

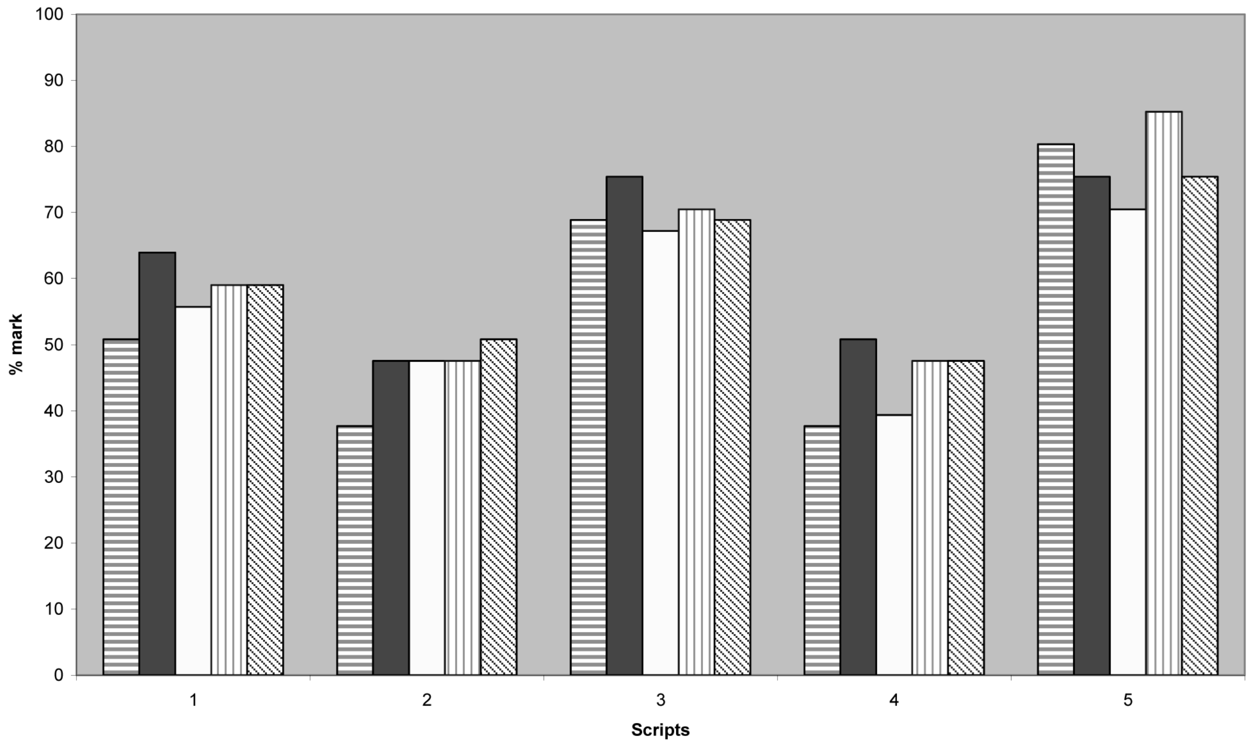

Figure 1: The percentage marks for each script are shown for the five duplicated scripts marked by either an academic (bar on left of each group) or by individual students (20 different students in total).

For CAA practicals, questions were marked by staff or post-graduate student demonstrators, such that one person could mark all student answers for one question. Marks were allocated manually depending on the quality of the answer, as in traditional assessment.

Evaluation of the assessment methods

All students were surveyed via an anonymous questionnaire in week 1, prior to starting the unit, to establish attitudes to peer assessment. Completed questionnaires were received from 249 students. After both types of assessment were completed, and marks revealed, a second questionnaire was distributed to all students at the start of the second semester and returned by 269, in order to determine subsequent opinions of the assessment methods. A workshop was also held in week 3 of semester 2. This was run by PASS leaders to obtain further attitudes directly from the students to the assessment methods. Attendance at the workshop was rewarded by receipt of a £10 voucher.

Staff opinion (academic and administrative) regarding the peer assessment was acquired via face-to-face interviews and informal email feedback.

Results and Conclusions

Of the 457 students that were due to attend the peer marking sessions, 6 were absent, 10 challenged their mark following publication of results, and 5 subsequently requested a remark.

Duplicate scripts marked by different students did not always return identical marks (**Figure 1**), but the variation is not extensive. Generally students marked more generously than the staff member, except for the highly scoring script (**Figure 1, Script 5**), where 3 students returned a lower mark.

A fuller analysis of the marks awarded for CAA and PA will be presented at the conference. In addition, opinions and attitudes towards the assessment methods ascertained from the questionnaires and from the focus groups will be discussed.

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[O11] Truth and transferability: discovering physical science educational realities

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Keywords: truth, problem based learning, science culture

Abstract

This project aimed to investigate if perceived successes in the Physics Group-Based Research Projects (GRePs) at the University of Leicester could be transferred to the core curricula. Although both the GRePs and the core curricula utilise problem-based learning both staff and student informal feedback had been more positive about GRePs, which focus on a range of specialist areas. Therefore the project involved uncovering the truths of the perceived successes in GRePs, i.e. criteria for success and how these manifested themselves, then investigating if these manifestations were appropriate in the new context of the core curricula. Three research methods were utilised and their results triangulated leading to the conclusions. Firstly, audio of key GRePs' staff interviews was recorded and later transcribed. Secondly, student assessment results of GRePs and the core curricula were gathered. Thirdly, students were surveyed concerning their impressions of GRePs utilising QuestionPro, an online survey instrument. The project's conclusions may be useful to staff as they consider rolling out GRePs-like approaches to the core physics curricula. Finally, reflections born of the study in the light of the pedagogical research program were captured.

Introduction

Truth is a notoriously slippery customer although this may entirely depend upon your own perspective. Certainly physicists may like to believe that it is possible to objectively describe reality (whatever that may be) through the derivation of models usually in the form of laws which society then reifies in numerous school text books as we all have doubtless experienced. However, any physicist worth her or his salt will also be very capable of discussing the limitations of models in that they are (possibly used with a qualifying 'for the time being') approximations of reality particularly as they allow our descriptions of the aforementioned phenomena to be honed over time. This is basically the tenet of positivism, that some kind of absolute description of the Universe is possible.

Post-positivism, on the other hand, refutes this tenet by almost arguing for the opposite relationship between the observer and the observed. That is, it recognises – in a way strangely similar to Heisenberg – that the observer and the observed are inextricably intertwined in the same reality. Thus the outcome is that objective descriptions of reality become trickier to derive. So, instead of placing ourselves at the centre of the Universe in an almost Copernican revolutionary way post-positivists seem to argue that the Universe instead surrounds us. As such it becomes illogical to describe a reality which we all share since your view of the Universe may look completely different to mine.

For some time educationalists seemed to argue these conflicting viewpoints quite ferociously. Luckily, educationalists may now be more inclined to recognise that positivism and post-positivism, at least in terms of methods if not methodology (or philosophical origins) can be used in harmony rather than diametric opposition. Thus, today we may find qualitative methods reminiscent of post-positivism being used alongside quantitative methods more reminiscent of positivist approaches. Indeed, both perspectives are used within the research project described here. This does not, however, mean that this 'marriage' is necessarily a happy one. Indeed, at times these unlikely partners undoubtedly quarrel as shared understanding is hammered out at the interface of their respective perspectives. However, these more general discussions will be saved for the end of this paper. First, the context for this research project is established. This approach in itself helps to paint a 'thick description' (Lincoln and Guba, 1985) of the project with the intention of furnishing transferability – the post-positivist 'equivalent' of generalisability (Barker, 2003, p.18). In other words, we describe our 'truth' or perspective in the most complete way possible despite or rather because of our inherent limitations. Hence, when the future interested scientist attempts to observe our Universe from their own 'truth' or perspective they should be aware of the artefacts of our own fallibility.

Context

In one form or another Problem Based Learning (PBL) has been utilised at the University of Leicester since the 1980s when it was actually then closer to what was known as Resource Based Learning. This hints at one of the key problems in describing research concerning PBL notably that it is actually a plethora of methodologies which can vary greatly even within disciplines but especially perhaps across them. At the University of Leicester, Department of Physics and Astronomy there is a model in use which has been honed over the years and aims to standardise the approach although other models such as the Maastricht model, the Medical School Model and the Floating Facilitator Model, etc. (Raine and Symons, 2005) are generally recognised amongst practitioners.

PBL at the University of Leicester is currently utilised for the Group-Based Research Projects where students typically work in groups of four on problems presented as staged scenarios. Facilitation is provided, usually by postgraduate students, to guide students towards solutions to the problems. Typical of PBL the problems are designed to be open-ended in that any number of solutions may exist. Thus the role of the facilitator becomes one of treading a fine balance between supplying answers to student questions and simply supervising students' own inquiry. Thus the facilitator may supply methods and pointers to resources to help students reach the solutions. Usually after several such facilitation sessions and students' own independent work academics from the Department may talk to students to obtain feedback as to progress and help with seemingly intractable problems as appropriate. Finally academics will be involved with coursework assessment.

Currently the possibilities offered by PBL across the curriculum are being investigated at Leicester. Thus the recent Project LEAP had a number of aims including 'To disseminate and encourage the adoption of best practice in PBL in physics and astronomy' (**www.le.ac.uk/leap**, accessed 1/3/2007). More recently the University of Leicester formed part of a consortium, together with the University of Reading and the Open University, for a successful HEFCE bid to establish a Physics Innovations Centre for Excellence in Teaching and Learning (piCETL).

Aims and Objectives

The aims of this research programme are broadly to investigate the effectiveness of PBL at the University of Leicester. Obviously this is from all perspectives, including students, academics, support staff and administrative staff. More widely, if resources allowed, it would be interesting to examine public perceptions of PBL including those of employers and parents. However, for the time being the objective is to investigate one aspect of PBL practice which, as already stated, has been deemed in folklore terms at least, to have been a success. Thus the point of this research is to concretise this claim leading to the following research question.

Research Question

Simply, the research question is '**can perceived successes in the Group Based Research Projects (GRePs) be transferred to the core curricula?**' The means of answering this are described below.

Methodology

As described above the methodology to be used is not simply taken from one finely demarcated perspective but from a multitude of such perspectives. Hence, this postmodernist (perhaps) bricolage of methods may not easily be named in terms of one simple methodology. Instead it borrows from positivist and post-positivist systems of thought although admittedly the latter is acknowledged more than the former. Hence, it sometimes proves necessary to qualitatively interpret quantitative data although it is believed that this relationship is unidirectional in that problems may arise if a quantitative analysis is attempted of qualitative data due to the fundamental differences in assumptions underlying each perspective. These statements are illustrated next.

Method

First, key GRePs and some PBL staff were interviewed resulting in 7 audio recordings. A total of sixteen questions were designed to be used in a semi-structured interview style. That is, if something of interest emerges during the process of interviewing with this approach the interviewer is free to explore these issues rather than rigidly adhering to the questions. Thus the questions *frame* the interview.

Second, students were asked to volunteer to take part in the study. Initially the intention was to also interview students but it soon became apparent that, due to the large number of volunteers and given the limited resources for the study, this would prove infeasible. Therefore, after some investigation, the decision was taken to utilise an online questionnaire – where students could log on and answer a variety of questions utilising various styles of questioning. The software used, **www.questionpro.com**, also allowed tracking of participants, seamless emailing of reminders and quite detailed and visual analysis methods as well as downloading of results to Microsoft Excel. This latter approach was taken for our purposes.

Third, individual GRePs results for each of the 8 options and overall assessment results which utilise PBL were obtained. These have been subjected to a simple statistical analysis, for example calculating means and standard deviations, then *qualitatively* interpreted through visualisations. Thus it will be possible to *triangulate* the multiple methods which will help to ensure a complete and consistent picture is obtained of the state of GRePs and PBL, as reflected by staff and students, at the University of Leicester.

Analysis

The interviews were analysed by reading them with the research question in mind and highlighting those speech utterances which both relate to the question and summarise a series of exchanges between the interviewer and interviewee. Thus the result of this exercise is a series of 'chunks' of data which pertain to the research objectives. These chunks can then be categorised and reported as results of the analysis.

Fortunately, the use of the online questionnaire tool, QuestionPro, greatly simplifies both the management of respondents' responses and subsequent analysis. For instance, it is possible to produce online reports as to how many respondents have completed the survey so far. Furthermore, when the survey closes, it is possible to produce further summary reports which will, for instance, produce percentages of responses for Likert scales together with mean averages, standard deviations and variances. Short answer responses were also collated. Each question's answers then form a separate 'sheet' in a form that can be downloaded and displayed in Microsoft Excel.

Finally, all relevant assessment results were obtained either already in the form of an Excel spreadsheet or were subsequently entered into such. Once the assessment results are in this form it is relatively simple to begin to interact with the data. First of all this involved converting the results into the same type, i.e. percentages. Next it was necessary to compute mean averages (including confirmation of those already obtained) and standard deviations. These were then plotted for the core curricula and GRePs before being interpreted, as described next.

Results

25 students completed the survey out of 40 volunteers (asked to participate during one first year and one second year lecture). 76% of the group were males. Out of 8 GRePs, most people took 'astrophysical techniques I' (12), 'the earth's space environment' (8) then 'astrophysical techniques I' and 'spacecraft imaging systems' (both 5).

With regard to how GRePs successes can be transferred to core curricula one student said 'I think that projects should reflect more of what goes on in the real world, such as SpaceCraft Imaging systems – we used webcams and basic PC software rather than similar industry systems. For the Space Science and Technology course this should have been covered in more detail.' On the other hand a representative dissenting comment was 'They can be used as a support to the curriculum, but not as the main method of study. More detailed explanation of the key concepts is necessary to some students.'

Students see teamwork as the skills especially gained in GRePs. Most students (44%) thought the best format for GRePS is one lecture followed by one tutorial (repeated). However 60% felt GRePs are 'too rushed' although the majority felt time spent on labs is 'just right' (55%). Impressions of the workload were almost equally split: 'the workload is just right' (45%) and 'there's too much work' (40%).

From interviews with staff it emerged that some students may not distinguish between

GRePs and the core curricula so a question was asked where they could state the differences. It was fairly clear that the presupposition was unfounded, e.g. 'You are expected to know more than you were taught.' and 'For the group research, you have to go away and look up things for yourself. In the core curricula, a lecturer will teach you the material.' More generally regarding PBL a slim majority felt it 'worked' (48%), a larger majority felt that enough time was allowed (68%) and 21 of 25 participants felt that feedback was adequate. A further slim majority (52%) felt that there is 'sufficient equipment'.

When asked if they had any further comments to make about PBL 17 out of 25 participants made, in the main, rather negative comments. The following is fairly typical:

> 'There were plenty of problems, but not a lot of learning. The idea was supposedly that we were given a problem that we were to solve in our own way, but we were only given set equipment so all ended up doing the same thing. Other possible solutions could've been carried out if the equipment was available. Also the 'no help' rule seems foolish, I understand it was to make us think on our own and come up with the solutions, but when we are unable to do anything and just sit there for 3 sessions making no progress it seems a complete waste of time.'

As to suggestions for future improvements to PBL at Leicester they range from negative, caustic criticism to something a little more useful. Examples of the latter include:

> 'Give students feedback on PBL projects! Make PBL more interesting, relevant and educational - giving students the transferrable AND professional skills they need once they graduate. Organise PBL better, make handouts more relevant, clearer, and with more necessary information. Find lab demonstrators who know what they're doing and aren't uninterested/apathetic. DO NOT replace traditional laboratory experiments with PBL. Allow longer/more lab sessions for PBL experiments to be satisfactorily completed. Allow students more flexibility and scope in solving problems, rather than having one solution.'

> 'Either scrap it totally and go back to traditional laboratory experiments, or implement the changes students, such as myself, have suggested and conduct another survey at the end of the next academic year to see how satisfied students are then.'

The vast majority of participants expressed that they move from 'traditional' 'school-based learning' to PBL with difficulty: 12% 'with great difficulty', 36% 'with difficulty' and 36% 'with moderate difficulty'. In terms of the organisation, delivery and facilitation of GRePs a slight majority felt it was 'slightly poor' (24%), 'good' (28%) and 'good' (24%) respectively. In terms of the organisation, delivery and faciliation of the core curricula larger majorities felt it was 'good' (32%), 'good' (52%) and 'good' (36%) respectively.

Question 10 of the questionnaire asked students to indicate how they **felt** about their PBL experience at Leicester. The composition of the eight ensuing scales is based upon a cognitive model of emotions by Ortony, Clore and Clare (1990). The graphs (**Figure 1**) thus *qualitatively* indicate where students rated themselves along a continuum as indicated. Further dissemination may report this in more detail.

Figure 2 demonstrates the relationships between mean percent averages and their standard deviations for all of the University of Leicester undergraduate Physics modules

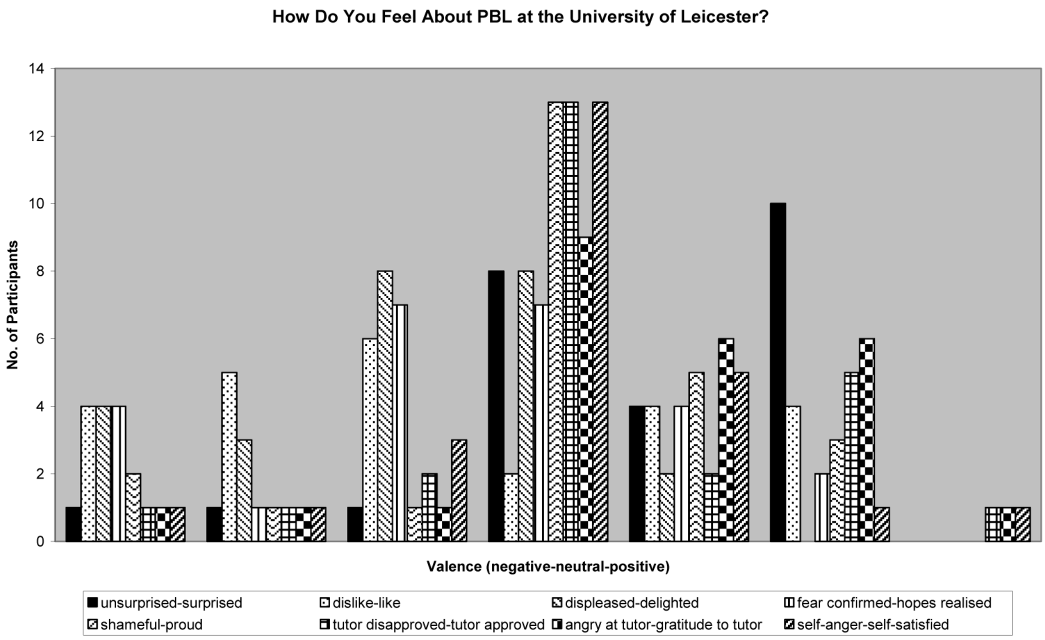

Figure 1: Student 'feelings' towards the PBL experience

which currently utilise Problem Based Learning. Notably, as **Table 1** demonstrates, modules can be compared both across years and whether they belong to the 'core curricula' or the GRePs. The main result here is that although the First Year Core Curricula subjects compare favourably with their like in the Second Year for the GRePs the First Year assessment results seem to *qualitatively* under perform when compared to their Second Year counterparts although admittedly the data is a little sparse. Since this result may have been commented on by tutors the interviews should be examined. However, unfortunately time has not yet allowed a complete analysis so this forms part of future work.

Conclusions

Perhaps the most obvious conclusion, evident in **Figure 2** as well as reported by academics, is that students who enter the First Year and are asked to pursue PBL in GRePs in their first term are unprepared for the differences between this approach and those employed in their previous studies. This is also evidenced in the survey. One opinion expressed by an academic was that Physics at Further Education and lower levels currently contains little laboratory based sessions. Hence the feeling was that students do not have the necessary skills with which to engage in research-based or Problem Based Learning. Certainly it does seem that there is a clear discrepancy between the achievements of students taking GRePs in the First Year and more successfully in the Second Year.

Students seemed quite divided as to their opinions regarding PBL. While some felt that it was a bona fide way to approach Physics others felt that it was not. It does seem though that concerns about adequate resources being available, i.e. availability of equipment, are shared by both academics and students. Certainly it seemed there was a general consensus amongst students about the need to allow adequate time to undertake PBL. Both academics and students also expressed concern about the quality of facilitation.

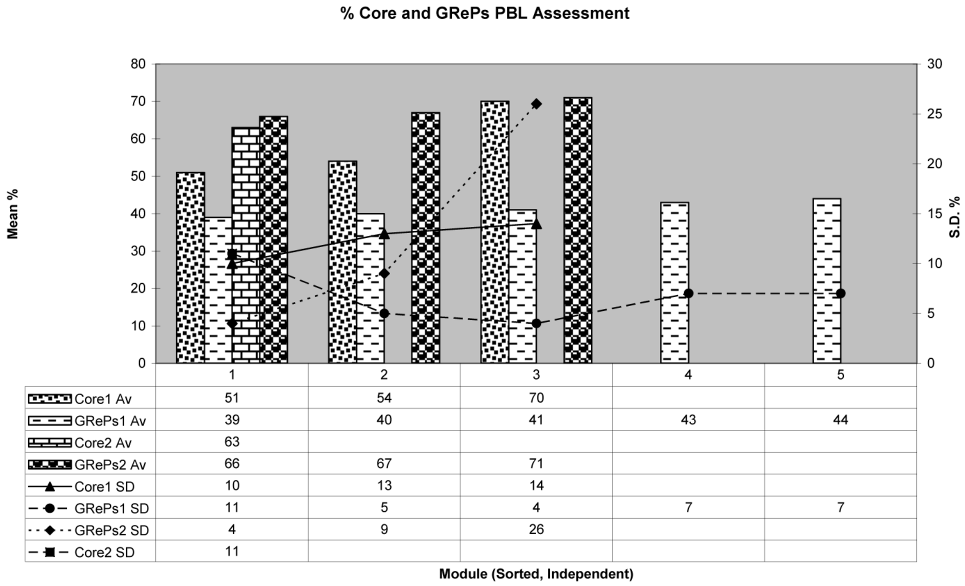

Figure 2: Averages (Av) and Standard Deviations (SD) of PBL assessments

	Core1	GRePs1	Core2	GRePs2
S1	Crosswinds	Planetary Cratering	Laboratory Physics 2	Spectroscopy II
S2	AC Theory	Nano-Aerosols		Astrophysical Techniques II
S3	Optics	Spectroscopy I		Spacecraft Imaging Systems
S4		Astrophysical Techniques I		
S5		Earth's Space Environment		

Table 1: Index to Core Curricula and GRePs Subjects in **Figure 2**

In terms of generalisations of student ‘feelings’ towards PBL although there was an indication of students being ‘displeased’ and indicating ‘dislike’ towards PBL they also indicated ‘gratitude’ and ‘pride’. This would indicate that there is a foundation upon which to initiate improvements in PBL. These are discussed next.

Recommendations

Probably the most obvious recommendation based upon this research is to move GRePs from semester one in the First Year to semester two. In this way students can become more accustomed to Higher Education level Physics prerequisite skills, particularly laboratory-based skills, receiving training as appropriate. Fortunately, piCETL is currently acquiring new laboratories as part of the associated HEFCE funding so this may address the concern regarding equipment availability. Additionally, it is suggested that training of facilitators should be re-examined in the light of these research findings and steps possibly taken to improve the current provision.

Thus, with these recommendations in mind, the ‘perceived successes’ of GRePs (with the caveat that the perceptions may not be the whole ‘truth’) could be transferred to the core curricula.

Discussion

This project has shown that it is possible to inquire as to the current perceptions of teaching practice in Higher Education. It has also attempted to show how it may then be possible to expose the reality of the situations – or Universe – being studied as the analysis is moved towards a less biased basis through methodological 'rigour'. However, in-keeping with the opening salvo of this paper it is almost impossible to remove all bias as, at the simplest level, this research project has taken place within the context which it is purporting to study. Hence, there may be inherent restrictions as to the degree of 'truth' it is possible to obtain, in-keeping with Heisenberg.

Truth will forever remain a 'slippery customer'. The purpose of science is to ever move us further towards that goal of a description of reality. However, whilst being a noble pursuit worthy of many great adventures, this pot of gold is likely to remain undiscovered at the bottom of the most beautiful and enigmatic of rainbows.

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[O12] JiTT in Physics

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Keywords: JiTT, physics

Background

The first year undergraduate intake to the School of Physics and Astronomy at the University of Manchester comprises approximately 230 students, with an average A-level score of AAB. All of these students are required to take the Dynamics module, which covers some simple vector algebra and classical mechanics, in their first semester. This module has had a tradition of rather mediocre feedback on the student satisfaction questionnaires and poor exam results as compared with the other first year modules. However, it is one of the core modules in our first year, and future success seems linked to good performance in this course.

First year modules in the School of Physics and Astronomy have, until now, been delivered in a very traditional manner, typically through two lectures per week. In addition, students undertook a one hour Dynamics 'workshop' per week where they were encouraged to work together in groups in order to solve problems and debate the physics principles. The students' learning was further supported by a one-hour tutorial.

From anecdotal evidence, there are strong indications that the students' attitude towards learning when arriving at university does not always meet our expectations; we also believe that continuing to rely mainly on 'chalk-and-talk' is not preparing our students to take the responsibility for their own learning. Clearly, we are hampered by the structure of the GCSE and GCE curriculum, which often places greater emphasis on the method of answering as opposed to the depth of understanding. The clear break provided by the transition to the university environment is probably the best time to try and install a different ethic amongst our students.

New Approach

In the academic year 2006-07 we changed the delivery of the Dynamics module in several ways:

(i) we used the 'Just-in-Time Teaching' (JiTT) method (Novak *et al*, 1999) as inspiration for our method of delivery,

(ii) we adopted a blended learning approach combining a face-to-face presentation with e-learning and,

(iii) we introduced weekly electronic assignments.

The aims of this innovative approach were:

- To provide a much more student-centred approach to learning;
- To encourage the students to take responsibility for their own learning;
- To instil a deeper conceptual understanding of fundamental physics principles rather than superficial learning to pass exams;
- To increase students' engagement with the material;
- To improve student retention;
- To enhance exam performance;
- To change the students' attitude to learning.

What is JiTT?

JiTT is a pedagogical strategy which was developed in the USA (Novak) in 1996 as a joint project of the Physics departments at IUPUI (Indiana University–Purdue University Indianapolis) and at the United States Air Force Academy. Since then the strategy has been adopted by other disciplines and other institutions worldwide.

The JiTT approach is student–led. In its standard form it does away with traditional lectures in favour of much more student-interactive lectures. The students are required to read up the material in the textbook and do some web-based 'warm-up' exercises prior to receiving any formal instruction on a particular topic. The 'warm-up' exercises are submitted electronically a few hours before the lecture enabling the instructor to see what the students are having difficulty with and what their misconceptions are. He/she is then able to prepare the lecture material according to the needs of the students. This is done just in-time before the lecture, hence the name. The core element of the JiTT strategy is therefore a closely coupled 'feedback' loop whereby the students' pre-lecture preparation affects the content of the lecture. The lecture thus becomes much more interactive, building on the students' prior self-study.

The majority of reports in the literature on the use of JiTT refer to relatively small cohorts of students compared with our first year intake of 230. Therefore we adopted a slightly modified JiTT approach.

Modified JiTT approach

Our modified JiTT approach consisted of five stages for each of 11 weeks, in order:

(i) An introductory lecture

(ii) A period of self learning

(iii) An online test

(iv) A feedback session

(v) A standard tutorial

Introductory lecture

Rather than having the two traditional lectures per week, the students were given a single overview presentation at the beginning of each week. The aim of the overview presentation was to briefly introduce the students to the material they needed to study that week. It was not intended to be a normal teaching lecture but rather to point the students in the right direction and facilitate their further self-study.

Self-learning

A substantial amount of learning material was developed for the University's Virtual Learning Environment, (VLE). The material was structured into eleven topic areas corresponding to each of the eleven teaching weeks of the course. A variety of formats was used within the VLE. In addition to the usual textual material, a large number of 'talklets' (Levitt, 2004), were also incorporated. These small screencasts consist of an animation or PowerPoint presentation, with a recorded verbal explanation, concentrating on difficult concepts or solutions to problems. The idea behind these talklets was that students could study the material at their own pace, with access to some mini-lectures. Physlets (Christian, 2005) (physics java applets) were also included to aid students' conceptual understanding by the use of interactive simulations wherever possible.

Following the overview presentation, the students were then expected to study the detailed material for that week provided on the VLE.

On-line assessment

When the students felt that they had understood the material sufficiently well, they were required to complete an on-line assignment. The assignment consisted of 5 or 6 problems each week, with an estimated workload of a little over an hour. The 'Masteringphysics.com' website provided by Pearson Education as a companion to the students' core textbook 'University Physics' (Young and Freedman, 2004) was used for this purpose. This website provides a comprehensive library of problems for each chapter of the textbook. The problems fall into two classes: (i) Skill Builders (SP) and Self-Tutoring Problems (STP), which have hints which the students can open if they need them, and (ii) End-of-Chapter Problems (EOC) without hints. Students may have several attempts at a problem until they obtain the correct answer. The maximum number of attempts we allowed was six. In all cases, the students are able to request the solution but in the case of the EOC problems, only the answer is provided, not the methodology. One of the powerful aspects of the system is the ability to provide hints based on an analysis of an incorrect answer.

The deadline for submission of the on-line assignment by the students was 2.00 a.m. on the Friday morning of each week, and it counted for 15% of the overall mark for the module.

The Mastering Physics website also provides a considerable amount of data for the teaching staff. The most useful set of data was a comprehensive analysis and summary of how the students had fared on each individual problem, which included,

- The number of students who had completed the problem
- The average time taken to complete the problem
- How difficult the students rated the problem, on a scale of 1-5
- The percentage of students who answered the problem correctly

- The percentage of students who requested the solution
- The average number of wrong answers per student
- The average number of hints used per student

Feedback session

The next component of the module delivery consisted of JIRP (Just in Time Response and Problem) sessions which were held each Friday afternoon. For these sessions the cohort of 230 students was divided into two groups and separate parallel sessions run for each group.

The feedback data from the Mastering Physics program were reviewed every Friday morning. Unfortunately, the usefulness of these data were somewhat limited by the fact that the aggregation time is based on a US timescale, which was not very convenient for us (between 10-12 in the morning UK time). Nevertheless, the data available did give a good indication of the areas the students were finding difficult, enabling the content of the JIRP sessions to be decided. If the majority of the students had experienced difficulties with specific problems, these were discussed. Additional problems were also included which either emphasised a point or concept, or were more challenging than the Mastering Physics problems. This consolidated students' understanding and helped to prepare them further for tackling the tutorial problems set for that week. 'Warm-up' questions were sometimes used at the beginning of these sessions to generate discussion of particular issues or concepts.

Tutorial sessions

Finally, the students were asked to attempt a set of tutorial problems, for discussion in a small-group session (4 students) the week after the JIRP session. The tutorial problems set each week were generally more complex than those of the on-line assignments, so that the students' understanding of each week's topic was consolidated and their analytical skills gradually developed.

Outcomes

Successes:

- The majority of students (approx 95%) submitted the on-line assignment each week. This submission rate was far greater than that for normal tutorial work.
- Results for the mid-semester test and the end of module examination were better than for previous years, the average mark for the latter increasing from 50% last year to 67% this year, with a similar exam.
- Favourable feedback was obtained regarding the talklets on the VLE. Students did find these useful for the reasons intended, i.e. they could have the solutions to problems explained to them again, if they had forgotten, or had not followed the explanation given in the overview lecture.

Pitfalls:

- Feedback from the student satisfaction questionnaires was disappointing. The students complained about having only one lecture per week rather than two.

- Students' expectations were not met and despite being reminded on numerous occasions that they needed to study the material on the VLE, many resented having to do this. They did not appreciate the difference between the overview lectures and the normal traditional lectures that they were receiving for the other modules. They expected to be taught all the material in the one lecture and many of them were quite indignant that they should be expected to follow these up with self-study on the VLE.

- Many of the students did not like using Mastering Physics.

- The default penalty for using a hint on the Mastering Physics assignments was set too low (only 2%). This will be set higher in future. Some students just clicked their way through the hints in order to get to the solution without understanding the underlying physics. They quite openly admitted this when they came to the JIRP sessions.

- Attendance at the overview lectures dropped rapidly to about 50% as soon as students realised that the material was available on the VLE.

- Attendance at the JIRP sessions was not good either. This was probably due in some part to time-tabling problems: in the second half of the semester it was the only session the students had on a Friday afternoon.

- Students generally managed to work their way through the Mastering Physics problems when they were provided with hints, i.e. the SB and STP problems, but found great difficulty when these were absent, i.e. the EOC problems. This caused a great deal of frustration for many students, to the extent that we avoided the use of problems without hints in the latter part of the course.

Discussion

Examination performance has been significantly enhanced this year. However, the new method of delivery has met with resistance from the students, since it did not meet with their expectations. Even though a 30 minute presentation was given to them during Freshers' week, explaining how the module would work, the idea of the overview lecture and the need for them to study the material on the VLE, many students were very reluctant to take responsibility for their own learning. It is interesting that Duncan, 2005 also reported 'shattering' students' expectations when a classroom response system or 'clicker' system was introduced at the University of Colorado to promote more interactive lectures. Many students found the change disconcerting and Duncan emphasised the need to explain repeatedly the purpose and benefits of the new approach to the students.

It was unfortunate that the Dynamics module was the only module being delivered using the new approach. All the other first year modules consisted of two traditional lectures per week which were more like the type of 'spoon-feeding' instruction the students had received previously at school. Consequently students compared the overview lectures with the more detailed traditional lectures they received for their other modules and did not appreciate the need to do more self-study for Dynamics. They felt that a different mindset was required for Dynamics, a mindset which was quite alien to them.

New students are generally unaware of the completely different learning culture at university. There is much evidence of this in the literature. For example, Redish *et al*, 1998 performed a very comprehensive survey of students' expectations upon entering university and how these expectations critically affect students' response to a course. They describe typical students entering the first year of university as 'binary thinkers' who believe that it is the responsibility of the lecturer to convey knowledge to them rather than appreciating the need to be proactive in developing their own understanding.

It is debatable whether the idea of students immediately taking responsibility for their own learning in the first semester is too radical a change given their previous experience of school education. When Price, 2006 introduced a WebCT package for first year chemistry students at the University of Bath, he found that it was hardly used in the first few weeks of the course because the students were overwhelmed by the number of new procedures and activities upon entering university. However, Redish *et al* argue that the change of context provides a valuable opportunity to change expectations but they do acknowledge that this is a not a trivial exercise. It forms part of the 'hidden curriculum' and it may take several attempts to get it right. There are clear signs that we have made a difference in our first attempt, but the negative reaction probably detracts from the effectiveness of our message!

One of the main surprises of this work was the resistance against using the masteringphysics.com web-site for course work. We intend to perform a detailed analysis of the problems in the near future, but initial indications are that we should

(i) Manage students' expectations of the site better;

(ii) Make sure all questions have hints;

(iii) Redesign the hints, so that they will not allow a 'click-through' approach.

We were probably somewhat naïve in our expectation that questions that work well for sizable groups of US students would work for our students, considering the different teaching styles and prior training.

Conclusions

The modified JiTT approach did require students to take more responsibility for their own learning and because this was quite different from their previous school experience, it was met with some resistance. Nevertheless, by the end of the first semester, students had successfully mastered the material to the extent that their examination performance was significantly better than in previous years.

In future, greater attention will be given to the management of students' expectations when entering university, in order to develop the culture of independent learning as early as possible.

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[O13] Student networks and learning styles: a case study exploring investigative projects

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Abstract

There are many potential benefits of initiating independence and empowerment of students relating both to the learning experience and its management. Monitoring networking behaviour can provide insights into what happens when tutors 'let go' of a community of learners. Investigative research projects are a prominent element of science degrees, and when initiated and completed by a student can be rewarding for both students and tutors. This study explored the characteristics of learning networks using data gathered opportunistically on an undergraduate residential course for 2nd year Biology/Environmental students from two Universities, taught in an Enquiry Based Learning format. Individual, student-led projects were completed in four stages. Information was collected to explore who was interacted with, for how long and how important interactions were perceived to be. Questionnaires during student project development indicated that students distributed themselves fairly evenly between tutors, with total tutor-student fidelity throughout the project stages very rare. There were no obvious gender effects on networking (peer or tutor) and also no obvious association between networking behaviour and the learning (personality) styles of the tutors or learners. The quality of interactions from tutor and learner perspectives and the use of tutors as resources are discussed.

Introduction

There are many good reasons to enhance student independence (away from tutors and towards peers) and encourage learner communities. It is widely accepted that a great deal of learning is fundamentally social in nature. Learner-centered designs encourage social learning (e.g. Bransford *et al*. 1999) and can nurture autonomy in students, reduce some pressure on tutors and facilitate the management of large cohort sizes. Student networking and learning circles are receiving increasing attention in light of e-communication (Levin 1995). Studies into online modes of delivery have provided evidence for several shifts in learning behaviour: Philosophically from objectivism to constructivism; theoretically from behaviourism to socio-cognitive views of education; and, pedagogically from direct instruction to facilitation of collaborative learning (Shea *et al* 2007).

Networks of learners can be encouraged in more traditional teaching forums, for example through Enquiry Based Learning (Kahn and O'Rourke, 2004) and Collaborative Enquiry (Wenger, 1998) approaches. Increasingly in modern HE, cohorts comprise individuals from very different social backgrounds/personality types with differing abilities/approaches to learning. There is scope to explore and highlight how learners interact and use their peers and tutors as resources to help to achieve their learning goals. Residential courses provide a useful opportunity to explore learner-learner and learner-tutor interactions for several reasons: (1) learner trust is high; (2) there are no absences in the observed group; (3) resources are limited to the essential and there is room for creativity in basic equipment development (other than a potential surplus of tutor time); (4) EBL and PBL formats (e.g. Blumhof *et al*. 2001) encourage problem-solving and discussion; (5) the emphasis is strongly on the student; (6) there are fewer distractions from academic work.

Personality types are complex, but represent appealing factors to consider when exploring how individuals interact to progress their projects. Decades of research into learning styles has generated a controversial picture of the appropriateness and usefulness of categorising learners (Coffield *et al*. 2004; Mortimore 2005). However, it is appealing to use them as one line of evidence to explore patterns of differences between individuals (and their tutors) particularly in terms of their learning strategies (Felder and Silverman 1988).

This paper describes a selection of key data gathered whilst monitoring undergraduate students (and the supporting teaching team) during the development of investigative projects on a residential course. This develops previous research into factors that influence how students evaluated themselves and their peers during the development of these investigative projects (Langan *et al*. 2005; Langan *et al*. in press). Previous work has indicated that gender effects and other social factors affect self, peer and tutor grades of the summative assessment in this course. Consideration of the learning network and inclusion of a measure of personality type were anticipated to clarify how students achieve their learning goals. Using questionnaire surveys at four stages of project development, the frequency and perceived value of interactions between individuals were recorded. Information about gender, university affiliation, learning style and final attainment in the summative assessment are used to further explain the networking patterns.

Methods

Data were collected during a residential field course to southern Spain (July 2nd - 18th 2005). Students originated from two Manchester universities ($n_{uni1} = 15$, $n_{uni2} = 5$). Tutors ($n = 14$) represented three Universities and all had experience of teaching and assessing field biology. One member of staff was a research technician and was included as a tutor in this study as she interacted with all students at some point and provided advice in terms of technical and sometimes methodological bases. Another female tutor joined the course at its mid-point. Full, voluntary participation in the study was given by all staff and students and participants willingly volunteered personal information. Most students were studying for biological or environmental degrees and this was reflected in the research and teaching specialisms of the tutors.

The course format has been detailed previously (Langan *et al*. 2005). It can be considered to be Enquiry Based Learning in format as students devise their own investigative research projects, develop their methodologies and set their own goals. There is a structure to the course that has four deadlines that need to be met. These were used to time the delivery of questionnaires (coded to be anonymous) that surveyed the frequency and duration of interactions associated with project development during the prior stage. The stages comprised; Stage 1 – formulate research questions (with a scheduled discussion group); Stage 2 – complete methods development (including submission of ethics and health and safety documentation; Stage 3 – data collection and collation (check spreadsheets/proposed analyses); Stage 4 – statistical analyses (including graphical outputs and oral presentation preparation).

A meeting was held with all participants of the field course both at the very start to explain our research aims/approach and after each stage to gather the questionnaire and answer any questions to clarify our requirements. For the purposes of this paper it is sufficient to note that questions explored who was interacted with in order to progress the investigative projects, for how long, and an opinion (a 7 point scale with descriptors) of how useful the interactions were. Tutor:student interactions were further classified depending on whether they were tutor or student-initiated. For the purposes of this paper the tutor questionnaires can be considered to be identical (deviating only by a few additional questions such as opinions of how much of the progress was deemed to be tutor-driven).

On the final day of each course, students delivered five minute presentations summarising their individual research projects; assessed by tutors, a subset of peers and themselves. The presentations challenge students to distill their intensive two-week projects into concise, clear, informative dialogue aimed at a 'scientific' audience. The marks are used in this study as a measure of student attainment for the field course and were gathered as a triangulated assessment approach, thus all speakers were assessed by all tutors, all students who are not speaking in sessions and by themselves. Full details of this process and the assessment criteria are in Langan *et al*. (2005). At the end of the course we carried out a more general 'exit' questionnaire (used in this paper to provide anecdotal evidence) and also carried out a survey of learning styles (Felder and Silverman 1988) of all students and tutors participating in the course.

Results

Network diagrams generated to visualise the complex learning interactions were simplified to include only data about perceptions of who provided the most important advice at each of the four learning stages (**Figure 1**). Numbers of student-tutor interactions suggested that students tended to disperse themselves fairly evenly between available tutors, with total fidelity between students and tutors very rare (**Figure 1a**). There were no obvious effects of gender occurring during networking with tutors (**Figure 1a**) or peers (**Figure 1b**). It is noteworthy that the two tutors who were never cited as 'most important' were the research technician and the member of staff who joined the course at the mid-way point.

Overall, almost 90% of students were cited by their peers as having provided the most important advice at (at least) one stage, with only one complete student:student interaction repeatedly being the most important for all four project stages. The highest number of citations as 'most important peer advisor' across the four surveys was eight (received from five peers). There were no significant differences between male and female students in the mean number of tutors they interacted with during surveys when considering tutor-initiated interactions (t = 1.01, df = 18, P = 0.33) or student-initiated interactions (t = 1.58, df = 18, P = 0.13). There were also no sex differences in terms of number of students that a student interacted with (t = 0.37, df = 18, P = 0.71).

Students that interacted with more tutors assessed themselves more highly (r = 0.57, df = 18, P = 0.009). However, there was no relationship between student attainment and number of tutors interacted with (for all interactions, r = 0.08, df = 18, P = 0.73, or for student initiated interactions, r = -0.25, df = 18, P = 0.28). Self-assessment was also not associated with the number of students a student interacted with (r = -0.27, df = 18, P = 0.25). Tutor marks were associated negatively with the number of students that a

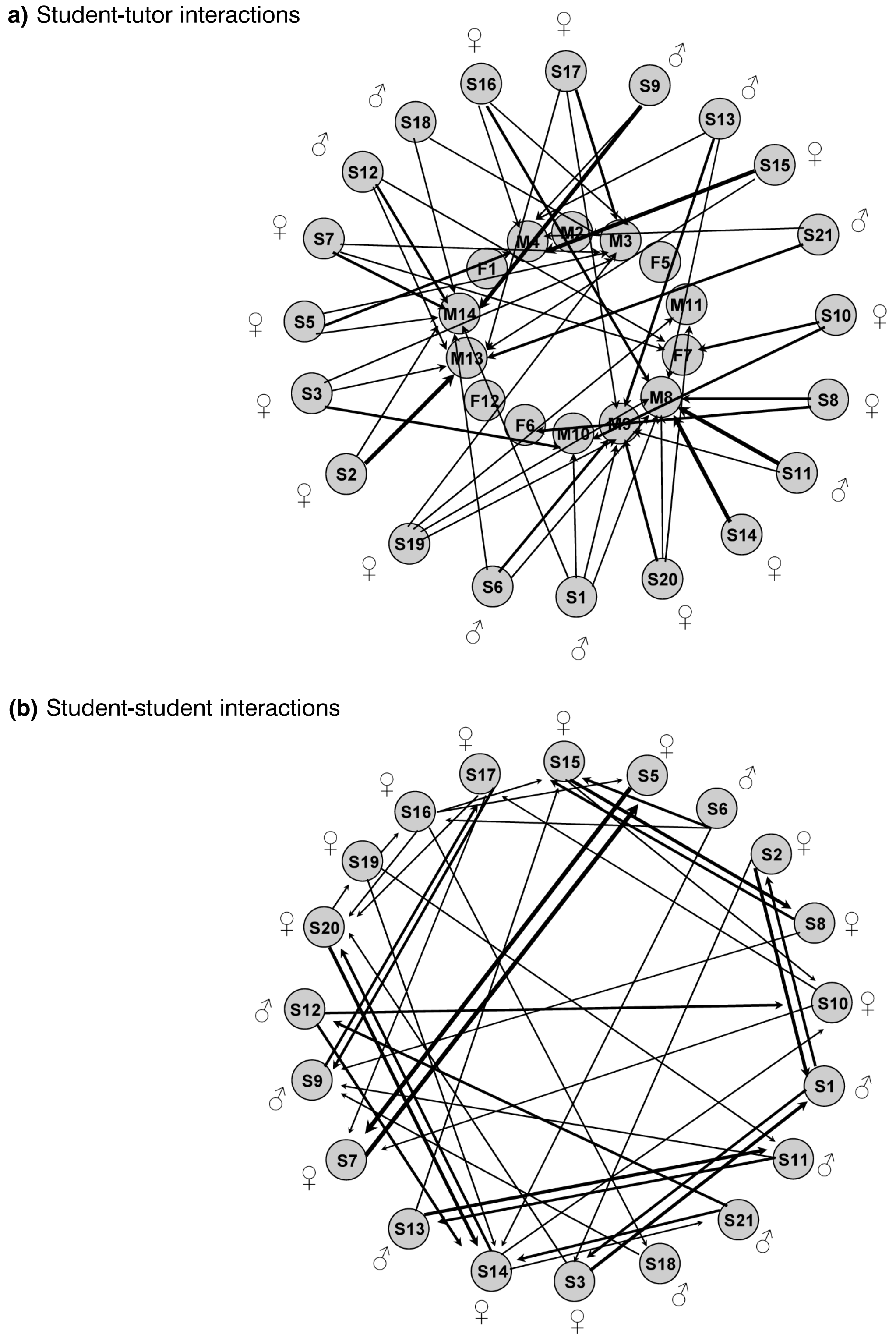

Figure 1. Network diagrams indicating who was cited during questionnaires as providing the most important advice at each of the four stages of project development. Line thicknesses indicate number of stages that (a) tutors, and (b) peers were cited (thickest - always cited as most important at all four stages; thinnest = cited as most important at only one stage). Both diagrams show student codes (S1-S20) and in (a) the inner circle represents the 14 tutors with 'M' denoting males and 'F' denoting females.

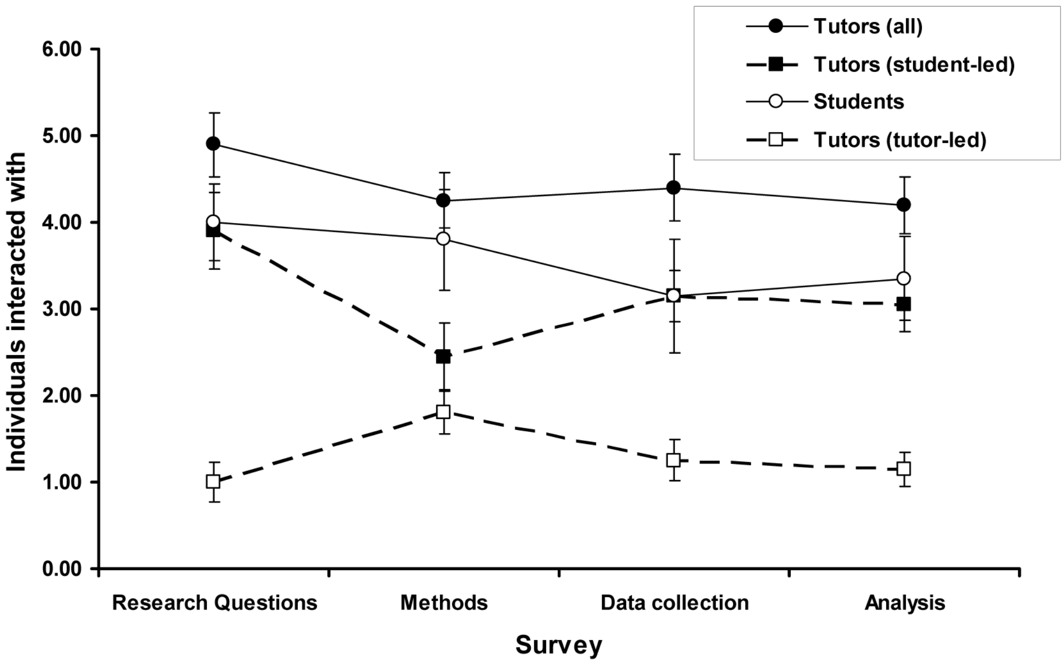

Figure 2: Mean numbers (± standard errors) of individuals a student interacted with over the four study periods varied in terms of both tutor and peer interactions

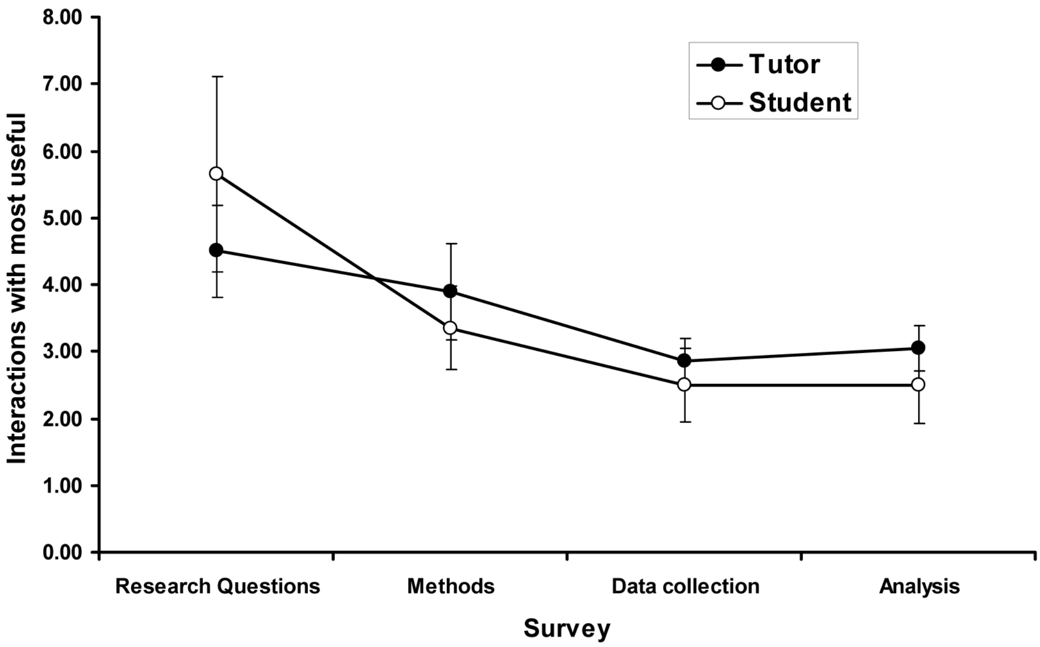

Figure 3: Mean number (± standard errors) of interactions with the most useful tutor and most useful student followed a very similar pattern across the four study periods

student had interacted with, such that students that interacted with more students received lower marks ($r = -0.46$, $df = 18$, $P = 0.04$).

The total numbers of people interacted with ('educationally'; i.e. in order to develop their projects) remained fairly constant during the course (**Figure 2**) typified by advice from 4-5 (29-36%) of tutors, mostly student initiated, and with about 3-4 (15-20%) of their peers. The only major change across the course was the increase in tutor-led advice (and drop in student-led interactions with tutors) after Stage 2 when methods were developed (alongside risk and ethical documentation). Consideration of the most important people

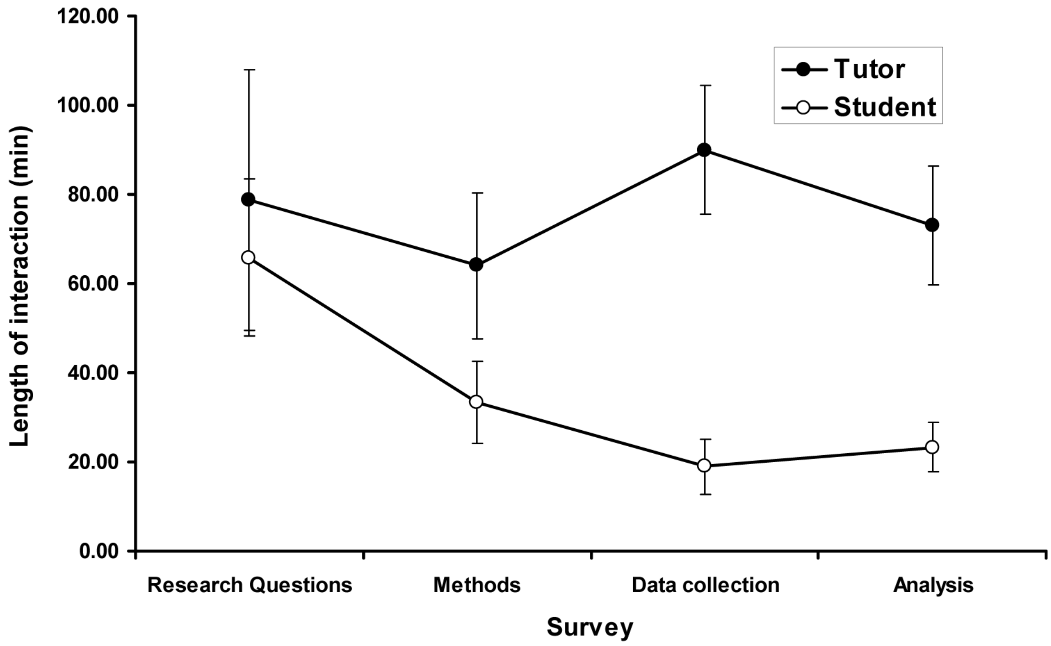

Figure 4: Mean duration of interactions (± standard errors) reported by students with tutors and students with students varied between survey periods. Duration of interactions was consistently longer with tutors than with other student and there was a general trend of shorter student:student interactions as the project progressed

that were interacted with suggests a general decrease in the number of tutors and peers interacted with as the projects developed (**Figure 3**) with (the most useful) tutors being engaged with more after the development of project ideas stage. Lengths of interactions with peers markedly reduced over the projects (**Figure 4**), whereas tutor discussions were lengthier than student:student interactions throughout the course. Interaction time peaked for tutors during the analysis phase when fewer, but longer, discussions about statistical tests and their outputs took place.

Discussion

Social and academic interactions during residential courses are complex and it would be very difficult to document and interpret complete network diagrams. There are many well detailed methodologies to explore social networking, notably 'Social Network Analysis' (de Nooy *et al* 2005). This study presents a preliminary and basic look at the some of the 'educational' interactions that took place. Working opportunistically and using a 'lighter touch' questionnaire approach (in four key stages) and 'indicative' measures of interactions (such as the person who provided the 'most useful interactions') we feel that we captured useful insights into networking behaviour of students. This study was made possible (and enhanced) by the residential setting and benefited from considerable choice of peers and tutors by students to interact with to progress the projects.

As educational researchers we attempted to remain independent and objective as members of the teaching team and the learning network under investigation. One benefit was that we experienced how difficult it was to estimate the timings of interactions, or remember more minor interactions. However, overall we feel that the importance of key interactions (which were most likely recorded) were useful to examine this study's aims and we accept losses of more peripheral information, such as exact durations of interactions, will likely have occurred.

Levin (1995) provides insights into the development of learner communities (from learning circles) and suggests a common published theme about notions of learning networks is the importance of a social structure for supporting network interactions. The process to achieve this is suggested as best designed to include clear, episodic phases with associated timelines. This fits well with the structure for the course we investigated, and may explain the perceived success of students that we gained from unstructured discussions with students (both in their own opinions and those of the tutors) of a productive social networking function to the field course (with perceived benefits to the quality and direction of their own research).

The findings suggest tutor interactions were longer than those with peers, and peer discussions reduced in duration over the field course stages. For many students, the project initiation stage catalysed student debate and a willingness to share ideas of potential projects. There were few tutor-led discussions in these early stages, this type of interaction growing in the next stage when tutors helped to confirm methods, resources and risk/ethical outputs. After settling on a project theme, there was a good dispersal of learners between tutors and a decrease in the number and length of interactions (the latter only for students). Fidelity throughout the project between student and the tutor considered ‘most important advisor’ a rarity. Using visual interpretation of the network diagrams as a preliminary (first line) of evidence, no obvious patterns arose to explain choices of people interacted with, when considering learning style types, gender or university affiliation. There is scope here for more detailed quantitative analyses. Anecdotal evidence supported an a *priori* expectation - that networking decisions were related to tutor subject specialisms and also the friendships in peer groups (that either developed on the field course or existed previously). However, we were wrong to anticipate that friendships would lead to many occasions when students cited friends as the most important interaction.

These factors need to be more carefully considered for future research. From the stage that students developed their methods to project completion there was a steady decrease in how often they interacted with the most important person at each stage. People cited as important usually changed during project development as learners became familiar with the social group. It seems that students had a fairly stable ‘norm’ in terms of the numbers of people they interacted with during project stages (4-5 tutors, 3-4 peers). The only significant variation in this pattern was identified only at a finer scale; i.e. tutor-led interactions increased during methods development maybe as a consequence of ensuring safe/ethical work. The general decrease in numbers of interactions could indicate greater independence in learning as the course progressed. This was balanced by an increase in the duration (and often depth) of discussions in the latter stages when the project’s findings became available.

There were misconceptions by those students that interacted most with tutors that they had achieved higher grades in the summative assessment. This raises questions that learners understood what comprises quality in the learning task and that tutor advice needs to be utilised (developed) and not reiterated without being questioned/transformed. It is feasible that in their previous learning experiences, incorporating a single tutor’s advice (who then marked the work) could have such a direct association. It is interesting to note that tutors discuss student projects on an *ad hoc* basis during the course, and it may be that it is known when students have increased assistance. If this knowledge is being used during assessment of the presentation then this should be built into the learning outcomes and the assessment criteria. Tutor marks also correlated negatively with the number of student interactions. In the absence of further evidence it may be over-simplistic to assume that this simply reflects that the ‘weaker’ students needed more support and this requires further exploration. This study provides a preliminary look at the complex networks and it is noteworthy that a broader aim of this work and previous studies (e.g. Langan *et al* in press) is to elucidate how students perceive their academic progress (for example comparing tutor and self awarded grades) and identify mechanisms to enhance learner autonomy (such as the network used to reach the final summative assessment).

These findings can inform practice, providing evidence of stages that need brief, focused advice from tutors and times when fewer, longer discussions are needed. We support the use of techniques to catalyse collaborative learning and learner networks and feel that highlighting the need to be receptive to approaches from peers (tutors and students) at key stages could be valuable. It is also recommended that cohorts are educated about how/why students and tutors should approach collaborative work to form interactive learning networks; and that rules for working are agreed in advance of study. Further work is currently being undertaken to classify learners and tutors using multivariate techniques, primarily in an attempt to combine the four learning style indices, with other basic classifiers (e.g. gender, university affiliation) to potential sub-groups within the network and further explore the networks observed.

Acknowledgements

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[O14] Open ended problem solving and the influence of cognitive factors on student success

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Abstract

Most problem solving activities in chemistry focus on the development of quantitative skills and the solving of algorithmic problems. Problems which are more open ended in nature are less often encountered and are more difficult to develop and to assess in terms of student performance. However, such problems present advantages in terms of motivating students and in providing a more realistic experience of problem solving as a skill.

We have developed a set of context-based open ended problems which are being used with chemistry undergraduates at several levels. The problems have been evaluated for intellectual demand and compared to traditional chemistry based problems of similar demand level. Students' success in tackling these problems is being investigated. The influence of cognitive variables such as working memory and field dependence is being investigated and attitude testing and interviews are being used to probe the effect of this style of problem on undergraduate engagement and motivation.

Introduction

A survey published recently by The English Manpower Services Commission showed that 80% of the top 10% of British companies invested significant amounts of time and money into training (Buzan, 2003). Employers from around the world have identified the main areas requiring improvement as: Oral communication skills, written communication skills, creative thinking, planning, problem analysis, problem solving, motivation, analytical thinking, acquiring further knowledge and good interpersonal skills. Many of these skills, however, are often absent, and students need to have acquired these skills and be able to tackle unfamiliar and/or open-ended problems (Belt *et al*, 2005). The ability to apply their knowledge to the situations that their future employers will present them with is essential.

Problem Solving

'Whenever there is a gap between where you are now and where you want to be and you don't know how to find a way to cross that gap, you have a problem' (Hayes, 1991). Problem solving is something encountered in all aspects of life (Reid and Yang 2002). It is a skill that makes a large part of a graduate's employment and students should be better prepared with problem solving skills when they reach the workplace. Developing problem solving skills has been the subject of much research into science education (AAAS, 1993, NRC, 2003, Barak and Dori, 2005 and Zoller, 1999). The types of problems set in examinations or assessments in higher education chemistry are largely algorithmic (Kempa and Nichols 1983). Algorithmic problems use mainly lower order cognitive skills (LOCS) whereas more open ended problems call upon higher order cognitive skills (HOCS). Setting more challenging problems will enable the development of HOCS, and

allow students to overcome those challenges and solve more open ended problems. This approach will help a student's progression through the stages of intellectual development.

The use of context to teach sciences has been the subject of much research. Obviously solving chemistry problems requires a good knowledge of chemistry (Frazer, 1982). However, problem solving in many cases has been unsuccessful even when students possessed most of the requisite knowledge (Sumfelth, 1988, Shaibu, 1992, Aidigwe, 1993 and Lee *et al*, 1996). Students with basic knowledge of chemical terms did not recognize the relationships between concepts and therefore were unable to apply their knowledge (Sumfelth, 1988). Problem-Based Learning aims to stimulate students to learn by presenting them with a real life problem that they wish to solve (Margetson, 1998). Rather than just giving them the content and saying, 'learn this', questions are asked before all the information is given. Using previously acquired knowledge, acquiring new knowledge and learning new skills, they are expected to, answer the question, solve the problem.

Cognitive styles

Much research has been undertaken into the factors that affect problem solving (Norman and Yang, 2002). Gabel and Bunce (1994) proposed that the factors affecting students' success in problem solving are threefold: the type of problem and the underlying concepts of the problem; the learner characteristics, including cognitive styles, developmental levels and knowledge base; and learning environment factors, including problem solving strategies or methods, individual or group activity.

Working Memory Space (WMS)

The WMS is where new information from the outside world and information retrieved from long term memory (LTM) is held and processed. The size of the WMS coupled with previously held knowledge in LTM is therefore a major determining factor in learning and problem solving (Johnstone and EL-Banna, 1986 and Johnstone, 1997). In group work the individual working memory spaces of the members of the group is combined. This can minimise the effect of limited WMS (Reid and Yang, 2002). Many studies have concluded that co-operative problem solving has lead to greater success (Johnson and Johnson, 1975, Tingle and Good, 1990, Basili and Sandford, 1991, Kempa and Ayob, 1995 and Qin *et al*, 1995). Such group work can also help overcome misconceptions by sharing information, exchanging experiences and ideas (Basili and Sandford, 1991). Tingle and Good (1990) studied 178 high school students in chemistry and provided further evidence that students were able to teach each other by using models and analogies and asking questions during group discussion. Success in problem solving may increase as a result of this.

M-Capacity

M-Capacity is analogous to working memory and is defined as the mental-attentional energy available for a particular task (Pascual-Leone *et al*, 1978). It has also been termed M-power, the power of a person's mental concentration mechanism (Niaz, 1988). M-capacity can be broken down into structural M-capacity (M_s), the total available M-capacity and functional M-capacity (M_f), the amount of M-capacity that is actually used. For those with high processing capability M_f is said to be close to M_s and those with low processing capability M_f is much lower than M_s. As with the information processing model (Johnstone and EL-Banna, 1986 and Johnstone, 1997) the M-capacity of a person is a determining factor in problem solving.

Field Dependence/Field Independence

Field Dependence/Independence is also a determining factor in academic achievement. A student who is field dependent has difficulty separating relevant information from irrelevant information or 'signal from noise' (Tsaparlis, 2005). A field dependent student will be processing both signal and noise and will therefore be using more functional M-capacity (M_f) than a field independent student who will process only signal (Niaz, 1989).

Attitude and motivation

'If university teachers are asked, what is the most important student characteristic associated with successful studies, they usually mention traits such as attitude, motivation, and genuine interest.' (Berg, 2005). Through pre and post course attitude questionnaires Berg found that several students displayed significant changes in attitude towards learning chemistry, both positive and negative (Berg, 2005). The most significant changes were further investigated through interviews with the students.

Methodology

This paper describes the investigation of the effect of cognitive styles and attitude on the problem solving abilities of students in a department of chemistry. A set of context-based open-ended problems was designed with the aim of helping students develop higher order cognitive skills. Tests for cognitive styles were performed by groups of students and were followed at a later date by problem solving sessions. Attitudes towards chemistry, problem solving and the use of real-life context were also assessed by the use of questionnaires, before and after the problem solving sessions. The problems were evaluated for difficulty and then ranked by the students after the problem solving sessions. Problems were tackled individually and in groups. Groups were arranged according to field dependency scores. Data was then gathered from the test results, performance in the problem solving sessions, performance in A-Levels and the degree so far. Statistical analysis was then performed on these data to look for correlations between any of the variables. Attitude questionnaires were then analysed for significant changes. From this a small number of students were selected for interviews.

Below is an example of one of the problems.

> *The rivers and oceans contain levels of dissolved gold of between 5 and 50 ppt. Extraction of gold from seawater has been seriously considered many times. Approximately how many kg of gold are present in the world oceans?*

Results and Discussion

Early results show a few general indications: There appears to be a correlation between A level scores and problem solving ability. Attitudes towards problems with real life or work related context have increased positively. All of the students found the more open ended problems more challenging yet more enjoyable than conventional ones. From the sessions with the 30 05/06 Year 3 students, where all the problems were tackled individually, there is an indication of correlation between M capacity and attainment, i.e. problem solving ability. From 60 06/07 Year 2 students' sessions, where problems were tackled in groups and individually, there appears to be a correlation between Field Independence and problem solving ability.

The interviews with year 2 students proved encouraging with plenty of positive comments about the problems. E.g. '*fun, got to discuss and decide which route to take to solve problem', 'explore range of answers and knowledge of chemistry', 'better to have questions in context!', 'everyone threw in own ideas and discussed', 'had to use brain in a better way', 'enjoyed whole experience, exercised mind'.*

More statistically significant data will emerge with repeated sessions with each year of the chemistry degree course and this year's second year students will be followed throughout their course enabling a longitudinal study to assess improvements in problem solving ability with practice. Further interviews and case studies will take place and analysis of exam scripts to assess performance on algorithmic problems will enable comparisons to be made with the new problems. The impact of industrial experience will also be investigated in problem solving sessions with year 4 students some of whom have had a year out working in industry and others who have not. New problems with a more work-based/industrial context have been prepared for these sessions.

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[O15] Podcasts in undergraduate science education (or 'can you teach physics in .mp3 format?')

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Keywords: physics education, podcasts, clickers

Abstract

As more and more students acquire mobile devices capable of playing audio and video (phones, music players such as iPods, laptops) many science educators have dabbled with podcasts and videocasts to deliver educational content. The enabling technologies are new, but the underlying educational principles are not. The default action appears to be 'podcast one's lecture'. But is this enhancing student learning or is it potentially a retrograde step?

This contribution surveys how podcasts are currently being deployed in the teaching of undergraduate science curricula, citing examples from current practice. In addition, we present results from a final year student Honours project at the University of Edinburgh that has quantitatively investigated the efficacy of using audio podcasts to address student misconceptions about rotational motion with a cohort of over 200 students. Suitably prepared audiocasts, even without images or video, are shown to have a small, yet consistent positive effect on student understanding (evidenced by in-class questions a few days later, with data collected using a personal response system). The potential uses of podcasts in teaching contexts are discussed.

Introduction

Podcasting, a compound of the words iPod™ and broadcasting, is a relatively recent addition to the collection of tools that collectively make up the next generation of digital services, often termed 'Web 2.0' tools. The growth in the number of podcast feed pages, where users can subscribe to a series of podcasts and automatically have new episodes 'delivered' to them, is staggering. There are now more feeds than the total number of radio stations in the world.

It is therefore no surprise that this expansion, fuelled by the widespread availability and low cost of personal hardware, has given fresh impetus to educators to exploit the opportunities this offers. Apple have sold over 8.5 million iPods™ in the last quarter of 2006 alone and students are some of the biggest buyers of consumer electronics like laptops and personal audio players. It is a point of ongoing debate as to whether or not this is genuinely a novel educational development, or merely a re-invention of an old wheel in a new technological guise. However the response from the educational community has been swift: as of October 2006 the iTunes™ Music Store lists over six thousand podcasts in the education category.

A major challenge is to successfully establish mechanisms that integrate these new technologies into the curriculum, in pursuit of enhanced and / or more flexible, 'learner-centred' learning. However, the default method for utilising podcasts seem to be to record lectures (there are many examples of simply audio recordings of lectures in the relevant area on the iTunes™ music store). Notwithstanding the value to some students who may be able to review the lecture, whilst in possession of appropriate other notes or visuals, or to ameliorate disability or accessibility issues, this does seem a somewhat unimaginative use of the technology.

A detailed review of the educational possibilities of audio and or video as distribution media is beyond the scope of this contribution. Here we briefly mention some recent reports of deploying podcasts in educational contexts. The range of potential uses for a podcast is broad; a good summary is presented in annotated case study form (Nie, 2007). Within the UK, the IMPALA project (Impala, 2006) has collected a valuable repository of online materials (papers, screencasts etc) covering the broader pedagogical possibilities offered by podcasts (Nie, 2006), case studies of use to provide supplementary materials (Edirisingha, 2006), and orientation to future in-class activities (Woodward, 2007) going far beyond the simple act of a digital recording of a lecture. Chan and Lee have described a pilot study that uses podcasts to address student preconceptions and anxieties on an information technology course at an Australian University (Lee, 2005; Chan, 2005). A subsequent study investigates student-generated podcasts (with minimal staff input), prepared to support new students (McLoughlin, 2006). A study in Engineering in Leicester (Edirisingha, 2006) describes the use of 'profcasts', material distinct from on-campus teaching or self-learning activities. The same authors also propose a model for integrating these within blended learning environments.

This paper addresses the use of podcasts as pre-lecture resources, to provide advance exposure to conceptually-difficult topics to be covered during class teaching in the following week. Our aim is to explicitly test how, if at all, podcasts can be used to enhance student understanding of these concepts, in a subject context that traditionally relies on visual representation to communicate concepts. We describe some of the experiments we performed in order to obtain some quantitative data on the usefulness of prior exposure to material. We then evaluate the results, conclude with some implications this might have for the use of podcasts in teaching.

Methods

The context for this investigation is the introductory first-year Physics course at the University of Edinburgh, the pedagogical design details of which have been reported elsewhere (Bates, 2005) together with details of students' behaviour in using the online support materials to aid learning (Hardy, 2005). The course has an extensive online component to complement face-to-face teaching, and approximately 250 students enrol each year. Recently, we have successfully integrated an Electronic Voting System (EVS) into whole-class lectures (Bates, 2007), which is the mechanism used to collect student responses to various questions during the lectures for later analysis. The handsets are issued to students at the start of the course, and retained for its entire duration. Loaned to students like a library item, we retain a record of which student 'owned' which handset.

The main challenge for this investigation was how to provide clear, systematic, and reliable data to support ideas that are, at worst, wholly abstract. We chose to create two podcast episodes, on targeted topics that we know (from previous experience teaching the course) students find difficult. These would be delivered a few days ahead of the material being covered in class, with a few weeks between the two episodes. The podcasts were designed to engage the students with the material and to prompt them to think about what would be covered in the following lectures, and question their own understanding about the topics based on any previous exposure to them. They contained relevant examples to contextualise the material, and were both approximately 8 minutes long. Scripts are available online (Stevens, 2007).

The class was divided into two groups according to the days of attendance at course workshops. (Students sign up to whichever workshop day they choose, or their timetable permits.) Those electing to do workshops on Monday and Tuesday were allocated as being in Group 1, those on Thursday and Friday in Group 2. In the first experiment, the podcast was delivered to Group 1 students at the start of their respective workshops. Three days later, the whole class was posed various concept questions at the start of a lecture. These were answered in the usual way using the EVS handsets and data saved for analysis. A few weeks later, the experiment was repeated with Group 2 receiving the podcast in their workshops and the whole class being questioned three days later. In effect, by repeating the experiment in this way, each half of the class acts as a control group for the other half. Issues of equity are addressed, as each student received one (and missed one) podcast.

By broadcasting the podcast, we were making use of a captive audience. In fact, it is suggested by other pilot studies that the majority of students play podcasts as downloads through a PC (Woodward, 2007). In some respects, it may seem that we had somewhat artificially distorted the concept of a podcast, by not offering it for download. If it were offered for optional subscription or download to a selected portion of the class, we could not be sure of uptake. The issue of mobility is not crucial here; we are not looking to open up new learning avenues by exploiting the fact that the material could be used anywhere. Instead, we are aiming to tap into student self-study time, be that on the move or at a PC.

A more important issue was to ensure that, on average, the two groups of students could be considered equivalent in ability. This was evaluated on the basis of student performance in an online diagnostic test undertaken at the start of the course, based on the standard physics concept test, the Force Concept Inventory (Hestenes, 1992). The two groups (N=85 and 88 students respectively) had mean scores of 18.6 and 18.0 (both out of 33), with standard deviations of 6.1 and 7.1 respectively. The two distributions returned a Student T-test value of 0.35, suggesting there is indeed no significant difference in ability between the groups.

Here, we report only selected results from the second podcast episode (due primarily to space limitations). This podcast was designed around misconceptions concerning angular momentum and content and questions were developed together. An initial question was used as a starting point, one that had seen much use previously and had typically produced very poor performance by students indicating severe misconceptions. Three others were also designed, each to address a particular misconception about angular momentum. The content of the podcast would then be designed specifically aimed at resolving these misconceptions. It was decided to use two separate voices to give a conversational tone to the podcast and we related the material directly to that used in a formal teaching environment (the lectures), by using two 'personalities' who crop up frequently in the course. 'Alison and Billy' (A and B) are used during lectures to concretize abstract algebraic examples.

We made use of a simple, every-day example (observing a car being driven) that included all these different aspects and to state some of the actual misconceptions in the podcast script. The questions are illustrated in **Figure 1**. The first is designed to lead the students in gently, with a very easy and often-stated example. Question 2 is the original question from previous

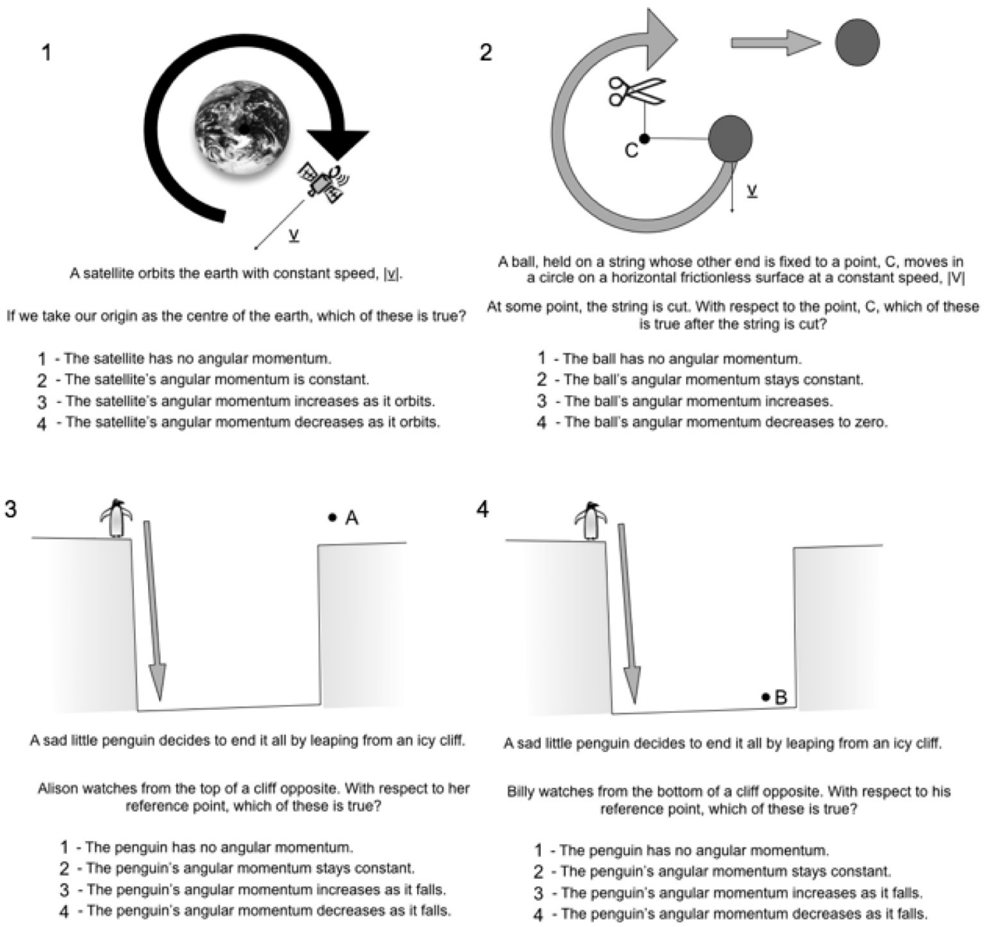

Figure 1: Questions used to evaluate the impact of the podcast

course content, similar to that shown in **Figure 1**, in the sense that a similarly small (often negligible) number of students choose the correct answer (2). The classic misconception in this case is illustrated by choosing answer 1. Questions 3 and 4 are designed to test the students understanding of how different choices of origin and changing velocity influence the angular momentum of the object. The correct answer in both cases is 3. These two questions are similar in scope, and go beyond the concepts tested in the previous question.

The podcast was then delivered to Group 2 (on Thursday 9th and Friday 10th November 2006) and the above questions posed in the lecture on the following Monday. The total number of respondents for these questions varied between 99 and 105.

Results

A record of handset ownership enabled us to correlate answers with group membership. In analyzing results, we made a number of pragmatic assumptions:

- Students attended workshop classes on the days they were allocated to attend them.
- Students brought and used their own handset in lectures.
- Students answering outside the possible choices (e.g. number 5 or above for the questions shown in **Figure 1**) were discounted.

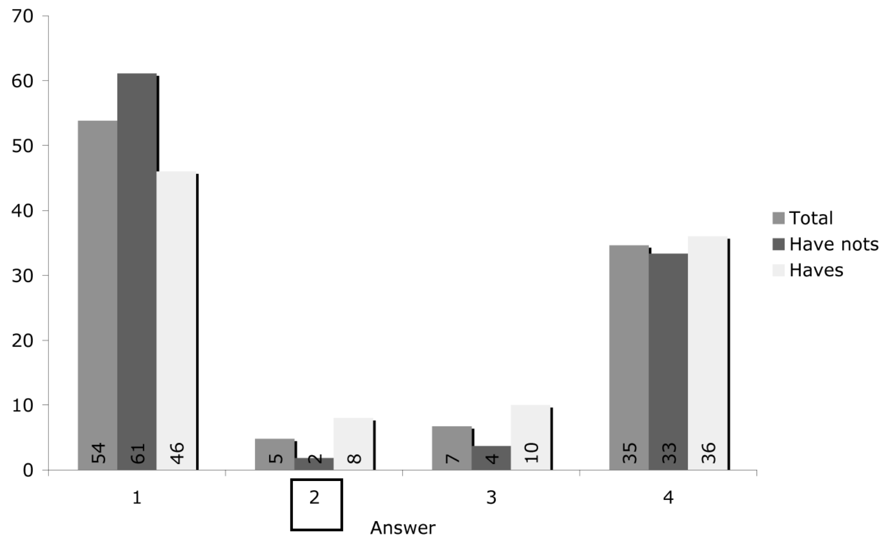

Figure 2: Response distribution for question 2

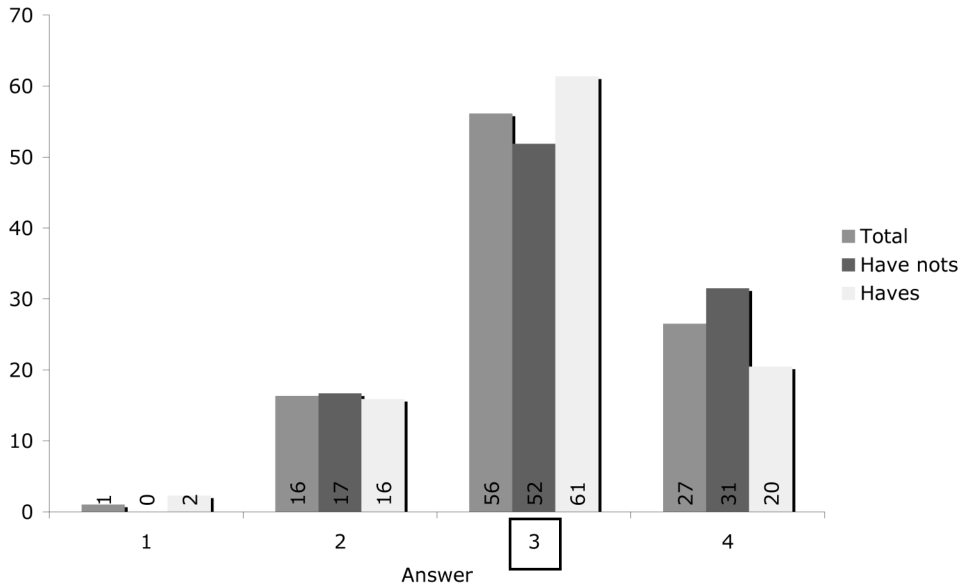

Figure 3: Response distribution for question 4

Selected answer distributions to the questions in **Figure 1** are shown in **Figures 2** and **3**, broken down into groups who 'had' and 'had not' heard the podcast. The results for Question 1 (not shown) confirmed that nearly all students found this question to be straightforward, requiring a pre-University level of conceptual understanding of circular motion. In the case of those students who had earlier heard the podcast, practically this entire group (98%) chose the correct answer, compared with 88% from the group who had not heard the podcast.

Question 2 addressed a commonly-held misconception about angular momentum. What is particularly interesting in **Figure 2**, is that not only do a slightly larger proportion of those students who had the podcast choose the correct answer (item 2), appreciably fewer chose the 'classic' incorrect answer (item 1), which is indicative of a fundamental misunderstanding, which can be paraphrased as 'only things moving in a circle have angular momentum'.

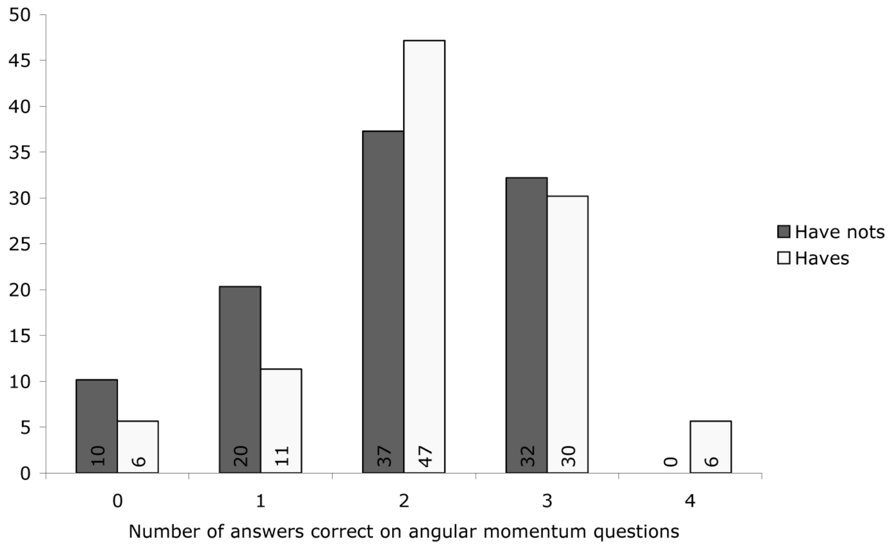

Figure 4: Number of correct responses for angular momentum questions

The observed trend of slightly more 'haves' than 'have-nots' choosing the correct response is again seen in the responses to questions 3 and 4. The results for question 4 are illustrated in **Figure 3**. The fourth question attracted a larger proportion of incorrect answers than the third, despite the fact it is essentially the same question.

In assessing the response distributions of all four questions collectively, there is a consistent, if small, trend. In each case, approximately 10% more of the 'haves' get the correct answer than the 'have-nots'. To further investigate this, we have calculated the number of correct answers for each student from the set of four angular momentum questions used after the podcast. The resulting histogram is shown in **Figure 4**. The distributions are similar, with a slight shift of that for the 'haves' to a higher number of correct questions. This is reflected in the mean number of correct answers. For the group of students having not had the podcast it was 1.9, for those who had it was 2.2. The results should not be over-interpreted though; both distributions have large standard deviations and a Student T-test does not indicate any statistically significant difference between them.

Discussion

The subtitle for this paper was 'Can you teach Physics in .mp3 format?' The simple answer is a cautious 'probably' but of greater importance is to address why you might want to do that and what the additional benefit to the learner is intended to be. We do not claim to have quantitatively demonstrated the unequivocal effectiveness of podcasts in improving conceptual understanding. In some ways, we had set ourselves high targets that mitigated against this. We were using only audio in a subject where exposition via diagrams, sketches and mathematics are believed to be essential to its successful teaching. We were aiming to target and address widely-held misconceptions which have confounded large proportions (sometimes, all) of previous cohorts. Finally, we had no previous experience of writing, producing or delivering such material for maximum effectiveness, and learned a great deal on-the-fly.

Evaluating the impact of these podcasts, it seems fair to say that the effectiveness of the podcasts seemed to increase when the content was more directed and as our own experience of authoring and integrating them within the course developed. We had, and in some respects continue to have, reservations about whether podcasting is the best way to approach conveying concepts in physics, an inherently visual subject.

One area under active development is the use of a multiplicity of media in more skill-focussed activities. We are currently devising a new course aimed at fostering and enhancing problem-solving skills, which is deliberately biased towards skills over content. This course will be entirely activity-based with no formal lectures. Informed by what we have learned here, we plan to make use of multiple media outputs (podcasts included) to convey techniques or examples to students.

The future use of emergent technologies in educational contexts seems set to develop apace. But this should not be because it is the latest fashionable thing to do. The aim, to quote Millar (2001, p289) should be to engage the learner;

> *'Science should be taught in whatever way is most likely to engage the active involvement of learners and make them feel willing to take on the serious intellectual work of reconstructing meaning'.*

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[O16] Web 2.0 and science education: beyond entertainment

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Keywords: learning objects, blended learning, podcasts, video, RSS, web 2.0

Background

The second-generation of web-based services ('web 2.0') are distinguished by 'an architecture of participation' (O'Reilly 2004), e.g. blogs, wikis, podcasts, etc, which distinguishes them from the passive 'lecture notes online' syndrome associated with the early days of the world wide web in higher education. In theory, online interactions should facilitate student attributes such as reflection (Kolb, 1984), and the acquisition of skills beyond the basic 'knowledge' competence in Bloom's taxonomy of educational objectives (Bloom, 1956). However, according to Jakob Nielsen, it is not possible to overcome participation inequality, the phenomenon where a very small proportion of users actively contribute to online discussions (Nielsen 2006). Such inequality could severely limit the effectiveness of new web services for learning. My previous research has shown that Nielsen's findings are not necessarily true in an educational setting where students contract to undertake specified tasks in return for course credits (Cann *et al* 2006). In this situation, it is possible to use the assessment lever to modify user behavior so that participation inequality is eliminated and students gain higher level competencies through online interaction. As the author of an academic blog and podcast which attracts thousands of listeners per month (microbiologybytes. wordpress.com; Cann 2006a), I have been investigating the problem of how to translate the success of this public forum into the design of learning objects which will be equally popular with my own students.

Podcasts are characterized by the distribution of media files over the internet via syndication feeds. Typically, users subscribe to RSS (Really Simple Syndication; Cann 2006b) feeds using an aggregator or podcatcher, such as iTunes. Almost all podcasts have a homepage on the internet so that users can find and subscribe to the podcast. Sometimes, this is in the form of a blog (weblog), so that user-generated comments and feedback can be shared. On the pages of microbiologybytes.wordpress.com, I not only make the podcast feed available to new subscribers via hyperlinks, but for accessibility reasons, also publish text versions (with images) of the audio and video files delivered via the RSS feed. In addition, I also provide static hyperlinks to the media files which subscribers receive via the feed. Analysis of server logs reveals that although the podcast has over 1200 regular subscribers, media file downloads delivered via casual 'driveby' clicks on the static hyperlinks routinely exceed subscriber downloads by a factor of five or six to one. In addition, the existence of stable hyperlinks to media files means that the podcasts tend to be consumed as reusable learning objects rather than being seen as an ephemeral magazine type offering. These experiences and observations framed my thinking as I began to investigate possible roles for audio and video podcasts as learning resources, in particular the value of the RSS subscription model for delivery of learning media.

Methods and Evaluation

Using two cohorts consisting of ~150 first year and ~90 second year biological sciences students, I delivered additional supplementary support materials to these groups of students via an institutional VLE. On a first year key skills numeracy and IT module, I attempted to use weekly audio podcasts as an adjunct to online lecture notes and face to face computer sessions in a blended learning model of student support. As with the public podcasts, in addition to an RSS feed, static hyperlinks were made available to students via the VLE so that the media files could also be downloaded without a podcast subscription. The podcasts ranged in length from 7 to 20 minutes in length and included feedback on the previous assessment, with some music in each episode.

Figure 1: Recording during a help session for use in a feedback podcast

Although measurement of podcast usage statistics is fraught with difficulties, it is clear that the popularity of my public audio podcast did not translate direct to the student cohort studied. Students accessed the audio files ~5200 times, but this equates to an average of only 0.32 downloads per student per episode, with a 2:1 ratio of direct downloads to subscription downloads. 22% of file downloads were made on campus, 78% from elsewhere (including halls of residence). A total of over 80 different web browser versions, podcatchers and web-based feed readers were used to access the recordings, emphasizing the importance of adhering to standards in writing links and feeds.

This quantitative usage analysis was extended by qualitative research via a feedback questionnaire and randomly selected student focus groups. Only 2/23 (9%) of the focus group attendees had listened to any of the weekly podcasts, although 8/23 (34%) had listened to any podcast previously. Students were more likely to have listened if they were familiar with other non-academic podcasts. The main reasons cited for not listening were that they ‘didn’t feel the need’ or there was ‘not enough time’. Technical issues and unfamiliarity with podcasting were cited as significant barriers to uptake. Strikingly, the podcasts were seen as ‘entertainment’ or ‘not relevant’ to academic study.

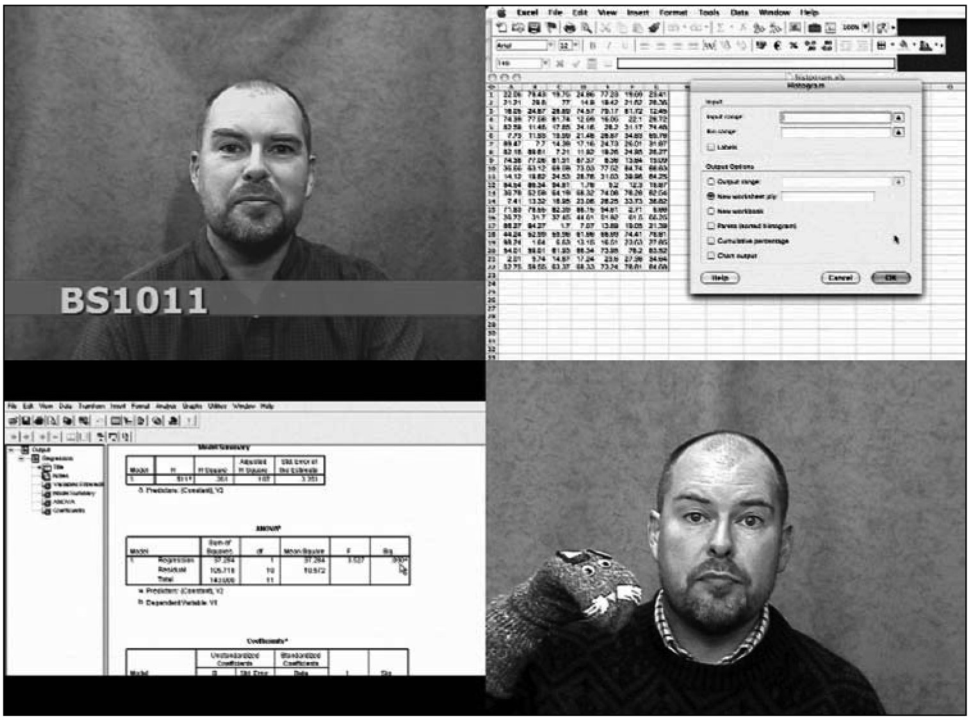

Figure 2: Videos

As a result of these findings, for the second part of the module in the following semester, a number of changes were made. The RSS podcast subscription model abandoned in favour of direct access to short YouTube style videos (www.youtube.com) via the VLE. The videos ranged in length from three to five minutes and consisted of a short ‘talking head’ introduction, screencasts (digital recording of computer screen output with audio narration), and occasional interventions by a puppet character with helpful tips.

In contrast to the audio podcasts, the video format generated an average 1.75 downloads per student per video, over five times the response rate from the same cohort to the audio files provided the previous semester. Possibly because of the size of the video files (5-12 Mb), 58% of accesses occurred on campus and 42% from elsewhere. A total of 110 web browser versions was used to access the video files via the VLE.

The focus group comments supported the positive reception for this format in comparison to the audio podcasts. 9/12 (75%) of students had watched one or more of the videos (c.f. 9% for the podcasts). 11/12 (92%) had watched an online video clip previously, implying that familiarity with this format as well as direct ‘click and watch’ access was responsible for much of the increased uptake. Other comments from the students included ‘Much better than the podcasts’ and ‘I prefer the videos to your lectures’.

A further trial of the video format was carried out on a cohort of ~90 second year students to support a set of statistics assessments. The format was the same as for the first year cohort but without the puppet character. This group responded with an average of 0.92 downloads per student per video, nearly three times above the response rate to the audio podcasts.

Discussion

In both public and student cohort-specific trials, the push delivery subscription model, and RSS feeds in particular, is a barrier to access. While a small minority of eager consumers are happy to subscribe, a participation inequality phenomenon is evident here as in other forms of online interactive media, e.g. blog comments. A large majority prefer the drive-by click and download model (pull rather than push) to access the learning objects to the subscription model. In the case of student cohorts accessing the materials via a VLE, this is a potential advantage rather than a problem, simplifying delivery of learning objects by eliminating multiple channels and the additional software necessary to access them (podcatchers, iTunes, etc).

The initial studies I have carried out raise a number of points which require further investigation. The runaway success of 'viral' video sites such as YouTube provides a model for high levels of penetration into student populations which cannot be ignored in the design of learning materials, but considerable further research is necessary to determine both the effectiveness of these new formats and cost-benefit analysis of their production. One of the most striking findings from the focus groups I have conducted are students preconceived perceptions of these new formats. Students have repeatedly commented that they will only listen to audio podcasts on computers because these are associated with 'work', whereas personal mobile devices such as mp3 players and mobile phones are reserved for 'entertainment'. Students carve out a range of online spaces and are reluctant to let social and academic spaces overlap. This finding has important implications for the design of learning materials and delivery channels.

Based on these observations, careful thought needs to be put into the design and production of educational 'viral' videos. Excessive informality may be less attractive to students who perceive themselves to be in an online 'work' environment than a slightly more authoritative delivery. The apparent informality of the most successful 'viral' videos can be deceptive – lonelygirl15, the most successful YouTube video blog (en.wikipedia.org/wiki/Lonelygirl15), was in reality a carefully crafted product of skillful filmmakers.

Widespread use of online video learning objects has implications in terms of staff resources and training. Traditional HE audiovisual departments are not ideally placed to produce this type of learning material.

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[O17] Research Skills Audit Tool: an online resource to map research skills within undergraduate curricula

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Keywords: audit tool, skills, research, assessment, learning

Introduction

The first interdisciplinary project of the University of Reading's Centre for Excellence in Teaching and Learning in Applied Undergraduate Research Skills (CETL-AURS)[1] was to 'map' research skills teaching and learning within undergraduate curricula. Here, research skills are defined as a combination of transferable[2] and discipline-specific (cognitive, technical and practical) skills.

Increasingly, employers are demanding that graduates enter the workplace with the necessary skills and knowledge to benefit the organisation with little further training, particularly with regard to transferable skills. These essential and desirable skills include communication (written and oral), IT and team-working. Many academics suggest that the use of transferable skills is intrinsically embedded within curricula to a greater or lesser extent; for example, course work is expected to be submitted before deadlines, oral communication skills are used extensively during in-class presentations and collecting additional information is essential for research projects and exam revision. These few examples are dependant on time-management, IT, communication and information handling skills. However it is often less clear if and where students are taught or have opportunities to further develop their transferable skills.

Several universities have perceived the teaching of transferable skills to be important enough to warrant the creation of compulsory skills modules. For example, Psychology students at London Metropolitan University must attend a discipline-based skills module (Elander, 2003). Examples of Universities offering specific skills modules include Exeter, Middlesex, Dundee and Gloucester. These usually supplement the embedded teaching of skills in other modules. Nevertheless, the use of dedicated modules to teach transferable skills has been questioned. Knight and York (2002) suggested that skills learning is too complex a process to be satisfied by a single module; they argue that embedding the teaching and practice of transferable skills throughout a degree programme allows the student to utilise and develop skills in different situations, which is more effective than using the skill in 'artificial situations'.

By their very nature, discipline-specific skills are embedded across a range of modules. The degree to which these skills are reviewed, in terms of how applicable or appropriate they are, both in terms of the curriculum and to employers, is usually dependant on individual module co-ordinators. Within the sciences, as technology improves and experimentation results in a greater understanding of processes, the type and range of discipline-specific skills being taught is likely to change, which is important because the needs of employers are also likely to change over time. The Higher Education Academy has recently produced a range of 'Student Employability Profiles'[3], which list the skills that should be gained by students studying particular disciplines. It is anticipated that, in response to these profiles, HEIs will be under increasing pressure to identify where and how discipline-specific skills are being taught and assessed within curricula. Regardless of the method of delivery, there is increasing pressure to identify skills learning opportunities in degree programmes and in individual modules (deVries and Downie, 1999). It has been suggested that when developing a new programme, the skills criteria can be identified at the initial planning stages, therefore modules can be tailored to teach and assess the desired skills (Borthwick, 2002). For existing programmes, however, identification of existing skills teaching and assessment is required to determine whether or not there are any deficits in skills learning opportunities.

The CETL-AURS Research Skills Audit Tool

The research skills audit tool is one of a number of approaches CETL-AURS has adopted to investigate research skills teaching, learning and assessment. Parallel projects include the development of resources for prospective students to describe the importance of research skills within undergraduate curricula, and a series of student questionnaires and linked workshops, which attempt to quantify students' perceptions of research and to provide opportunities for them to reflect on their research skills competencies.

The aim of the CETL-AURS research skills audit tool is to provide a quick, user-friendly resource to identify the range of research skills being taught and assessed within individual modules, as well as providing information on the types of feedback provided to support students' future skills development. Module data can then be combined to provide an overview of research skills teaching, learning and assessment across an entire degree programme. This is important because whilst it is clear that research skills teaching is firmly embedded within curricula at the University of Reading and elsewhere, detailed information regarding where or how these skills are taught and assessed is often lacking; this in turn raises the question of the scope for skills progression within curricula. One key difference between the research skills audit tool and similar studies that have been previously conducted is that here research skills auditing can be used alongside data from the HEA's Student Employability Profiles. This can help facilitate discussions between academic staff and employers in terms of skills expectations and may help to better align curricula with the changing needs of industry.

To support the development of the research skills audit tool specialist software called PROFILE (www.profile.ac.uk), developed at the University of the West of England, was used to support the tool's interactivity, data collation and ultimately the wider dissemination of this skills mapping resource.

Overall the research skills audit tool comprises four sections and to make this resource as user-friendly as possible answers to questions generally require no more than a box to be 'ticked', together with an option to provide more detailed information. The audit starts with the user entering details of the module, including its title, module code, credit weighting and the degree programme within which it operates.

The first section of the audit tool (**Figure 1**) investigates the types of transferable and discipline-specific skills being taught and the range of teaching methods being employed to teach these skills. A free text box allows the user to enter as little or as much information about the discipline-specific skills.

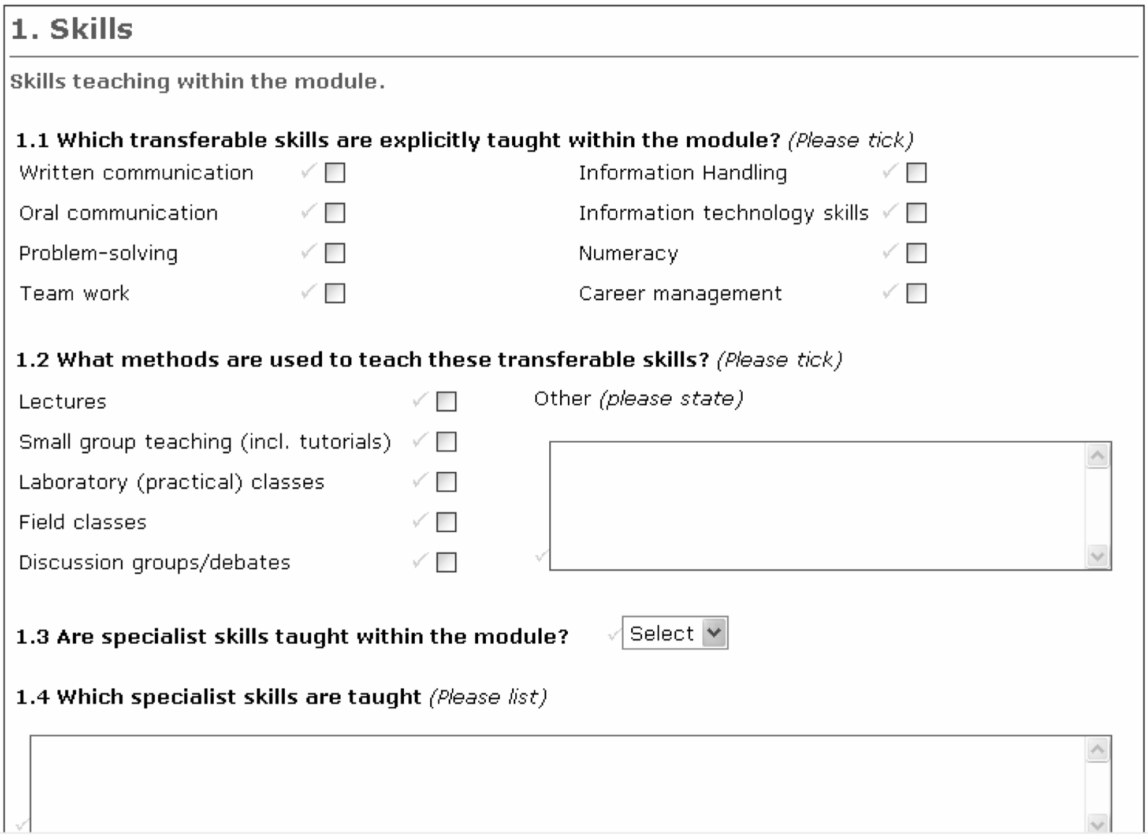

Figure 1: A screen shot of Section 1 of the Research Skills Audit Tool

Section 2 requires information to be entered about the methods of assessment for each of the transferable and discipline-specific skills, and whether or not these assessments are formative (for feedback purposes only), summative (contribute to the module marks) or a combination of the two (**Figure 2**). This section makes use of drop-down boxes to facilitate ease and speed of data entry.

The third section of the audit tool asks for information about the feedback given to students and whether or not it is oral or written and how this relates to the type of assessment (formative, summative or both). The fourth and final section asks the user three 'trigger' questions about the information they provide to students within module description forms. In a similar manner to the Centre for Bioscience's assessment audit tool[4], at the end of the research skills audit there is a text box entitled 'Action Plan', which has been provided to encourage users to reflect on the responses they have entered.

Module co-ordinators are required to 'log in' to the Profile system, which ensures the results of their individual audits remain confidential and can only be accessed by other staff by invitation. The exception to this is the programme director ('Administrator') who has automatic access to the relevant module data within his/her degree programme. Once the module coordinators have completed their audits, the programme director can immediately produce a report of the results directly from within Profile. The resultant data table can then be imported into Excel, allowing for quick and easy data manipulation, analysis and presentation. These data can then be used by the programme director to evaluate skills provision within and between modules across the curriculum.

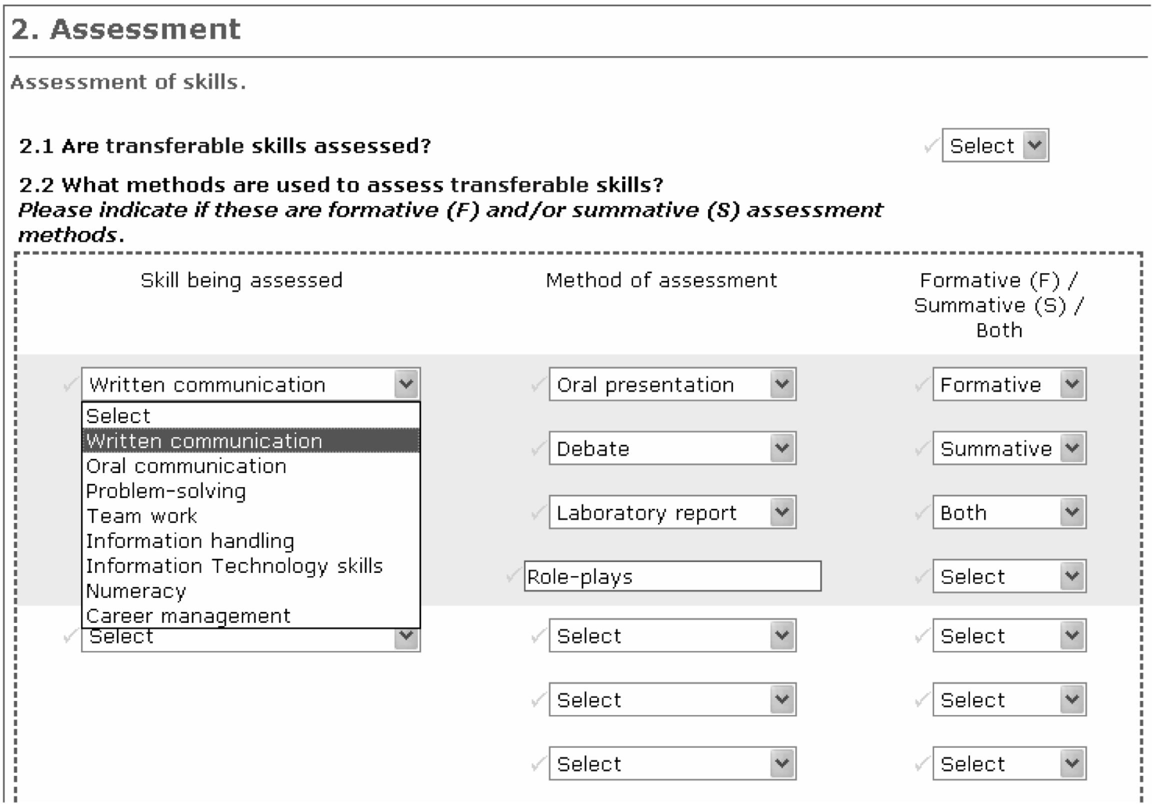

Figure 2: A screen shot of Section 2 of the Research Skills Audit Tool

Implementation of the Research Skills Audit Tool

The research skills audit tool has been completed for the degree programmes BSc Rural Environmental Sciences (RES) and BSc Agricultural Business Management and as a direct result of completing the audit a number of changes are being implemented, both at the module and whole-degree level. In particular, the convenor for the module ‘Practical Rural Environmental Science’ (BSc RES) noted that although several discipline-specific skills were taught, none were assessed. Formative and summative assessment of these skills has now been included in this module. Across the BSc RES degree programme, the audit tool highlighted the need to ensure progression in the teaching (and assessment) of data analysis and taxonomic skills. The programme director is now encouraging the use of more project work within the core field work module with the aim of further embedding teaching and learning of these skills.

Evaluation of the Research Skills Audit Tool

Module coordinators were asked to comment on the audit tool, with particular emphasis on the appropriateness of the questions, its user-friendliness and its usefulness. Several staff commented on the layout of the forms (smaller screens require the user to scroll horizontally to see the whole form) and in some cases the uncertainty of what actually constituted a ‘discipline-specific’ skill. On average, module coordinators took 16 minutes to log in and complete a form for a single module. Of the evaluation forms returned, 83% of staff either agreed or strongly agreed that the audit tool was user- friendly; over 80% agreed or strongly agreed that the audit helped them reflect on their teaching and assessment methods and the information provided in the Module Description Forms[5]

(MDF), and that they would implement changes to their MDF as a direct result of completing the audit tool. In addition, several module coordinators indicated that the audit had led to them review the methods of assessment they were using and had raised questions regarding a lack of formative assessment within their modules. We therefore believe that the research skills audit tool has been a success both in terms of its ability to quickly generate detailed skills information within and across modules but also in terms of its use as a resource to support staff to reflect on the research skills teaching and assessment within their modules.

Conclusion

The research skills audit tool has been well received by both module coordinators and degree programme directors. On an individual module basis, the audit has provided a systematic method for staff to reflect upon their teaching and assessment of research skills. We have developed a resource that is quick and easy to use and which can provide quantitative data for both modular and programme-level skills review. One of the main advantages of the audit tool is that data can be easily collated and used for a range of purposes, including preparing for Periodic Reviews, development of new modules, revising existing modules, student focus groups and skills discussions with graduate employers. For further information please contact Dr Gillian Fraser g.a.fraser@rdg.ac.uk.

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[1] CETL-AURS is a Higher Education Funding Council for England Centre of Excellence in Teaching and Learning in Applied Undergraduate Research Skills.

[2] At the University of Reading transferable skills encompass communication, problem-solving, IT, numeracy, team-working, interpersonal and learning skills.

[3] HEA Student Employability Profiles **http://www.heacademy.ac.uk/profiles.htm**

[4] Centre for Bioscience Assessment audit tool is available at **http://www.heacademy.ac.uk/800.htm**

[5] At Reading each module has a detailed module description form (MDF), which provides staff and students with details of the module learning outcomes, assessment methods and other relevant information.

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[O18] Students' responses to academic feedback provided via mp3 audio files

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Keywords: feedback, mp3, audio, formative assessment, perceptions, learning

Introduction

Providing feedback to students is time consuming for academics (Carless *et al*., 2006). However, despite the time invested in it, the feedback academics provide may not be effectively used effectively by all students (Higgins *et al*., 2002) and a possible reason for this is that students need to develop their ability to use feedback (Sadler, 1989).

These concerns have lead to the development of electronic means of delivering student feedback more quickly and of enhancing the quality of that feedback (Pitt and Gunn, 2004). A further attraction of the use of electronic forms of feedback is that, compared to handwritten comments, it is more easily archived, copied and distributed for quality assurance purposes.

Research evidence (Shriver, 1991; Shriver, 1992) has shown that hearing 'think-aloud reading' can help writers to develop a greater appreciation of the needs of readers of their work, and that this appreciation can lead to improvements in writing performance. Advances in technology mean that it is now possible for tutors to easily record and distribute spoken feedback to students via e-mail as mp3 audio files. This type of feedback is analogous to the 'think aloud reading' investigated by Shriver.

This study aims to consider the effectiveness and feasibility of providing feedback on academic work to students using mp3 audio files. Effectiveness will be considered in terms of how this type of feedback is perceived by students and how students utilise this type of feedback when they receive it.

The work follows on from that of Orsmond *et al*. (2005) who have previously identified that students may use feedback in four distinct ways. These are to enhance their motivation, to enhance learning, to enhance reflection and for clarification. This study considers students' perception of mp3 feedback (i.e. concerning clarification) and students' implementation of mp3 feedback (i.e. concerning learning, motivation and reflection).

As feedback is integral to all learning this project has wide applicability across the disciplines.

Method

The study involved 15 student volunteers from Biological Sciences at Staffordshire University and 2 tutors (the authors of this paper). The students were studying human biology awards and comprised 9 Level 2 undergraduates and 6 Level 3 undergraduates. Eleven of the students were full time and 4 were part time. Ethical approval to conduct the study was gained from the Faculty Research Ethics Committee.

Students submitted samples of their work for formative feedback to the tutors either as hard copy or as e-mail attachments. No restrictions were placed on the type of work that could be submitted. Work received included essays, parts of dissertations and written reflections.

After reading the students work, the tutors recorded the feedback on a desktop PC using Audacity (Audacity, 2007). The recorded files were then converted to mp3 format using Switch (NCH Swift Sound, 2007). Both of these packages are available as freeware. The mp3 files were then sent to the students as e-mail attachments.

Semi-structured interviews of the 15 student participants took place within 3 weeks of receipt of the feedback. The interview schedule comprised items concerned with, firstly, students' perception of the feedback they had received (e.g. what they thought of the overall quality of the feedback and what they thought the tutor was attempting to say in the feedback) and, secondly, students' utilisation of the feedback (e.g. did the feedback help give more meaning to the assignment and was the feedback helpful to their learning). The interviews took place in the presence of the two tutors and were deliberately informal and confidential. The tutors made contemporaneous notes and all 15 students consented to having the interviews audio recorded for transcription.

The qualitative analysis of the interview data involved clustering units of relevant meaning and identifying general and unique themes (Cohen and Manion, 1994).

Results

Overall, the students responded very positively to this type of feedback. All students said they would like to receive more feedback in this format. They all judged the feedback to be of good quality, but for a number of different reasons. Amongst those reasons were a) that it was easier to understand because handwriting is often illegible, b) that it had more depth because possible strategies for solving problems were included rather than just stating what the problems were and c) that it seemed 'more genuine' indicating that speech is received in a more personal way than writing.

- *'I mean feedback's good anyway, but if it's more helpful then it's better all round'*
- *'Audio can convey more complex thoughts than written'*
- *'It seemed more conversational'*
- '*The spoken word meant more than words on a piece of paper'*

Thirteen of the 15 students listened to the feedback more than once with some doing so while they were doing other things such as walking to work. They also appreciated the ability to pause, rewind and play sections again

- *'Found myself listening to it three or four times'*
- *'Could pause and think with the audio'*

All students listened to the feedback with a copy of their submitted work in front of them at least once and 12 of the 15 students made notes on the written work as they listened to the feedback. They seemed to be able to understand the feedback to a greater extent compared to written comments.

- *'Tone of voice conveyed information as to whether the changes [needed] were minor or major'*

- *'Circles and question marks written are difficult to interpret'*

Many students also stated that they would use the audio feedback they had received to improve their work for other tutors.

- *'It seems like written feedback just goes with one essay, but the audio feedback could go with other essays as well'*

The tutors were also positive about the use of this form of feedback. They were aware that they were able to provide more detailed feedback using examples of how the work might be changed within the same timescale as would be involved in providing written feedback. While in this study tutors found that providing audio feedback did not save them time, it might do so with more practice.

Pitfalls identified during the course of the work concerned the large size of the mp3 files generated (up to 11Mb) making them incompatible with some e-mail systems. In this study mp3 files could not be e-mailed to 2 of the 15 students. In these cases they were provided on disk.

Discussion

This preliminary study indicates that students perceive and implement mp3 audio feedback in different and more meaningful ways than written feedback. Findings that a large majority (13/15) of students listened to the audio feedback more than once and that they (12/15) made notes on the original work as they listened to the feedback do demonstrate that they did consider the feedback in some depth. Not only did students take the feedback seriously, they seemed to appreciate the feedback more in the sense that all 15 students found it to be of good quality and several commented that they that found the feedback more personal or that it showed that the tutor cared about the work. These two aspects of audio feedback (i.e. the quantity of feedback given and the means by which the feedback is delivered) are distinct, yet interrelated.

Both this study and our previous work (Orsmond *et al*., 2005) do indicate that students value tutor feedback. This is particularly interesting in the light of subsequent work (Orsmond *et al*., 2006) which as indicated that students actively seek feedback from a variety of sources. They often enter into dialogue to obtain formative feedback from others both within and without their student cohort prior to approaching tutors and what they are sometimes seeking from tutors is confirmation of the feedback they have already obtained elsewhere. This can bring into question the impact that tutors' formative feedback might have on students learning. It has to compete with other, possibly conflicting, feedback in order to influence students. This may be an important factor behind the conclusion of Higgins *et al*. (2002) that the feedback academics provide may not be effectively used by all students.

It could be that audio feedback is particularly influential to students learning because it meets many of the requirements for effective feedback outlined in Brown *et al*. (2003) including being detailed, prompt and understandable to students. Audio feedback may be more understandable to students because they are more used to information being conveyed as sound than as written words possibly reflecting their increasing use of multimedia technology in their lifestyles and, perhaps mobile phones in particular. In this context it is also interesting to note that participants gave the ability to pause and replay audio feedback as an advantage. It did not seem to have occurred to the students making these comments that they could also pause and then reread written feedback.

Students also commented that the audio feedback was more detailed than written comments and this theme was also picked up by the tutors who found themselves naturally providing examples in their audio feedback of how the work might be changed. They felt this would not have happened to the same extent in written feedback because of either time or space constraints for marginal comments. Additionally there was an appreciation that subtleties of thought that indicate merely possibilities for change (rather than direct instructions to change) are more able easily conveyed using the spoken word than in writing. Lea and Street (1998) have also commented that brief feedback comments from tutors often have little meaning to students. Finally it is worth noting that 4 of the 15 students interviewed reported that the often did not read written feedback because they found tutors handwriting difficult to read. Audio feedback overcomes this illegibility.

While the findings of this study are very positive concerning the benefits of mp3 audio feedback, it must be acknowledged that this is a pilot study based on a small number of self-selected volunteers who knew in advance that they would be asked to participate in an interview concerning their opinion of the feedback. As such the study group might be considered to be biased; however there was ample opportunity in the interviews for the students to state that the feedback did not meet their expectations if that was indeed the case. All 15 students said that they would like to receive more feedback in mp3 audio format with only a small number (2/15) stating that they would like to receive the feedback in both audio and written format. These factors lead the authors to believe that mp3 audio feedback is an approach that can enhance student learning and which should be pursued in further studies. It is also acknowledged that it could be a ‘novelty factor’ that made students pay particular attention to the audio feedback in this study. This can also only be judged in the light of subsequent studies in which students are given more feedback in this format.

Such future studies might investigate the integration of mp3 audio feedback into virtual learning environments such as Blackboard and its application within summative assessments including its compatibility with institutional quality assurance procedures. To aid such integration into other environments it may be possible to reduce the large size of the audio files by refining the recording process. However the authors have concerns that in doing so the sound quality might be reduced to such an extent that the personal aspect of the feedback as perceived by students might be lost.

These finding are currently being used to develop guidance for tutors regarding approaches to providing the most effective feedback to students in this format. This guidance will be developed following a more detailed comparison of written and mp3 audio feedback comments on the same piece of work and will be summarised in a longer version of this paper to be submitted to Bioscience Education e-Journal.

Acknowledgements

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A longer version of this paper will be submitted for publication to Bioscience Education e-Journal

[W1] Rousing the dead: a hands-on guide to interactive engagement strategies in lectures

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Lectures are still the mainstay of University science teaching to large classes, yet they have evolved little in terms of structure and function. They are still predominantly vehicles for the one-way transmission of information from lecturer to students, along some pre-defined trajectory that maps out the A-Z coverage of the syllabus. With the quantity (and sometimes quality) of digital information accessible to students (within and external to their course) it is little surprise that some students vote with their feet, believing they gain little from listening to a series of PowerPoint slides being read out.

In Edinburgh over the last couple of years, we have taken a path trodden by many others within the UK (see Draper (2007) for a comprehensive list of practitioners) in utilising electronic voting handsets (‘clickers’) in lectures on some courses. These have effected a radical transformation on our first year lectures in Physics, changing a fundamentally transmissive activity into a two-way conversation, mediated by the technology. This workshop is designed to share our experiences, and to illustrate and demonstrate the strategies involved in using interactive engagement techniques in lectures (see also Bates *et al* (2007).

I will present a snapshot of current activity across the UK, survey the technology options and give examples of different methodologies of integrating questions within a lecture format. The workshop will provide hands-on experience using real clickers (but you will have to return them at the end!), allowing workshop participants the opportunity to see the technology in action (and how straightforward it is to use). I will also address the key issue for academic pressed for time (‘Where can I find good questions?’) making reference to various collections of questions and repositories that are available for different disciplines. The issues that the use of such questions will raise in regard to coverage of content will also be discussed.

The second half of the workshop will involve small groups of participants devising their own questions suitable for use in these situations, drawing on their own experience as teachers. The groups will then report back and the whole workshop will have opportunity to answer the questions, again using the clickers provided.

The intended structure is as follows, with indicative timings:

1. Presentation, including hands-on demonstration and use of the Interwrite PRS hardware and software. (40mins) This will cover such aspects of cost, logistics and pedagogy (including what makes a good question and several different use scenarios in which this type of exercise can be deployed).

2. Q&A from presentation (10mins)

3. Break out to small groups (~4 people). Each group is tasked with devising 4 MCQ / partial knowledge MCQ questions suitable for use in these situations, drawing on the experience gained from the courses that they themselves teach. (30 mins)

4. Re-group. Each group will briefly present their questions, and the audience will vote on these and assess their usefulness. (30 mins)

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[W2] Linking DNA structure and sequencing using model based learning

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Keywords: DNA, models, visualisation, spatial thinking, DNA structure, DNA sequencing

Such is the iconic status of DNA in modern life that we are used to seeing the double helix depicted in sculptures and paintings. In 2003 a set of UK postage stamps celebrated 50 years since the discovery of this structure, and in the same year DNA even graced the two pound coin. For students of biological disciplines, however, it is important that their understanding of this pivotal molecule runs rather deeper than this. Experience shows that some of the fundamental principles involved in the molecular biology of DNA are actually quite difficult for students to grasp when taught via either conventional lectures or practical classes. Successful acquisition of such knowledge is, however, crucial for the comprehension of more complex DNA processes.

This workshop will offer the opportunity to participate in two interlinked 'hands-on' tutorials that have been designed to increase students' understanding of both DNA structure and the importance of this structural knowledge in strategically significant technologies such as DNA sequencing. We also offer an evaluation of the exercise when piloted with second-year undergraduates at the University of Leicester.

In the first tutorial, a semi-space-filling atomic model of a DNA molecule (purchased from Spiring Enterprises Ltd.; www.molymod.com) is used to conceptualise a number of issues related to the basic atomic structure of the double-helix. In addition, each student pair was given an atomic model of one of the four DNA building blocks (a 'nucleotide', consisting of one of the four 'DNA bases', one sugar group and one phosphate group). Physical handling of these semi-space-filling models helped the students to distinguish the bases, to visualise the interaction between bases and to understand the rules governing DNA base pairing. The directional nature of DNA strands and the double helical structure of DNA (including the major and minor grooves) are easily seen when using these models. The tutorial on DNA structure culminates with the opportunity to 'read' the DNA sequence of the model and subsequently build a replica 'mini-DNA model', using simplified and stylised DNA models (also purchased from Spiring Enterprises). Having to build the replica model reiterates the basic principles of DNA base pairing and DNA structure.

The second tutorial comprises a sequencing scenario to simulate the dideoxy method of DNA sequencing (Sanger *et al*., 1977) using 'pop-it' beads (purchased from Philip Harris Education; www.findel-education.co.uk) as DNA building blocks, to determine the sequence of a short stretch of DNA. A similar, but less sophisticated, activity was described a few years ago (Roels and Vranckx, 2002) which involved large numbers of paper letters and was based upon generating 'ladders' of radioactively-labelled nucleotides, a process that has been superseded by the use of fluorescently-labelled bases (Glazer and Mathies, 1997). In our activity, students act as DNA polymerase (Taq)

Figure 1: University of Leicester students participating in the DNA structure (left) and DNA sequencing (right) tutorial sessions.

to 'synthesise' short DNA products by making 'copies' of a provided nine-base-pair template sequence. To 'copy' this sequence a DNA primer is selected (represented by a 5-bead pop-it chain) and then further bases are added onto this primer, following the base-pairing rules learnt in the DNA structure tutorial session. Beads of different colours are provided in four bags. The majority of beads in each bag are pink these represent 'normal' bases (i.e. deoxy nucleoside triphosphates, dNTPs). One out of every seven beads in each bag is of a different colour and represents the 'terminating' bases, which are dideoxy nucleoside triphosphates (ddNTPs) that lack the hydroxyl group necessary for the connection of additional bases. If a 'normal' base is selected this is added to the chain and 'synthesis' continues. However, if a 'terminating' base is selected further bases cannot be linked to the chain. When twenty such chains have been produced these are sorted by size (simulating electrophoresis). Subsequently, the sequence of bases is 'read' by looking at the coloured beads terminating each chain, from shortest to longest. This section of the tutorial provides a useful scenario to visualise the complex process of DNA sequencing.

One of the great assets of these tutorials is their visual and 'hands-on' nature, which enhances students' spatial thinking. For instance, it became clear that students find the concept of the double helix difficult to grasp, until they can see (and touch) one in the DNA model. Another great strength of these tutorial sessions is that they are conducted in combination. To fully comprehend the process of DNA sequencing it is crucial to have clear appreciation of DNA as a molecule. Running the tutorials in succession provided the students with a visual blueprint of the DNA structure that could then be used seamlessly in the second tutorial.

We designed these tutorials to complement information already covered in a second-year undergraduate module (through a number of lectures and laboratory- and computer-based practical sessions), describing general molecular biology techniques and their application for addressing problems relating to genome research. However, the nature of these tutorials is such that they lend themselves perfectly to be adapted and simplified to explain and address the basic principles of the DNA double helix in the classroom in a fun and relatively inexpensive way.

Evaluation

Relevant knowledge acquired by University of Leicester second-year undergraduate students was tested by means of a simple questionnaire immediately pre- and post-tutorial, and again, without prior notification to the students, five weeks later. A clear post-tutorial improvement of understanding of the subject was noted, both in the questionnaire scores, as well as from the students' own perception — to quote for instance: '*It helped me to understand the structure. When I handled the model it really helped me to understand'*. and '*It made how [DNA] sequencing works clearer, I was quite confused before*'. In addition, there was a clear indication of the enhancement of student learning — to quote for instance: '*It was an enjoyable way to give us a greater understanding of the subject*' and '*It helped me understand the process with an element of fun. Working in groups with coloured beads is more fun than listening to a lecturer talk'*. Furthermore, the effect of these tutorials on students' performance in summative assessments is being evaluated.

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[W3] Creating and sustaining motivation in first year biosciences and health students

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Keywords: motivation, engagement, teaching, learning, biosciences

Introduction

At Leeds Met University in the Faculty of Health we deliver a degree course in Biomedical Sciences with specialised routes in Microbiology and Molecular Biology, Physiology and Pharmacology and in Human Biology. As is the norm we have a welcome (induction) week for our students that is delivered as a series of workshops. The aim of the workshops is to facilitate the transition into HE and to introduce students to Assessment Learning and Teaching (ALT) strategies utilised generically in HE and specifically on our courses. In addition we encourage our students to discuss their expectation and goals and to identify their support needs. We also emphasise the importance of engaging in personal and professional development planning throughout their time with us.

Participation and engagement in all of these activities is very high and enthusiastic and students typically comment that although they have anxieties they are mainly very much looking forward to HE study and are excited at the prospect of studying science and health.

However within a few weeks of the beginning of formal teaching attendance has perceptively dropped at all sessions and within a few more weeks failure to engage in formative and summative assessment tasks and submit within deadlines has occurred. For some students, failure to engage on a day to day basis is almost total whereas with others it is intermittent though still worrying and problematic particularly in group learning situations. It is almost exclusively younger students (18-20 yr olds) rather than our more mature students who fail to attend. It is also noticeable that some students who do attend are passive at best or appear disengaged throughout the teaching session.

As our students belong to a Faculty of Health an ALT strategy designed to create WELL students seems appropriate. A WELL student is one who not only attends but:

- Wants to attend
- Engages when they do attend
- Learns stuff that they need to learn for future employment and wants to learn
- Likes learning

It therefore becomes extremely important to try to identify all of the factors that may influence motivation to learn in this critical early period of transition in HE and to develop strategies that create and sustain motivation to learn.

Explanations for this lack of engagement highlight a culture in HE that occasionally blames the student. It is often assumed that their failure to attend and engage is because they are too absorbed in social activities and a desire to explore the limits of new found freedom without parental constraints. For students on Bioscience courses it is easy to add further blame for their inability to persevere with subject material that may be inherently hard to grasp. Tutors often label students who do not engage as intellectually inferior to students who do.

The tendency for blaming the student negates the responsibility for tutors to have to reflect on the extent to which teaching methods in Biosciences impact on creating a conducive learning environment. These methods traditionally involve the didactic delivery of large amounts of content that is presented as factual information in large lecture theatres. Learning is defined as the ability to absorb all of this information and regurgitate it on demand in examination based assessments (Hughes and Wood, 2003). These methodologies very strongly encourage and reward students who are surface learners (Biggs,1987 and 2003) but will actively prevent learning for students who need to make sense of information by using it to problem solve or in reasoned debate. There is at least a possibility that our disengaged students are simply turned off by outdated teaching practices that do not meet the needs of the modern bioscience professional.

In addition the language, practices and processes that tutors see as routine in day to day academia may be impacting on student engagement. On closer examination it is relatively easy to see that many of these practices wrapped up as they are in academic ritual and language may be mystifying and unattractive to many students. (Sanderson and Johnson, 2006).

Although there is a very extensive literature that explores theories of motivation and their application to learning (e.g. see Eccles and Wigfield, (2002) for an excellent and comprehensive overview) and an equally extensive one exploring the learning process itself (e.g. Race, 2005) there is also a need for a much more pragmatic approach.

I wanted to find out from students what had to be in place in a teaching situation to grab them and motivated them to want to learn. What do they have to say about what turns them on and turns them off to learning in a particular context? Which of these motivational and demotivational factors do they perceive as being under their control? Whose responsibility do they think it is to provide the motivation to learn?

These issues were explored with students in focus groups and workshops and these discussions generated interesting data (Sanderson, in preparation). Whilst highlighting a range of situational factors that impacted on motivation, teaching style and the dynamics of the tutor student interaction were ranked as the biggest influence. What turned them off learning were tutors that seemed demotivated, didn't involve them and presented information read from slides. What turned them on to learning were interactive session that focussed on checking understanding and skills development.

There is therefore a need for Bioscience tutors to examine their own approaches to teaching in different contexts and to consider the range of factors that affect their capacity to facilitate learning for all students. Whilst this can be viewed as normal reflective practice, busy days may not allow full absorption in the reflective process. Following reflection of this nature we may be better able to help students through the use of active learning techniques to stay engaged and focussed in situations that don't instantly grab them.

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[W4] Fifteen ways to hit your science students: enhancing the student experience and how to make it happen

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Keywords: inclusion, teaching, technology, accessibility

Introduction

As a science educator, effective learning and teaching is all about hitting your students in the most effective way. Although at times the use of a pair of wet fish, Monty Python-style, may be desirable, we are in fact referring to ways of enhancing the science student experience by the inclusive use of relevant tools.

Good practice in teaching is all about having the most impact for each individual student and making waves that travel to the deepest levels of their understanding, be that:

- in the lab,
- in the field, or
- in more formal classes.

This workshop will highlight fifteen effective and inclusive ways to hit your science students: that is, by using different media, by exploiting different mechanisms, and by understanding how to go about making the necessary changes happen.

Format

Using a stimulating mixture of short presentations and audience involvement in a range of group-based activities, this workshop aims to expose the participants to a wide range of approaches of effective inclusive science teaching and learning, giving them practical, achievable things to try, while underlining the ethos of inclusion in learning and teaching. Participants should leave with a definitive suite of actions that will enable them to hit their students more effectively.

What to hit your students with: Media

The inclusion benefits to science learning and teaching of a range of media will be discussed with the workshop participants, covering three broad areas:

- Printed media / Text – When creating documents there are a number of simple techniques you can implement to ensure they are accessible and navigable for your students. Discussion will centre around the most commonly used formats (e.g. Microsoft ® Word and Adobe ® PDF)

- Images – This section will discuss the use of images as an important tool in science education and provide hints and tips to ensure their effective use.

- Audio – People can sometimes be cautious with using audio-visual content as it can be seen as 'inaccessible'. This section attempts to dispel these myths and provide practical examples of their effective use.

How to hit your students: Mechanisms

Ways in which common tools and procedures can be best utilised to enhance inclusive practice in learning and teaching will be discussed, including:

- Repositories and sharing,

- Interactions (For example: Wikis, Bulletin Boards, Online Assessment, Media boards),

- Interactive voting,

- Interactive whiteboards.

Who can help you hit your students: Making It Happen

The final part of the workshop will examine ways of identifying the key people and key resources needed within an institution to effect change. Circumstances and individuals can obstruct good inclusive practice, often unintentionally. The workshop will compare experiences of these obstacles and suggest ways to remove them and suggest how to include key individuals in the enthusiasm for inclusion and accessibility in science learning and teaching.

Outcomes

Delegates who attend this session will:

- Be exposed to a wide range of approaches,

- Get practical, achievable things to try,

- Gain understanding of the ethos of inclusion,

- Have clear action points for implementation.

[W5] Stand in another's shoes. A 'Values and Rights' exercise to develop and assess students' ethical awareness

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Biomedical ethics has been taught in various guises in the School of Applied Sciences at Wolverhampton, from its inception in the early 1980s as part of an Honours Special Study Module to its current format of a full final year module entitled 'Biomedical Ethics'. The focus of study is enshrined in the stated learning outcomes of the module whereby students are expected to be able to:

1. Present and maintain a coherent moral position on the experience of human subjects in biomedicine, and sympathise with divergent and opposing ethical standpoints

2. Articulate that research with human subjects cannot be wholly isolated from its social, philosophical, ethnic and gender context.

In general, methods used to assess ethics learning are seen to be contentious, particularly in view of the potential diversity of aims. Whilst some proponents suggest a skills and knowledge based, decision making approach others prefer to use measures of moral development and value preference (Goldie, 2000). To allow students to demonstrate that they have achieved these learning outcomes, a 'Values and Rights' exercise has been developed that permits students to learn through the process of assessment. Students are presented with three descriptions of ethical 'dilemmas' for resolution. These dilemmas cover issues such as voluntary euthanasia, rights to treatment or animal experimentation.

An example might read as follows:

The Chancellor of the Exchequer has suffered a severe stroke. Although conscious, he is unable to communicate either by word or gesture and acknowledges nothing. Neither does it appear that he is able to comprehend any information passed to him orally or visually. He has to be fed parenterally and is incapable of attending to any of his personal functions. It is possible by a combination of extremely costly, high risk surgery and extensive rehabilitation that the Chancellor may be restored to his previous condition. True to his socialist principles, the Chancellor has always refused private health care and is dependent on the National Health Service. He is acknowledged as a man of formidable intellect and an economic genius on the verge of resolving some of the country's greatest financial problems. However, observers comment that with a family history of cardiovascular problems, he should have taken more care with his diet and stopped his 6o cigarettes a day smoking habit. Is there any ethical obligation to provide funds or procedures to try to cure him?

Needless to say there is no limit to the range of topics and descriptions that might be used. However, in accordance with the first learning outcome stated, students are not expected to provide their own views but approach each dilemma from a selection of ethical 'stances'. Examples of these stances include a utilitarian position, a contractual view, and a perspective of self interest. Students receive a full description of each of these stances and are expected to 'resolve' each dilemma in terms of each of the stances. An example of a contractual view would run as follows:

Moral choice is based on the idea of contracts between people (social contract). People matter as ends in themselves and deserve equal and fair treatment and justice(??). In order to make contracts fair the strong should have no greater bargaining power than the weak, and in practice should exercise any discrimination in favour of the weak. To do this people must agree on the principles of justice under a 'veil of ignorance' without knowing the position they will hold in society and ignorant of their own strengths and weaknesses. As in any bargaining for a contract each party will try to do the best for themselves but, since they are veiled in ignorance, asking what is best for themselves is the same as asking them to decide impartially what is best for everyone. This is actually a generalisation of the Golden Rule, or putting oneself in other people's shoes. Such impartial contractors will distribute benefits equally, unless it is to the benefit of the least well off.

Currently the exercise is used for a summative assessment at the mid-point of the module. Students receive the exercise one week before the assessment takes place and are encouraged to discuss this with as wide an audience as they choose. One week later they complete a dedicated answer sheet under examination, time constrained conditions. Staff mark the exercise using a comprehensive mark scheme and depending on the size of the module, the students receive a grade and rapid feedback on their arguments. In this way, the exercise serves a highly formative function and in the final summative assessment of the module we find that there is a more 'open minded' way of thinking by the students. Students perform well on this assessment in that it is possible for them to achieve high grades and it is unusual for them to experience failure. External examiners, past and present have commented favourably on both the design of the exercise and its completion by candidates. Interestingly the assessment receives favourable comment on student module evaluation forms.

This exercise is used, at present, for summative assessment; however it has considerable utility and can be used in a number of different ways to encourage ethical thinking in students:

- As a tutorial exercise without the formality of any mark scheme – simply a stimulus for discussion and argument
- As a formative exercise
- As a formative exercise with the mark scheme issued for self-assessment
- As a formative exercise with the mark scheme for peer-assessment
- As a summative exercise with the mark scheme issued for self-assessment
- As a summative exercise with the mark scheme for peer-assessment

As a device to encourage students to engage with the dilemmas posed by ethical conundrums this exercise of making them 'stand in another's shoes' provides a useful learning experience.

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[W6] Online Experimentation

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Over the last few years there has been a growing interest in the use of computers to teach practical science. There are several relevant drivers. Computers have been seen as offering a cheaper alternative to physical laboratories that require costly space, equipment, and staff. Their use is easily scaleable, which is attractive as demands increase for larger class sizes, while health and safety concerns have made it difficult to expose students to some areas, e.g. involving radiation and/or carcinogens. It is also argued that practical research science makes increasing use of simulations, with numerical methods underpinning or augmenting physical investigations. Against such arguments must be the major concern that science is ultimately concerned with the physical world and that students must develop real practical skills of experimentation and observation.

In this workshop we will explore practical methods of creating online experiments that can be experienced by widely dispersed students. A guided discussion will establish generic learning outcomes that university science departments are attempting to deliver through experiments and observations. The outcome from this exercise will inform presentations of recently developed types of online teaching experiments. These will include;

- Interactive screen experiments in which students control parameters used in pre-recorded real experiments.

- Distributed group-experiments in which students make individual measurements or observations and contribute their results into a shared data base which is interpretable by each individual.

- Remote observations in which an office or home based student is linked to students and teachers at a remote site and is able to influence the data acquisition at that site.

It is believed that such methods can mitigate some of the legitimate criticisms of computer based experiments and enrich the range of learning experiences we offer to students who may be constrained in their location or availability.

[O19] Creativity and research-led teaching

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Keywords: creativity, problem-solving, research-led, website

Introduction

Currently, full and demanding curricula for science subjects, in schools and universities, leave little space for the development of creativity in individuals. The Creativity and Research-led Teaching website (**http://www.fbs.leeds.ac.uk/creativity**) addresses this issue by promoting creative approaches to problem-solving in students working in isolation or in groups. The website incorporates a research-led approach by featuring short films of leading researchers describing their projects and problems/issues associated with their work. Students are asked to think of creative solutions to these problems. Alternatively, students may address other pressing problems in the biosciences. Participation by all students is encouraged from the outset as they engage with a range of exercises designed to promote creativity in individuals. This is a crucial element of the approach adopted with this website: it ensures that the more reticent students who may lack confidence are helped to reach their creative potential.

Students are placed in groups and as they develop their own ideas they may communicate these to other members of the group using the website's 'Group Chat' facility. The importance of a period for incubation of ideas is emphasized and, when students feel comfortable with their ideas and suggestions, they can submit these for more formal consideration by the group. The initial communication and submission of ideas can occur with group members geographically isolated from one another and this approach helps to ensure that the ideas of all of the group members are given a fair hearing.

Finally, students participate in formal and traditional round-table group sessions. Like the creativity exercises for individuals, these sessions are intended to promote participation by all students and are structured to ensure fruitful discussions with minimal conflict between participants.

Inspirational researchers

Students may access a number of short films that feature leading researchers discussing topics as diverse as GM bananas, tissue engineering and biosensors (**Figure 1**). They may choose to pursue problems suggested by the lead researchers. Alternatively they are free to address essentially any problem within the biosciences that they find interesting and challenging. Individuals are helped to generate ideas using a range of techniques.

Figure 1: Students may choose from a number of short films recorded by leading researchers

Promotion of creativity in individuals

Several textbooks together describe a large number of techniques designed to promote creativity in individuals working alone or in groups. The website features a number of approaches that prove useful when working with scientists. Here are a few examples.

Curiosity

Isaac Asimov said ‘The most exciting phrase to hear in science, the one that heralds new discoveries, is not “Eureka” but “That’s funny. . . .”.’ Scientists should be curious about the unusual and they should welcome the unexpected. The examples of Kevlar and Viagra are used to illustrate these points. The Du Pont scientist Stephanie Kwolek’s curiosity regarding an atypical and apparently contaminated polymer preparation led to the development of the super-strong, lightweight fibre Kevlar. The Kevlar of body armour is thought to have saved thousands of lives worldwide. Similarly, the curiosity of clinical investigators at Pfizer, concerning a minor side-effect associated with a drug undergoing trials for treatment of high blood pressure and angina, led to the development of the highly successful drug Viagra. Students are advised that, from time to time during their scientific careers, they will encounter unusual and unexpected results. They are urged to pursue these observations and make the most of them.

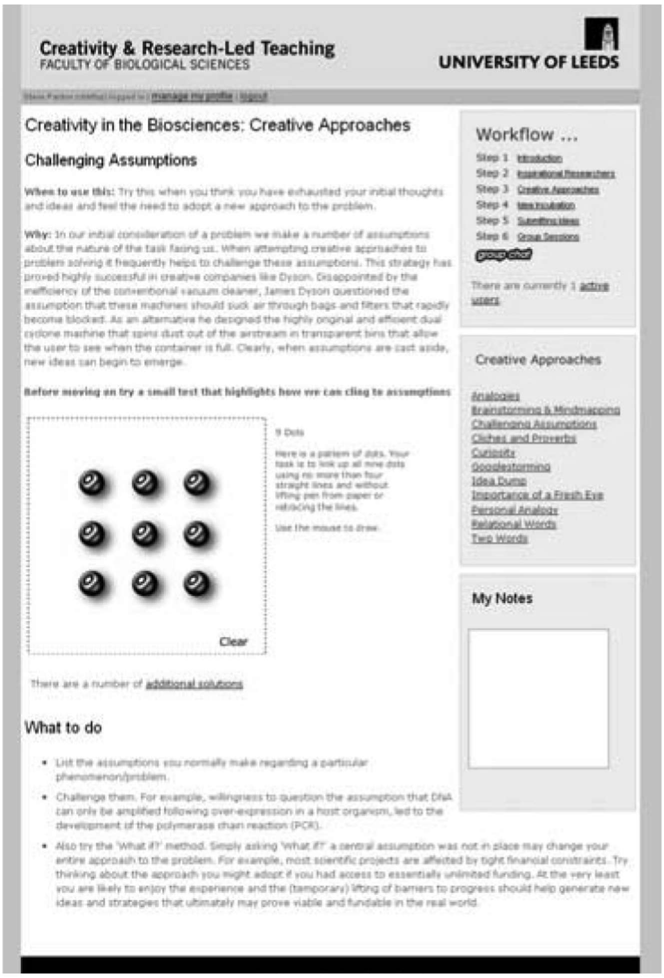

Figure 2: Students are encouraged to challenge assumptions

Challenging assumptions

During the early years of education in school, children are happy to question and challenge well-established ideas. However, as they mature, students are less inclined to ask questions and are often content with the status quo. Creative individuals are far less inclined to accept things as they stand and will consider alternative approaches and solutions to problems. We use a simple exercise to demonstrate how most of us cling to assumptions (**Figure 2**; see also **http://www.mycoted.com/Nine_Dots**). We then illustrate the importance of challenging assumptions in commerce, using the example of the Dyson suction cleaner, and in science using the example of the polymerase chain reaction (PCR). For the former, James Dyson questioned the assumption that vacuum cleaners must rather inefficiently suck air through filters that rapidly become blocked and designed the highly original and efficient dual cyclone machine that spins dust out of the airstream. For the latter, Kary Mullis and collaborators challenged the assumption that significant quantities of DNA fragments could be produced *in vitro* only following cloning and over-expression of the fragments in host organisms.

Students are asked to list the assumptions they normally make regarding a particular issue or problem. They are then asked to challenge the assumptions and to ask the question 'What if?'. Simply asking 'What if?' a central assumption was not in place can change the entire approach to a problem. For example, most scientific projects are affected by tight financial constraints. Students are asked to consider how they might approach a problem with unlimited financial backing. The temporary lifting of barriers to progress can sometimes help suggest ideas and strategies that ultimately may prove viable and fundable in the real world.

Analogy

In an analogy two things that are essentially different, but which nonetheless have some similarities, are compared. There are many impressive examples of the creative use of analogy in the biosciences and elsewhere. In particular, a number of innovative inventions stem from the identification of an analogy between a problem and a natural phenomenon. For example, a team of designers was given the task of devising improved motorcycle crash helmets and a member of the team asked whether there were any examples in nature of animals receiving serious blows to the head without suffering brain damage. A colleague suggested the analogy of the woodpecker whose beak has a spongy base that absorbs most of the impact from continual pecking. This observation led to a fundamental change in the way helmets are designed. Instead of constructing helmets from hard, impenetrable steel they were instead designed to harmlessly deform on impact, thus preventing the energy of impact from reaching the wearer's head.

Students are asked to define a problem then to try to generate an analogy, perhaps by looking to nature for inspiration. They then use the analogy to apply knowledge or technology from its source to their problem with the aim of bringing a new insight or perspective. The idea is that the analogy will help suggest an entirely novel solution to the problem.

Personal analogy

In this approach the person constructing the analogy places himself at the centre of a problem to gain a new perspective and kick start the generation of ideas. As a teenager, Albert Einstein asked himself 'how would the world appear if I were to travel on a beam of light?' He persisted with this approach and it eventually helped lead him to his special theory of relativity. Students are encouraged to look for novel insights and solutions by imagining themselves part of the problem under consideration.

Importance of a fresh eye

Many scientific breakthroughs stemmed from inter-disciplinary collaborations. For example, the fruitful partnership between Robert Bunsen, a chemist, and Gustav Kirchoff, a physicist, led not only to the creation of the spectroscope but also to major developments in the science of cosmology. Students are advised to network and collaborate with people from a range of backgrounds. They are told that by sharing problems with colleagues working in related disciplines, in industry or even with friends and family members, they may gain a valuable new perspective from the 'fresh eye' that each of these individuals will bring to the problem.

The website contains a further six methods designed to promote creativity in individuals. Students are advised to try as many techniques as possible as certain approaches will work better for some individuals than for others.

Group chat, idea incubation and submission

People are often at their most creative during periods of 'relaxed attention'. Students are therefore asked to incubate their ideas for a few days and to think about them when they are feeling relaxed, for example, when taking a shower or during sports or other recreational activities. They are also encouraged to exchange ideas with other members of their group using the website's Group Chat facility, although they may submit ideas anonymously if they wish. Electronic submission of ideas is straightforward and group members may use a 'fridge magnet' facility to compare and relate all of the submitted ideas as they move them around the screen on 'magnets'. This approach is intended to encourage new thoughts and developments based on the original ideas submitted by members of the team. The team should now have a list of ideas that can be taken forward for more formal consideration during group sessions.

Group sessions

Each group member will have had the opportunity to generate, develop and submit ideas for consideration by the group. Structured group sessions build on these ideas using one of three creativity techniques for groups: Brainstorming; Lotus Blossom, described originally by Yasuo Matsumura; and Edward de Bono's Six Thinking Hats (several books describe a wide range of creativity techniques for groups – see Further Reading). The sessions are designed to facilitate both detailed consideration of ideas submitted by individuals and the generation and development of new ideas during group discussions. As new ideas emerge, groups are encouraged to allow a further period for incubation before identifying and refining the idea(s) favoured by the majority.

Preliminary observations and conclusions

The website has been trialled with a class containing four groups of five Level III Bioscience students at the University of Leeds. It proved difficult to persuade students to engage fully with the techniques designed to promote creativity in individuals and it seems clear that the use of this facility must be more closely supervised in future years. However, the groups made many useful and creative suggestions during problem-solving. Some of the problems they addressed were based on the films featuring the lead researchers although the students were given the freedom to consider other pressing issues in the biosciences. Assessment of the activities involved oral, written and poster communications. For future academic sessions, a 'Dragon's Den' style of presentation, during which the group attempts to persuade a panel of 'experts' of the viability of their proposals and ideas, may be used as part of assessment procedures.

The Creativity and Research-led Teaching website may prove most useful in promoting creativity and innovation in more senior scientists; currently we are investigating the efficacy of our approach with postgraduate students and postdoctoral researchers. Indeed the overall approach adopted in the design of the website should have considerable potential in a wide range of settings and disciplines both in higher education and industry. The website will also support and encourage inter-disciplinary cross-talk and collaboration as colleagues from different backgrounds and disciplines work together on idea generation and exploitation.

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[O20] Microbiology and art: a comfortable combination?

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Art provides an opportunity for visualisation and communication of science, and I have found that in this context and others, microbiology and art link very well. Over the past few years, I have collected examples of this interdisciplinarity, and produced a lecture which I give to first year Biology undergraduates. The lecture is one of a series given during a module entitled 'Frontiers in Biology'. In the module, a lecture is presented by each specialist subject area within our School, and students sign up to an assignment in any of the six subjects. For all other subjects, the accompanying assignment is a poster plan. For microbiology, students have the opportunity to produce, alone or in groups, an item to illustrate some link between art and microbiology. There is no upper limit to the number of students who can take this option; students can work alone or in groups. Ideas are discussed during a tutorial, and assessment criteria are negotiated between myself and the student(s). The outcomes are diverse, often creative and inspiring, and several have been used to illustrate this article.

The topics covered in the lecture, entitled 'Microbiology and Art: the Final Frontier' are:

Deterioration of Art
Microbially-induced spoilage of art and heritage material is perhaps the most obvious link between the subjects, but I also describe aspects of prevention and control of such deterioration, and give examples of microbiologically-induced remediation. Students were especially interested to hear of this unusual example of applied microbiology, and several opted to do assignment work on, for example, spoilage of film, ancient Egyptian art and stone monuments, and on some of the EU funded conservation projects. Their work was primarily presented in poster format.

Beauty of microorganisms
The excitement generated when a 'good' specimen is found 'down the microscope' can be infectious: it is not only the success of finding the microorganism – sometimes they look really nice! Indeed, sophisticated imaging techniques enable differentiation of components of microbial communities, or individual cells, and such images are common in textbooks and in lecture presentations. Images can be enhanced and modified, and find a diverse range of uses: calendars (e.g. **www.veeco.com**), websites, graphic art posters, clothing (**www.iawareables.com**), toys (**www.giantmicrobes.com**) collage and so on. Student products included three-dimensional models; customised lab coats; silk paintings; and designer jewellery!

Microorganisms in art
Surprisingly, microorganisms themselves may provide material as well as inspiration for art: pigmented bacteria can be used to 'paint' images on agar plates; pictures made on microscope slides from diatoms can be purchased for educational use (**www.diatoms.co.uk**);

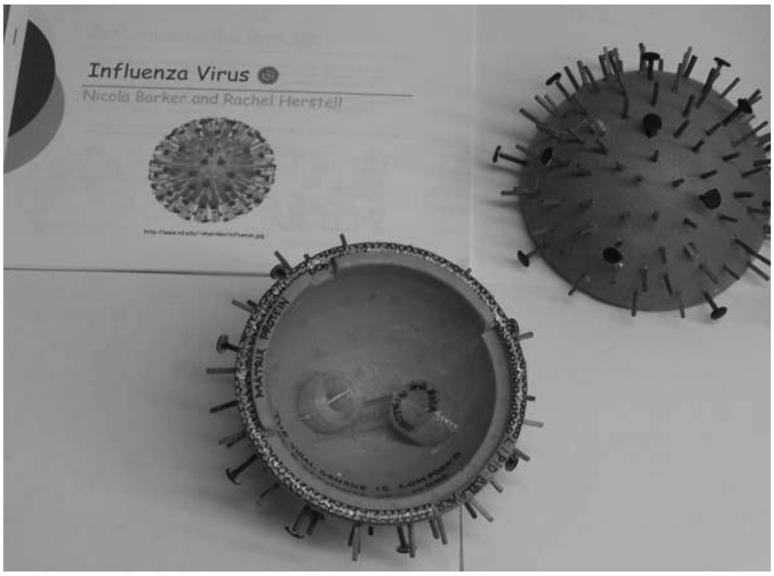

Figure 1: Model of influenza virus and accompanying PowerPoint presentation

models of toadstools can be found in many a craft shop, with more scientifically accurate models also available for purchase, or viewing (**www.hps.cam.ac.uk/whipple/explore/models/glassfungi**; **www.britmycolsoc.org.uk/resources.asp**). The 20-sided polygon, the icosahedron, provides the maximum volume for the minimum building material, thus is an ideal structure for both viruses and geodesic buildings such as the Eden project. During the assignment, some students produced 3-D models of viruses (**Figure 1**): one group ingeniously used the clear balls used for guinea pig exercise, as the transparent envelope!

The consequences of bacterial and viral diseases, rather than the microorganisms themselves, provide ideal subjects for visualising the destruction wreaked by plagues through history (e.g. **www.wellcome.ac.uk**), and upon individuals (e.g. The *Inheritance* by Edvard Munch). Students created PowerPoint presentations outlining the influence of plague on contemporary art; produced conceptual images using FISH technology; painted a representation of the history of science; produced a collage in 1930s style of the importance of tuberculosis in literature (**Figure 2**); designed panels for the AIDS quilt; profiled artists who interpret science through the medium of paint, constructed a large model of influenza virus, accompanied by PowerPoint lecture notes and smaller cutaway models, for use in lectures. Of course, not all products are aesthetically pleasing, nor do they meet the negotiated assessment criteria (**Figure 3**).

Combining Microbiology and Art

Previously, projects in poster and leaflet design (Verran, 1992, 1993) have incorporated consideration of communication, cost and co-operation with peers. More ambitious cross-disciplinary projects involved undergraduates in art and biology working together to design an artwork for the foyer of a new science building. Although not successful due to the cost implications, one proposed installation considered the importance of repeating, yet evolving structures in all aspects of science (fractals, DNA, evolution, polymers).

Discussions with artists at the University have led to projects where the outcome has been artwork, exhibition, or installation, rather than scientific paper, report or presentation. Postgraduate art students have also used microorganisms and/or principles of microbiology as part of their project work. Such ‘SciArt’ partnerships are not uncommon, and the Wellcome Institute is particularly interested in this type of development.

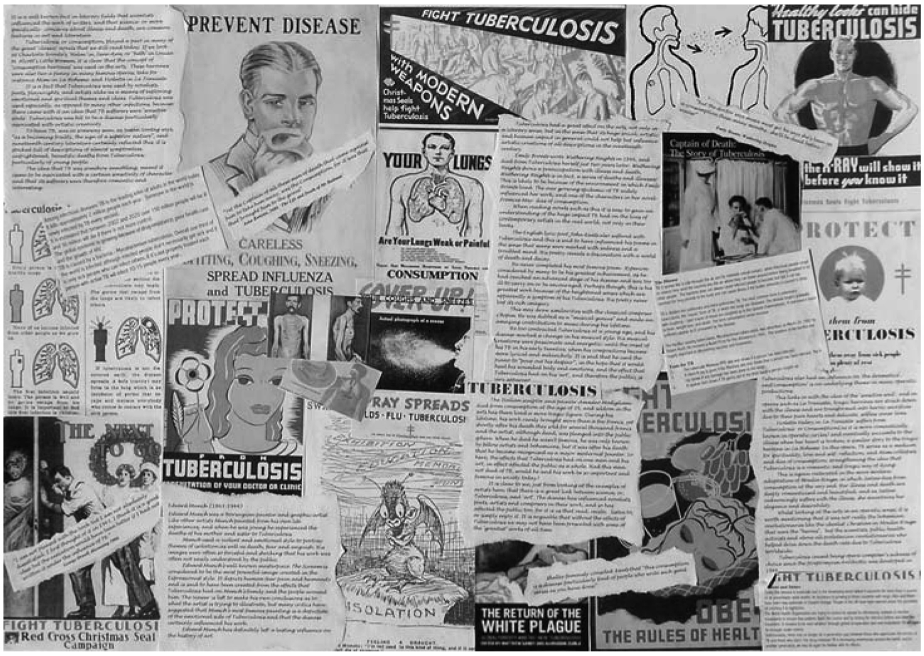

Figure 2: Tuberculosis and mid-20th century graphics, accompanied by text describing links between the disease and the arts

Figure 3: Fairly anaesthetic and poorly conceived collage to demonstrate use of fungi (wrappers, labels etc): unfortunately the real mushrooms which were also part of the collage went mouldy, necessitating the disposal of the piece!

Microbiology and. . . .

It rapidly becomes apparent that the combination of microbiology with other subjects such as literature (5), where the impact of disease on the development of particular novels can be explored; or music, where composition or lyrics can assist in recall of complex terminology, is easily possible. Subjects such as history, geography, politics, and economics are inevitably associated with the epidemiology and management of emerging and re-emerging disease – thus whatever the interest of the audience, microbiology becomes of interest and relevance! Indeed, this lecture has been given externally to a range of different audiences who have enjoyed its rather different slant on science.

Figure 4: the overall prize-winner of the 2005-6 competition produced three pieces representing Aspergillus in different formats. The montage of pieces is completed by a library image of the fungus, and a plaque commemorating the award.

Evaluation

This academic session (2006-7) marks the third iteration of the assignment. From a small initial group in the first year (approximately 20 students and 12 products), to over 50 in the second year, and a more modest 10 in the current session, the feedback from students has been very positive. Since the students are self-selecting, there is no sense of inadequacy, and there is a significant enthusiasm to employ talents other than those perceived as ‘scientific’.

Assessment for the Frontiers module is ‘100% coursework’, and comprises assignments in note taking, essay writing, writing lecture synopses in addition to the poster/art work. Marks awarded were generally high, provided that the students adhered to the negotiated assessment criteria. In 2005-6, from 50 students, 24 ‘products’ were awarded the following marks: 90 – 100%, 4 products; 80 – 89%, 3 products; 70 – 79%, 5 products; 60 – 69%, 7 products; 50 – 59%, 5 products.

It was also important not to use my office as a repository of dusty posters or models. Thus the students’ art was displayed at an event for which industrial sponsorship, including prizes, was forthcoming. The sponsor, Leica Microsystems, is well aware of the potent imagery which their equipment can generate, and have published a book of such images (**www.fluorescence-microscopy.com**). One of the student montages has been framed (funded by the sponsor) and is displayed in the School reception area (**Figure 4**); others have been used as teaching aids; even more satisfying is the number of students who ask for their work to be returned for them to use as home decoration.

An awareness of the different interests and learning methods of students is important in providing an appropriate stimulating educational environment, particularly when the numbers of students is increasing, and their entry qualifications and abilities are more varied. Enabling the expression of creativity amongst first year science undergraduates has been a particularly rewarding experience.

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[O21] Writing on the walls: helping students grasp scientific terminology

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Keywords: terminology, art, science, artist, teaching

Introduction

For over a hundred years Writtle College has specialised in training and education for the land-based industries, principally agriculture and horticulture. In recent years the College's course portfolio has been extended to include degrees in interior and garden design, landscape studies, rural resource management, leisure management, and animal and equine studies, all of which are validated by the University of Essex.

In addition, the College has established several Centres of Innovation which represent areas of strategic importance both for the College and the industries it serves. One of these, CADE (Centre for the Arts and Design in the Environment), was established to encourage collaborations within Writtle's academic community and with the arts and design communities beyond Writtle. CADE activities have included collaborations between students, staff and various artists-in-residence, a number of whom have been sponsored by Essex County Council, which have resulted in the production of several community artworks. CADE has also collaborated with healthcare organisations in the Eastern Region to produce conceptual designs for courtyards in a new hospital, and is currently converting a redundant farm building to provide studio facilities for recent art and design graduates wishing to develop their careers and businesses.

A very recent project involved artist-in-residence Lynn Schwartz, who was sponsored by Essex County Council as part of an exchange programme with Picardy, France. Lynn worked with Science staff who were keen to explore new and/or novel ways to help students to understand scientific concepts and the vocabulary associated with them. Lynn, an American who now lives in Montataire in Picardy, was selected for this two week residency because of her interest in systems, classification and exploring alternative ways of communicating ideas. She has knowledge of these scientific approaches because of her background in environmental science.

Lynn's remit was to produce a temporary or permanent art work whilst working and interacting with students and staff, to enable them to think differently about their environment. Although time constraints meant that the final artwork was of a temporary nature, Lynn has left a legacy with her sketchbooks and drawings, and has inspired students and staff to see their subjects in a new way.

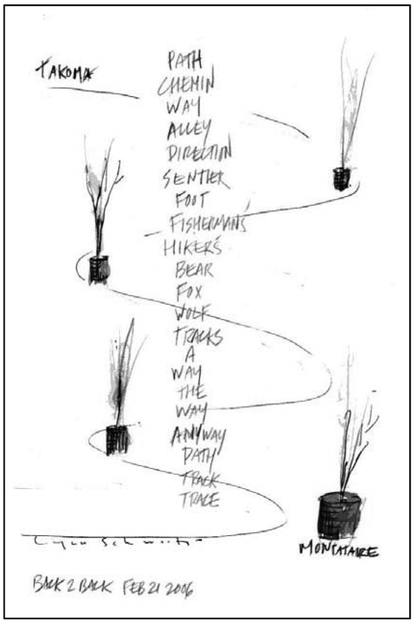

Figure 1: Representation of a walk from Takoma to Montataire, Lynn Schwartz, February 2006

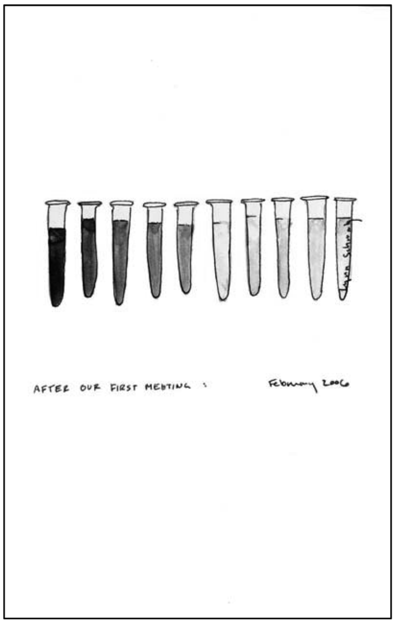

Figure 2: 'After our first meeting', Lynn Schwartz, May 2006

Exploring Ideas

A recurring theme in Lynn's work is the concept of journeying either real, undertaken in the built or natural environment, or a journey of knowledge, of the spirit or of the emotions. In attempting to make this concept explicit, Lynn has explored arresting ways to get people to think about their environment by challenging their usual view of it. For example, **Figure 1** illustrates a walk from one place to another; features being represented by words and containers which are key elements in Lynn's work.

Consequently, at the start of Lynn's residency she suggested exploring the idea that words and containers out of context could be used to stimulate discussion of scientific concepts. For example, observing the differences in depth of colour in test tubes (**Figure 2**) might lead to discussions about the concept of dilution and the use of light absorbance to determine concentration. Letters drawn onto cans placed in the landscape (**Figure 3**) might encourage discussion of the use of symbols as representations of elements, molecules and compounds. Lynn's drawings (**Figure 4**) exploring concepts of bonding and three dimensional structural representations certainly stimulated staff interest, eliciting such comments as 'the chemistry is wrong' and 'there are too many bonds attached to oxygen'!

As observational skills lie at the heart of the Biosciences, Lynn also suggested that we might encourage students to view their natural environment in different ways by undertaking a series of drawing exercises. For example, participants were asked to draw leaves, trees and people by concentrating solely on the outline of the object being drawn and without looking at the marks they were making on the paper (**Figure 5**). This approach helps to encourage observation, hand-eye co-ordination and prevents the conscious mind from influencing the image drawn (Edwards, 2001).

As students often have difficulty with scientific words, Lynn suggested that we might try presenting them in unusual ways. For example suspending word-carrying cans from leafless trees (**Figure 6**) might lead to a discussion of the meaning of the word on the can. If the word were leaf, for instance, the discussion could be about the structure and function of leaves, the functions of the chemical compounds found in leaves and leaf adaptations

Figure 3: Letters on cans, Lynn Schwartz, May 2006

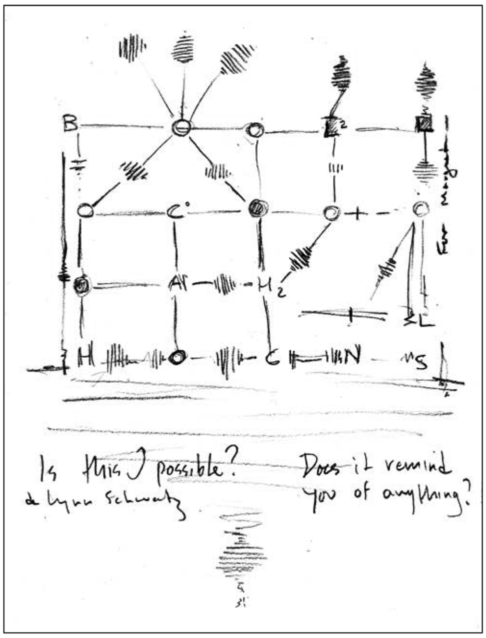

Figure 4: Chemical bonding, Lynn Schwartz, May 2006

such as those preventing water loss. Alternatively, words placed on flower pots could be used to indicate the factors influencing plant growth.

Lynn wanted to consider the normally unseen, and often overlooked, parts of the natural environment and considered representing a soil profile by painting different coloured bands on a structural column in the Science building (**Figure 7**).

The Installation

The art work which was eventually installed outside the entrance to, and in the foyer of, the Science building, brought together these ideas of journeying, words, containers and 'seeing' the natural environment. The art work started on the canopy outside the building, continued down an external column (**Figure 8**), apparently disappeared underground and finally re-emerged inside the building on an internal column (**Figure 9**). The journey

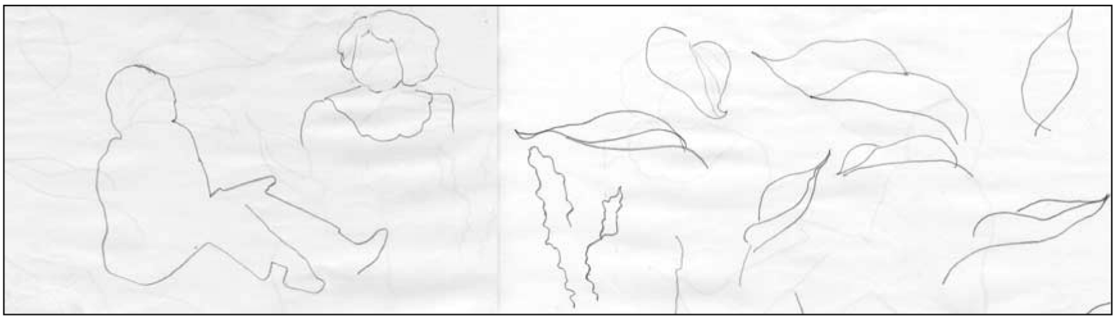

Figure 5: Line drawings, Ron Fryer, May 2006

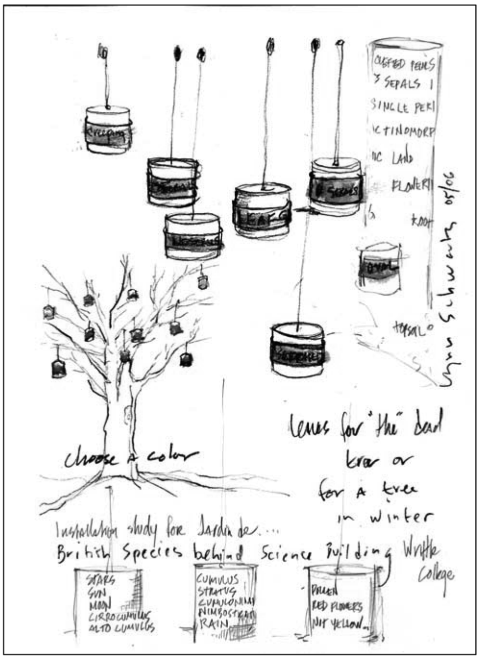

Figure 6: Words and containers, Lynn Schwartz, May 2006

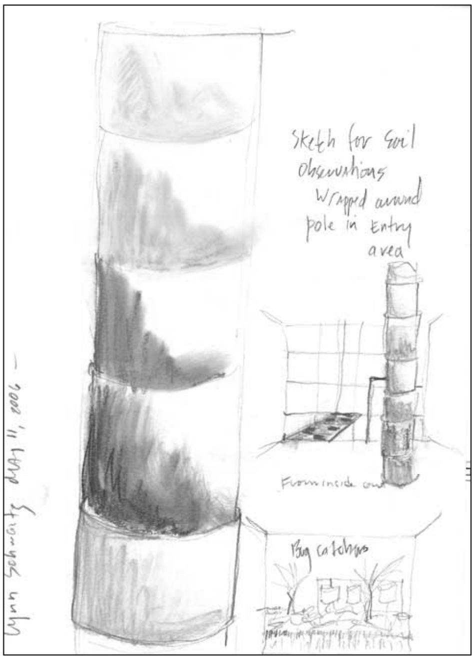

Figure 7: Representation Soil Profile, Lynn Schwartz, May 2006

represented by the artwork started with the words 'Universe, Stars, Sun, Moon, Atmosphere . . .' and ended with the word for a specific living organism and a description for its identification wrapped around the internal column. In the same way that the artwork can only be understood by moving around and observing it from different angles, the natural environment can only be fully appreciated by approaching it from different perspectives and involving many disciplines.

Reflections

A few staff and students found the ideas behind the residency difficult to comprehend, couldn't 'see the point' of the installation or didn't consider it to be 'art'. However, most visitors to the building were able to appreciate the connections made, and that words may be used not only to describe the world we see but also to conjure up many other mental images and, indeed, many other words. The experience was perceived as successful by all those involved, and further ways of explaining science through art are envisaged. Our hope is that a permanent version of the artwork will be installed so that it might help students learn terminology either as part of a lesson or as a revision aid.

Figure 8: 'A Certain Order', Lynn Schwartz, May 2006

Figure 9: 'A Certain Order' with detail, Lynn Schwartz, May 2006

In the final analysis, this piece of environmental art did reflect concepts and ideas, provoked responses, and did form the starting point for discussion, even among scientists!

Acknowledgments

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[O22] Involving undergraduates in outreach and public engagement through final year projects in science communication

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Keywords: projects, communication, outreach, public engagement

Abstract

Public engagement is an increasingly important issue in the sciences. With such rapid developments in science and technology, effective communication regarding the benefits and risks of scientific progress has never been more important. In the Department of Biosciences at the University of Kent, we have introduced science communication activities to the undergraduate curriculum as part of the final year research project. 'Communication Projects' were introduced in 2005 to complement our existing portfolio of final year project types. Students undertaking Communication Projects complete an extended period of in-depth literature-based research on a topical, controversial or poorly-understood area of science (examples have include the use of stem cells in medical research, the use of performance enhancing drugs in sport, and the risks of biological warfare), and then develop strategies for communicating the research to a non-scientific audience. Thus, the students write an extended dissertation on the outcomes of their research, and also prepare an oral presentation and associated materials in which the research is explained in a manner that is accessible to non-scientists. The oral presentations are delivered and assessed during National Science Week in local schools to students of mixed ability and age, and are repeated at public showcase events later in the academic year. These presentations are becoming an important addition to departmental outreach activities, and we are increasingly targeting schools with low participation rates in higher education and science subjects post-GCSE. The positive outcomes for final year students, teachers, school pupils and the university will be discussed.

Introduction

The ability to communicate science is an important skill among science graduates. At a time of rapid progress in medicine, biological and physical sciences, engineering and technology, effective communication is essential to encourage people to engage with science, understand the benefits and risks of scientific developments and form their own opinions about science and its place in a modern society. Ineffective communication can lead to misreporting in the media and inaccurate representation of the implications of scientific developments. Perhaps most damagingly, lack of public engagement leads to general disinterest in science and technology. Furthermore, the decline in studying science subjects in post-16 education, and consequent shortage of science graduates and science teachers, is leading to concerns for the sustainability of science and technology in the UK.

Several recent initiatives, implemented throughout the scientific community, aim to address this at a national level. There are significant developments in secondary science education with new A2- and AS-level courses that focus on ethical discussions on the impact that science has on society, while Research Councils, charities and industry all provide funding for scientists to engage with the public. However, while these schemes help those who already engage in science communication activities to do more, the root of the problem may well be that scientists do not consider public engagement to be an inherent part of their role in society, and regard any time spend communicating science to the public as a barrier to their research. The philosophy I outline in this paper is that we need to train undergraduates to recognise that communication of their subject and engagement with a non-specialist audience is an integral part of their role. This would provide a large number of science graduates with skills in explaining scientific issues, both in a formal and informal capacity, in an engaging and inspiring way, thus promoting public understanding of science and leading to a population empowered by knowledge and inspired by science and technology. The challenge, however, is to fit training in science communication into a practically-based curriculum with competing priorities and a very busy timetable for students and staff.

Final year 'science communication' projects

This paper describes the development of final year 'Science Communication' projects, an addition to the final year project portfolio in the Department of Biosciences at the University of Kent. Communication projects are undertaken on a topical or controversial area of science such as cloning, bird flu the use of stem cells in medical research. Students undertake an extended period of research, leading to the preparation of a **dissertation** in which the student reviews, in depth, the scientific literature and focuses on modern developments within that field. This ensures that students achieve appropriate depth and comparability with students undertaking other types of final year project (e.g. laboratory-based or dissertation projects). For example, in a recent communication project concerning the use of performance-enhancing drugs in sport, the student undertook an in-depth literature review on the cellular effects of drugs that are banned by the world anti-doping authority (e.g. anabolic steroids and erythropoietin), focussing in particular on how the complex cellular signalling initiated by these drugs related to changes in physiology that would be beneficial to particular sports.

Having undertaken in-depth scientific research as part of the dissertation, the students are in a position to develop strategies to *communicate* what they have learned about the science to an audience that does not necessarily have any scientific training. The 'communication' element of the project involves the preparation of an **oral presentation**, together with supplementary material such as an interactive website/CD-ROM or even a magazine article, *all intended for a non-scientific audience*. This allows the students to think in a way that they probably have not done during their University careers in order to develop strategies for explaining the science behind their project. The presentations must not be a superficial treatment of the underlying scientific principles; 'skimming the surface' of the subject is not sufficient. Indeed, the preparation of a dissertation based on in-depth research informs and underpins the presentation, ensuring that the content is cutting-edge. Thus, the student undertaking the communication project of performance enhancing drugs explained the cellular signalling described in the dissertation, and related this to ethical, medical, social and political considerations of the use of drugs in sport, in a way that could be understood by a group of AVCE Sports and Recreation pupils in a local school.

Communication project presentations take place in local schools during **National Science Week** in mid-March. The audience comprises pupils in years 10-13, studying a mixture of subjects. We work with a range of schools, including those with low participation in higher education and post-GCSE science, and the teachers within the schools act as co-assessors of the 15-minute presentations and students' fielding of questions.

Support and guidance

Communication projects are undertaken with the guidance of an academic member of staff, with whom students can discuss their ideas and obtain relevant information. The supervisor may well be an experienced scientist and teacher and will certainly be able to offer research guidance, but is not necessarily an expert in the specific area of research; thus, the supervisor and student are true partners in learning. Academic staff produce an exciting array of topics for students to choose from each year; some of these are topics that are very much in the public arena but warrant further discussion (e.g. the use of stem cells in medical research, the risk of biological warfare post-9/11), while others have been more esoteric but no less interesting or controversial (the evidence for a gene for homosexuality, the use of homoeopathic medicine, the benefits and risks of the Atkins Diet).

As the date of the assessed presentation approaches, group workshops are arranged in order to encourage students to think about what constitute good and bad presentation skills. The students work in small groups to critically analyse their own learning experiences, and to formulate their own 'checklist' of good and bad practice to use in preparing their presentations. Peer review sessions, in which the students present their talks to each other in a supportive environment, are also organised so that speakers can obtain guidance from their peers before the assessed presentation. Feedback has indicated that this helps to prepare the students for the daunting experience of giving a 20-minute talk to a diverse and unknown audience, and it clearly increases the standard of the presentations.

Evaluation and outcomes

Now in their third year of operation, communication projects are firmly embedded within the undergraduate Bioscience curriculum at Kent, with approximately a quarter of our final year students electing to undertake them. It is recognised by the students that the extended period in which they engage in research and effective dissemination provides them with very valuable skills for future careers. Communication projects also provide us with a formal mechanism to reward students who possess skills in engaging and stimulating a broad audience and increasing interest in science. It is clear that students who do not necessarily have the highest academic abilities can be natural, engaging and imaginative communicators. Furthermore, the preparation of a presentation enhances the understanding of the student's research topic encouraging a 'deep' rather than 'surface' approach to learning. Student evaluation has been very positive; indeed, one student was moved to write '*throughout the course of the project, I learned the important value of tailoring scientific communication for different audiences, which has given me a distinct advantage in my new job as the Commissioning Editor of two new and exciting scientific journals. I honestly don't think I would have done as well at Kent, or have this career, without the communication project*'. The projects have also been embraced by staff within the Department; all academic staff have now supervised at least one communication project student. In many cases, supervision of communication projects has inspired staff to increase their own involvement in outreach activities, and as a department we are now more aware of the importance of public engagement. External examiners have also praised the scheme as an effective way of integrating scientific depth and rigor with a training in science communication.

The integration of Biosciences students with the local community has also had a major role in raising the profile of the department. The school pupils and their teachers collectively benefit from the content of the student presentations, which is not usually covered within the rigid confines of the exam board curriculum. Such is the enthusiasm of the participating schools for the scheme that two of our partner schools have block-booked a whole day of the timetable for the student presentations. In selecting the schools in which to deliver talks, we work closely with the University's Partnership Development Office to target regional schools that currently have low participation in science subjects post-GCSE, and indeed the Higher Education sector in general. This year, communication project students will also present their work to local community groups and adult learners after end of year exams, and have a further opportunity to present at the 'Biosciences Communication Showcase', an open event to which schools, colleges and the local community are invited. These activities collectively generate significant local and regional media attention, raising the profile of the department, the University, and the student presenters. While it is too early to say whether the scheme has had a significant impact on UCAS applications, the increased local profile is having a very positive influence in the way we are perceived.

Another very positive which illustrates the impact that the Communication projects have had on students is *Student Science News* (**http://www.kent.ac.uk/bio/study/Outreach/Default.htm**), a newsletter covering topical scientific issues aimed at the 14-18 year old age group. It was founded by communication project students and is written, edited and published by them, all on a voluntary basis. The content of the newsletter includes topical scientific stories in the news, Kent-based research and 'fun' scientific facts in an exciting and accessible format. Five issues have been published, each of which had a print run of 6,000, circulated to almost 100 schools in the South East. A new editorial team is assembled each year, and this year the team includes students undertaking laboratory-based projects; the idea that science needs to be communicated effectively is also clearly being taken seriously by those who aspire to laboratory-based research careers. The newsletter also gives students ownership of a prestigious and high quality publication, and has certainly been an important addition to the CV of those involved over and above the effect it has had on their learning experience.

Ultimately, our aim is to train graduating students to recognise the importance of communicating science and public engagement. We hope that, as communication projects develop in future years, a tangible change in culture will continue to emerge in which public engagement is regarded by undergraduates as a worthwhile, valuable and enjoyable activity.

[O23] Back to school: educating ourselves about students' previous learning experiences

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Keywords: transition, higher education, staff development, retention

Abstract

This project examines the experience of students studying Biology at A level in order to facilitate their transfer to Bioscience degrees. The first stage was to map the existing year 1 undergraduate curriculum against the A level Biology syllabus. The second phase involved six members of academic staff visiting a range of local schools and colleges in order to observe A level Biology lessons and speak to staff and students. The third stage was to review teaching and learning in the first year of Bioscience degree in the light of the syllabus review and visits. This has resulted in a number of projects looking at aspects of teaching and learning, including developing students' writing and practical skills. There has also been a change in attitude amongst staff who went on visits, related to their assumptions about what students can reasonably be expected to know, which continues to be communicated to colleagues.

Introduction

Research in the field of retention suggests that one of the key reasons for leaving early is a mismatch between various aspects of students' expectations and what they find when they reach higher education. Preparedness is a major feature of the issue. Ozga and Sukhnandan (1998) argue that there is an interaction between preparedness and compatibility of choice of institution and course which affects completion. Wilcox *et al* (2005) argue that there are a range of factors involved in lack of preparedness, some of which can be addressed via learning and teaching strategies. The issue of who prepares and who adapts is an interesting one in the area of retention. Zepke *et al*, (2006) identify two discourses which are 'distinct, yet overlapping and complementary' (p588). One is characterised by its project of integrating students into the institutions norms, the other by adapting the institution to meet learners' needs.

Previous learning experience is a major source of students' beliefs about what higher education involves. Constructivist theories of learning stress the importance of understanding the learner's view. 'Recognising students' prior experiences and how students come to make sense of these experiences are essential elements in establishing an effective learning environment.' (Watters and Watters, 2007 p21) These ideas include the range of those underpinning epistemological understanding. Involving beliefs about knowledge and learning, epistemological beliefs cover both the subject matter itself and the ways in which understanding of the subject matter can be developed, and therefore includes beliefs about pedagogy. Kinchin (2005) has studied the development of these beliefs in science students and ways in which students can be encouraged to develop 'a more productive epistemology' (p29) Watters and Watters, (2007) argue that particular epistemological beliefs underpin approaches to learning and result in an approach to learning amongst most biological science students which emphasise memorising of facts and focussing on studying for tests. This can represent a rational reaction to teaching and assessment practices on the part of students, but may also be maintained when it does not bring rewards in terms of results.

Working within an adaptive discourse leads to the area of staff development; making explicit epistemological beliefs of staff and developing their understanding about prior learning experiences. Sellers (2005) describes the process of curriculum alignment, in which university teaching staff examine the curriculum students have followed before reaching higher education, in order to identify whether the institution's expectations are realistic and hence facilitate transition. Of course, the more diverse the student body the more complex this task becomes; at one end of the spectrum most students will have followed a similar curriculum relatively recently, at the other there will be a much wider range of pre-entry educational experience.

Background to study

As Student Support Officer, responsible for promoting engagement and retention, I was aware of the issues surrounding students' transition to higher education. A quinquennial review of one core degree programme made this a good time to conduct a project in which curriculum and learning and teaching would be examined in order to facilitate transition. The University's Academic Development Centre supported the study financially.

Method

During the first stage students' entry qualifications were reviewed and it was found that the majority of students on the relevant degree courses had recently studied A level Biology. Qualifications and Curriculum Agency (QCA) guidelines and examination board syllabi were reviewed and a digest prepared. Representatives of the first year teaching team compared this to the level one Bioscience curriculum.

The second stage involved extending the study to look at previous teaching and learning experiences in addition to the curriculum review. Seven members of the teaching team visited six local schools and colleges to observe A level Biology lessons, both theory and practical. Initial contact was through the University educational liaison officer. Within the opportunity sample a range of schools and colleges were obtained. The sample was composed of two Colleges of Further Education, two comprehensive schools and two selective schools, both of which happened to be girls' schools. Observations were supported by the provision of a semi structured recording sheet.

The third stage involved sharing and reflecting on the information and impressions gained from the observations and then identifying adaptations that could be made to facilitate transition to studying at university level. This involved a wider group than those who had been able to carry out the observation, and was informed by the data gathered.

Outcomes

It was felt that there were no major discrepancies between the two curricula, and that we were not expecting students to be aware of subject areas which they had not met before.

However, we were aware that a number of factors could affect the extent to which students were confident about their ownership of the subject knowledge. These would include factors such as attainment, engagement and epistemological beliefs, which could be influenced by previous teaching and learning experience.

There were a number of findings from the feedback from the school visits.

In terms of teacher support, students appeared to frequently request information and advice from the teacher during classes and when working independently on practical work. This included asking whether they were doing something correctly, asking what type of notes to make and in some classes asking about the subject content of the lesson. One colleague commented that the students she observed were 'constantly looking for reassurance that it was correct.' There are far fewer opportunities for this to happen during teaching at university. Students would more usually have the opportunity to speak to lecturers after a lecture, rather than during it.

Teachers frequently drew attention to the requirements of the syllabus and of the exam, often referring to model answers produced by the exam board. There is a large amount of legitimate material available to students on the web, including model answers and course work practical designs. This has obvious implications for students' understanding of the use of material from these sources when they reach us.

In the practical area students worked with limited amounts of relatively simple equipment. The number and range of practicals were also understandably limited. This has strong implications for the ways in which students are introduced to practical work at level one.

We observed some useful points about behaviour in the classroom that led us to change our expectations of how students might expect to behave. Most lessons observed saw numbers of students arriving late, one or two also included students leaving during the lesson. Because of the large group sizes students at our university are not allowed to enter late after an initial two week grace period, we now feel this needs more explanation. There was a large amount of talk related to the lesson in the observed classes; students would check information with friends and with the teacher. Teachers managed this rather than silencing it.

School visits made a great impression on colleagues, showing them the reality of the small group teaching and extensive guidance that students experienced. Many of us referred to our own sixth form and college experience which had involved a great deal of silent note taking from what were essentially lectures. This has lead to a shift in attitude by participants in the project who now feel that students' behaviour has a cause and a context. Previously this behaviour was seen as a cause for concern and censure. As one colleague said, 'Explains a lot of what was, to me, puzzling behaviour by students'. Colleagues became aware of the amount of independence that undergraduate study demands of students in comparison to their school or college experience. This understanding was shared with interest by colleagues who had not been able to go on visits, and meetings to discuss potential outcomes were well attended.

The understanding prompted by the observation data motivated the teaching team to consider changes to teaching that would enable it to reflect students' previous experience in the classroom. A number of changes have been adopted, related to being more explicit about the demands of higher education. One module leader has developed her module guides so that learning outcomes are explained in terms of the types of study that might help to achieve them. Assessment has been changed so that all Bioscience students write an essay at level one. The essay is preceded by a session on essay writing, and staff undergo a training session on feedback as teaching before marking the essay. In order to encourage students to attend to and act on feedback the mark is withheld until the completion of a feedback sheet indicating what aspects of the feedback will influence work on future modules. We have begun to look at fostering the development of practical skills, and are preparing to alter a key module so that students have the opportunity for formative and summative assessment of their practical skills as part of the module.

The more intractable area of teaching in large groups is still under discussion. The difference in the experience of small A level groups and large level one groups is very marked, and is not under the control of the teaching team. We are considering being more explicit about expectations of how these large groups operate as we are now aware that this is not something that students can be aware of from their previous experience. We are also experimenting with small changes, such as the use of a question box so that students can ask questions and seek clarification in a less public way.

Conclusion

The observations acted as a powerful means of enabling colleagues to question their assumptions about students' previous learning experiences. This resulted in open minded and creative examination of existing practice, and subsequent changes to teaching learning. Using the terms of Zepke *et al* (2006), we are engaged in both the assimilation and adaptation projects; trying to adapt to meet students experience and being more explicit about how we expect students to adapt. The work could be taken forward in a number of ways.

As a staff development exercise it could be carried out in its existing form across any discipline area that has a counterpart at school level. Even discipline areas which do not have an exact equivalent could look at feeder courses.

As a development of this project we will continue to explore ways in which we can bring the first year experience more into line with students' previous experience, and support students in developing approaches to studying in higher education. We could look in more depth at the epistemological beliefs of students and staff and then assess whether existing teaching and assessment methods support Kinchin's idea of a 'productive epistemology', by which he means one which is focussed on an active, enquiring approach to knowledge, where it is assumed that understanding takes time and is achieved through active engagement with the discipline. (Kinchin, 2005)

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[O24] Exploration, experience and evaluation: Peer Assisted Study Scheme (PASS), sharing the experience of The University of Manchester: 480 1st year bioscience students

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Keywords: Peer Assisted Study Scheme, collaborative learning, student facilitation, life sciences

PASS at the University of Manchester

Since 1995, at the University of Manchester, staff from 'Students as Partners'[1], have supported the implementation of PASS in over 20 subjects with more than 50% of these programmes in science based disciplines. PASS is a structured peer support scheme whereby trained, higher year students ('PASS Leaders') volunteer to support and facilitate the learning of 1st year students (participants). Leaders are paired up to co-lead and facilitate study sessions involving a group containing a maximum of 20 participants. The character of the PASS sessions is one of collaborative and active learning, as they are centred on discussion and interactions facilitated by the leaders. The primary purposes are to help participants to better integrate with university life and to provide a safe and supportive environment where participants can engage in self-directed learning practices, compare and develop learning strategies and study skills for HE, and so improve their understanding of the subject matter. Through this student-centred approach to learning, PASS intends to engage students as partners in their learning experience.

It is encouraged that for continued benefit, sessions are held weekly in a timetabled slot, which endorses the scheme in the students' eyes. Whilst attendance is not compulsory, PASS is presented as just another thing to attend; in this way students have to actively 'opt out' rather than 'opt in'. It is important to stress though that PASS is always considered supplemental to the core teaching and is not meant to be remedial.

The PASS model is based on Supplemental Instruction (SI), which was developed at the University of Missouri, Kansas City in 1973 (Arendale, 1994). Manchester adopted the '21 Principles' (The University of Manchester, 2007) developed by Jenni Wallace when she adapted the SI model in the 1990s for use in British Higher Education, (Rust and Wallace 1994, Wallace 2003,).

Using these guiding principles, the individual programmes in each discipline retain a common core, which ensures the standard of the Manchester scheme is maintained; as such, it is recognised as the UK National Benchmark. It is however the individual discipline and the students that take ownership of the programme and it is actively encouraged to engage students in its introduction and development. In promoting this level of engagement, one aims to end up with a scheme that is 'student owned and student led', which ensures that the scheme meets the needs of the student body within any particular discipline. At Manchester University, the schemes have developed to such an extent that the PASS Leaders were asked to co-deliver a pre-conference workshop at the SI International Conference, hosted by Lund University, Sweden, in May 2006.

Why introduce a peer support scheme?

The University of Manchester has two complementary peer support programmes: peer mentoring and PASS. Its aims for doing so are:

- to enhance the quality, quantity and diversity of Student Learning within a discipline
- to involve students as partners in their learning experience
- to provide further opportunity for the development of intellectual and professional competencies
- to provide students with a supportive environment to assist the transition to Higher Education.

The introduction of PASS to the Faculty of Life Sciences

In 2005-06, PASS was launched in the Faculty of Life Sciences (FLS) for its 480 1st year bioscience undergraduates. According to the data available, Manchester University thus became the UK pioneer on two fronts: firstly for implementing PASS in biosciences and secondly for implementing PASS on such a large scale. The FLS introduced PASS to:

- provide participants with a supportive environment to assist the transition to Higher Education
- support participants, through a student-centred approach, with their understanding of course material and hopefully promote their development as independent learners
- improve participants' academic performance and reduce failure rate (especially for the two course units associated with PASS: 'Genes and Evolution' in semester 1 and 'Drugs: from molecules to man' in semester 2)
- enable students to get a leader's view of course expectations
- provide both participants and leaders with an opportunity to develop or improve a range of transferable and study skills
- generate real time feedback about our first year course
- reduce the amount of time 1st year course coordinators (particularly those of the associated course units) spend answering individual queries from a group of about 350 students per unit
- increase peer interaction and challenge the barrier between year groups, so as to install a sense of community within the FLS large cohorts

Implementation and delivery of the scheme in 2005-06

At a Faculty level, the scheme was supported by the Senior Tutor, Teaching Fellows (associated with the selected course units) and administrative staff. Training, guidance and ongoing support were provided by 'Students as Partners' staff, based in the Teaching, Learning and Assessment Office.

To enable a more effective evaluation of the effect of PASS on academic performance, a controlled experiment was designed that equally partitioned the 1st year cohort (480 students) into two groups who would be offered PASS over one semester: Group 1 in semester 1 and Group 2 in semester 2. 30 Leaders were recruited and trained who then worked in pairs with randomly assigned groups of approximately 15-17 students.

Basing their discussions around the two lecture units, the leaders ran sessions every week for 1 hour during a timetabled slot between two 1st year core lectures. These sessions were either based around suggested topics from an academic coordinator or from an 'agenda setting' exercise at the start of the session. Whilst academic topics were the focus of the session, many groups discussed academic related issues (study techniques, revision techniques, and the placement scheme) as well as non-course related issues (settling into halls, choosing new accommodation).

The ensuing discussions were facilitated by the PASS Leaders who helped the participants to work together toward a solution. They did so by using their own experience of the course, by sharing their study strategies, and by using the techniques that they have learnt during their training as leaders, i.e. questioning, utilising group dynamics and problem solving methods.

Weekly 'debrief' meetings were held that brought together the Leaders to share best practice, concerns and the nature of discussions that week. This motivated Leaders and also provided immediate feedback for the teaching team about how the way in which material was being received by 1st years.

Results of semester 1 2005 and Discussion

Participation

The participation rate is a good measure to see if the students have responded well to this voluntary scheme. To benefit from PASS, it has been shown that students need to attend regularly, i.e. at least 40-50% of the sessions in either a continuous or discontinuous fashion (Donelan and Kay, 1998; Coe *et al*., 1999).

Each pair of leaders started with a group of approximately 15 participants, and in semester 1, 9 PASS sessions were offered from week 2 to week 11, with a break for reading week (week 6).

Out of the 232 students who were offered PASS, 23% became regular participants (i.e. attended 4 or more sessions). This was considered to be a very good level of participant retention for the pilot year (Coe *et al*., 1999; Ashwin, 2002) as many established SI schemes do not exceed this figure (Ashwin, 2003).

21% of students did not attend at all and 56% of participants stopped attending after trying for 1, 2 or 3 sessions before reading week (see **Figure 1**).The most significant drop in attendance was from week 2 to week 3 (from 72% to 41%), which is consistent with the

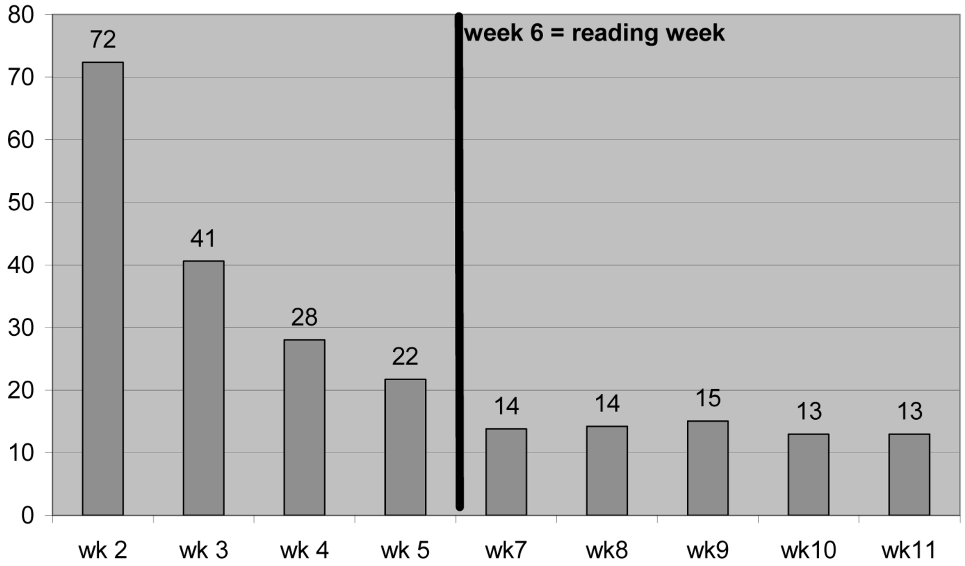

Figure 1: This graph presents the percentage of students (n=232) who attended PASS week by week in semester 1, 2005.

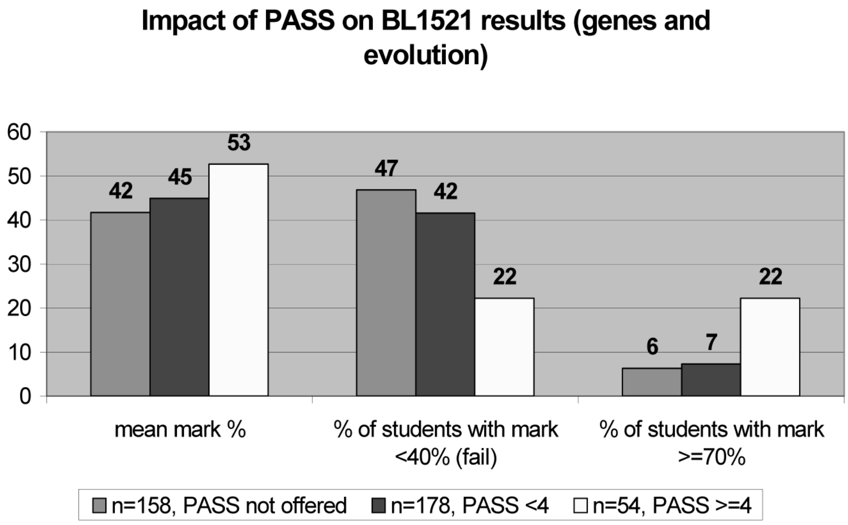

Figure 2: This graph presents the results obtained for BL1521 in January 2006 - mean mark (%), fail rate (% of students with mark < 40%) and 1st class rate (% of students with mark ≥ 70%) - for the regular PASS attendants (PASS ≥ 4) and the two control groups (PASS not offered, and PASS <4).

observation that many students did not receive a positive first impression of PASS. All the logistical elements were not in place by the week 2 session and the leaders reported the environment of the teaching laboratory was not ideal for so many large groups and made communication difficult.

Academic Performance

When evaluating the impact of PASS, it is rare to have experimental control groups and the analysis is usually carried out by comparing the results of 'regular' versus 'non-regular' participants. In our study, we had a large experimental control group of randomly selected students (~240 students who would be offered PASS in semester 2), and we also had a control group composed of students who never attended PASS or just attended for a trial period (less than 4 sessions)

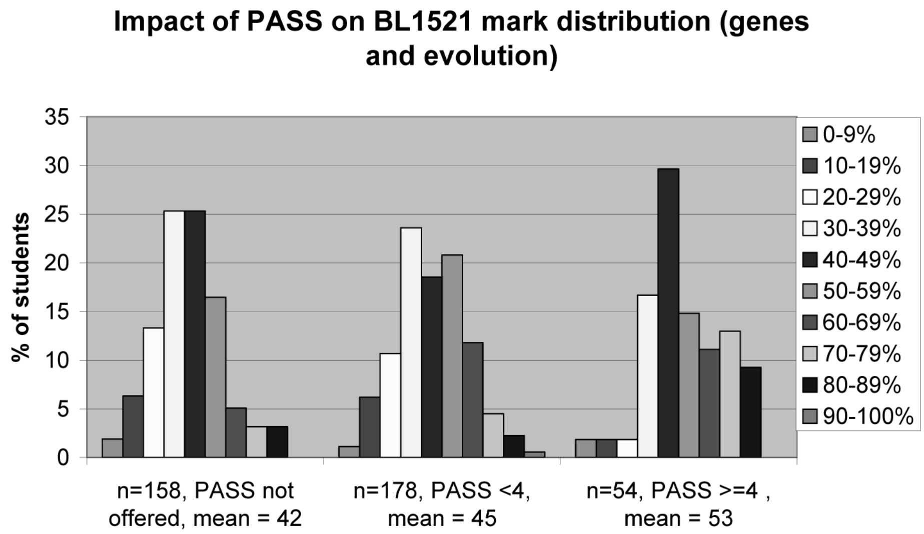

Figure 3: This graph compares the mark distributions obtained for BL1521 by the regular PASS attendants (PASS $\geq$ 4) and the two control groups (PASS not offered, and PASS <4).

Genes and Evolution (BL1521) was the unit associated with PASS in semester 1 and participants were encouraged to discuss its content and 'problem sets'.

To evaluate the impact of PASS on participants' academic performance for BL1521, the results of three groups were compared: the experimental control group (students who were not offered PASS, n=158), the control group of non-regular participants (that attended 0, 1, 2 or 3 sessions, n=178), and the group of regular participants (that attended 4 or more sessions. n=54).

The results obtained (mean mark, fail rate, and 1st class rate (mark $\geq$ 70%)) are compared in **Figure 2**.

The two control groups performed similarly. They displayed results within the same range, and a t test confirmed that their respective mean mark were not significantly different ($p>0.05$).

The regular participants to PASS did much better than either of the control groups:

- They showed a significantly higher mean mark: 53% compared to 42% ($\triangle$11 points) for the experimental control group ($p<0.001$), and 53% compared to 45% ($\triangle$8 points) for the self-selected control group ($p<0.01$).

- They showed a 2 fold reduction of the fail rate (22% compared to 47% and 42%). 12 regular participants failed the unit though, so clearly attending PASS does not guarantee a pass.

- They showed a 3 fold increase in the number of 1st class grades (22% compared to 6% and 7%).

The regular participants' mark distribution (**Figure 3**) revealed that this group was composed of students with diverse academic profiles and not simply of academically gifted students and students with problems. This suggests that PASS was not perceived as remedial or as a scheme for scholarly-oriented students only.

Looking at the overall mark distributions of each group, the two control groups followed a bell shaped distribution, whereas the regular participants' distribution was skewed positively. This shift towards higher marks for most categories compared with either control group suggests that attending PASS may have boosted the regular participants' grades by 10% or 20%.

Interestingly, when the 1st year students were invited to comment on the benefit gained from PASS, comments relating to 'understanding of course content' were the most frequent (70% occurrence), and came before comments relating to 'preparation for assessment' (40% occurrence). PASS therefore had engaged students successfully in a meaning gathering approach rather than a purely strategic one. This is an reassuring result, as Ashwin (2003) had shown in his report that a correlation between attendance at PASS and increase academic performance was only due to a more discerning understanding of assessment requirements, at the expense of a meaning oriented approach to learning.

Benefits (perceived by Leaders)

To evaluate whether PASS had succeeded in delivering its range of intended benefits to the leaders, a questionnaire was delivered in May 2006. Leaders were asked to indicate their level of agreement with a series of statements about the intended benefits of PASS. Leaders felt very positively towards the scheme:

- They all agreed that through PASS they developed/improved a wide range of skills: communication, team management, mentoring, team working, organisation, using own initiative, etc.

- They saw direct benefits to their own academic development as they became more self-aware as learners. For some, this translated into a change of behaviour towards becoming more autonomous and adopting a deep learning approach.

- The experience had had an impact on their personal development. They all claimed to be more confident at the end of it and felt valued by the Faculty staff. For some, this translated into being more focused and motivated towards their own courses as a result.

Conclusion

Our leaders must receive due credit for any successes of this pilot year as they have shown a commitment and enthusiasm throughout the whole experience. They also demonstrated a solid determination as they resisted the pressure to teach in order to retain students; even though this pressure was directly articulated by participants.

Based on the success of this pilot year, it was decided to expand PASS in 2006-07 and offer it to the first year cohort throughout the entire year. To address the shortcomings highlighted in the evaluation (data not shown here but will be discussed in presentation) and in response to the suggestions made to improve attendance, the following modifications have been made to the scheme in 2006-07:

- Our PASS and mentoring schemes have merged, so that the element of pastoral care undertaken by mentors (good supermarkets, accommodation for year 2 etc.) can be fully absorbed by the PASS leader, enabling the first session of PASS to focus on settling in at University, discussing course expectations and how PASS works.

- PASS is now generic to the whole 1st year course, and students decide weekly what is on the agenda. By placing the ownership of the scheme with the students, we expect it will continue to grow in strength and impact.

- To ensure that leaders always have something to talk about during the session though, team building activities and prompts for discussions about study skills have been devised.

- Groups are now formed from two tutorial groups, so as to increase familiarity amongst participants and hopefully improve attendance. This suggestion was approved by the 2005-06 participants at 65%.

- The PASS team has been expanded: a FLS intern together with a PASS student coordinator now effectively run the scheme. They also have put into place a PASS student committee, demonstrating that in its second year running, the leaders respond really well to the opportunity to make the scheme their own.

The introduction of PASS in FLS proved challenging but with the recognised benefits from Leaders and participants, support and encouragement from staff inside and outside the Faculty, its expansion to the entire year was almost inevitable. This presentation will share the benefits, challenges and these results in greater detail as well as a comparative study with this year's 1st semester results.

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[O25] 'From crime scene to classroom': new strategies for teaching using modern technologies

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Keywords: forensic, assessment, mp3, pedagogy, feedback

Introduction

In the last 10 years there has been a huge rise in the public interest in Forensic Science and in the number of undergraduate and postgraduate forensic science courses (Mennell, 2006). This has been pedagogically challenging to academic science departments. University forensic departments require staff bases which bring traditional academics, together with forensic practitioners, who are involved in some way, with the development and delivery of forensic science (Mennell, 2006).

From a pedagogic perspective, teaching forensic science can be problematic. Finding sufficient, realistic and informative scenarios for undergraduate teaching is a challenge. This challenge is compounded further in the arena of teaching forensic pathology. Gaining access to *post mortem* images and the details that give them context, is essential for quality pedagogic provision.

In this paper, we describe how the use of *real-life* case material has been used as a tool for learning and assessment. Briefly, working on the principles of *Problem Based Learning*, learners were presented with photographic material from Crime Scenes for analysis. The images were examined in a time constrained environment for information that would suggest the 5 tenets of forensic science: *who, what, where, why and how*. A short report was prepared, for submission, and oral presentation of the information was also made. Feedback was given using MP3 technology.

Methodology

Five sets of photographs from actual past cases were prepared, and placed within a 'Special Collections' area of the Learning Resource Centre at Staffordshire University. Students studying the module 'Forensic Pathology', accessed each set of photographs sequentially over several weeks. The aspects of pathology covered by the cases were: death by drowning; fire; road traffic incident; shooting and natural disease.

The cases were studied in small groups, under a time constraint of one hour per set of photographs. Sketches were made of each set of photographs, and annotated. The groups were then allowed a period of seven days to access appropriate literature in order to assist their interpretations and provide evidence to support their findings and conclusions. A one page written summary of each group's findings was submitted to the tutors for formative assessment. In addition, one group was selected at random from the cohort to present their findings from each case during a session with the whole class.

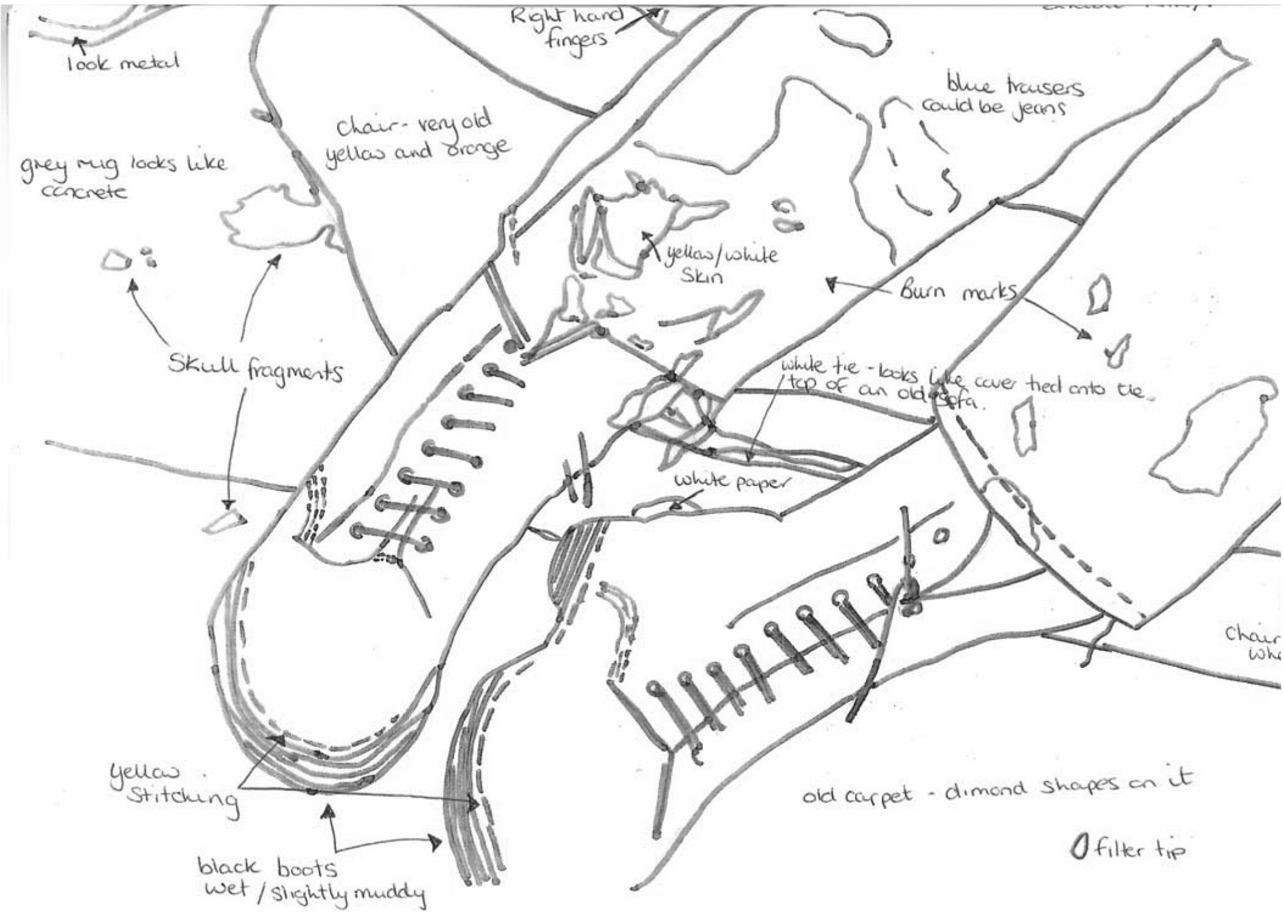

Figure 1

Figure 2

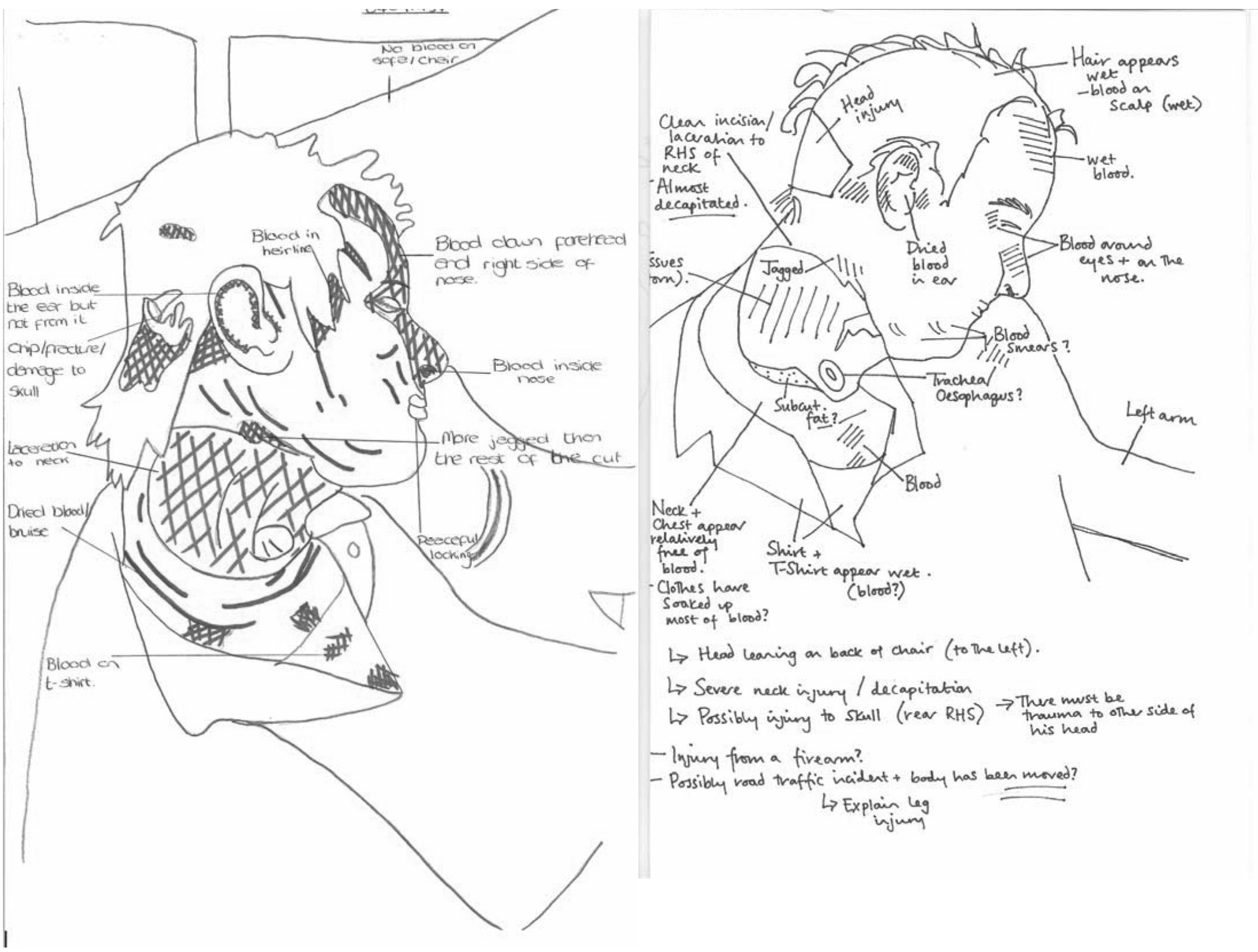

Figure 3 and **Figure 4**: Interpretations of the head injures

Feedback was offered to learners as 20 minute 'MP3' audio files, which were e-mailed to participants, and placed on the departmental shared access hard drive, so that they could be accessed directly or downloaded to personal MP3 devices.

Emphasis was placed on the process of analysis and interpretation of the cases, rather than focussing on the 'correct answer'.

The assessment of this module was via a piece of written work, centred upon a crime scene scenario. In completing this piece of work, learners were required to apply their learning from the five cases covered.

Outcomes

The majority of learners produced detailed sketches, with good observation and attention to detail. **Figures 1** and **2** show one student's interpretation of one of the photographs; the text on page 153 is the students interpretation of that information.

Figures 3 and **4** show how different students interpret the photographs in a similar manner. **Figure 5** shows how a student has interpreted a complicated scene and 'deconstructs it' into useful components.

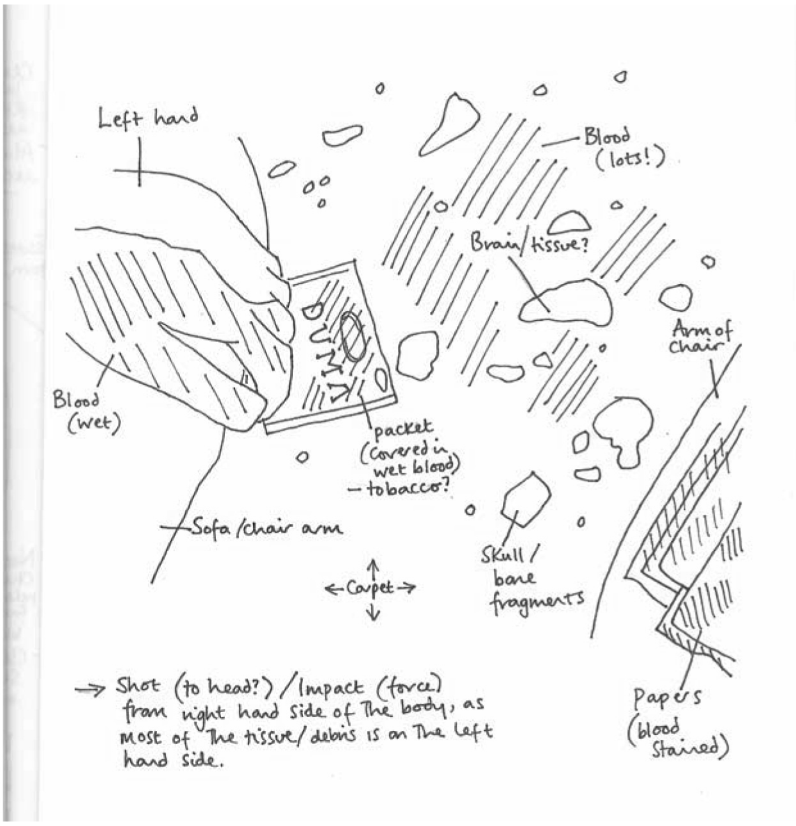

Figure 5: Interpretations of the very confused environment on the floor next to the body

Student interpretation of Forensic images (please refer to Figures 1-4)

The first image was of the ventral surface of the two distal, inferior lower limbs, wearing dark blue denim trousers and black, ankle boots, 10 holes per boot, and thick, royal blue thick socks. Lying diagonally as though the victim is sitting on an old fashioned, possibly 1970's, patterned, orange covered sofa or chair with the inferior surface of the boots resting on a dirty, dark patterned carpet. Under the right lower limb, beneath the flexed patella region there were two digits, bent at the Metacarpophalangeal articulations and Interphalangeal articulations, displaying the carpals and phalanges of the II and III digits. These appeared to be smeared in blood, possibly indicating a struggle with the assailant or having been wiped or fallen from other injuries.

The soles of the boots appeared wet due to their shiny appearance, possibly with blood, when considering further crime scene photographs. The trouser section covering the right limb in the tibia region was ripped and torn open, revealing the epidermis, with a right-angled flap of material towards the top of this section. The material also appeared to bear dark brown staining possibly blood or more probably charring around this area, although, in this view the epidermis appeared mostly unaffected. It is unclear whether the tear damage occurred prior to the smouldering, possibly due to a struggle with an assailant as there is possibly bruising in the mid tibia region, indicating snagging on a sharp object. A single, white burnt cigarette butt was found positioned on the patterned carpet, to the left of the left foot of the victim.

There are several possible explanations for the appearance in charring, as it was not extensive, bearing no obvious markers for the presence of an accelerant and *causing little superficial damage to the underlying epidermis (Lennard, C. 2001). The localised burning evidently pointed to the seat of the fire as occurring in the mid-tibia region. Post-mortem exposure to low, radiant heat, in the form of an electromagnetic wave, where there is no contact between the body and source of heat, possibly from an electric bar heater, may cause this type of damage (DiMaio and DiMao, 2001). Upon external heating the extent of damage caused is dependant on the applied temperature, the ability of the body to conduct heat away from the area and the time during which the heat is applied (Saukko and Knight, 2004). As the dermis was covered by a layer of clothing any heat damage to it was delayed due to this thermal protection factor (Ripple et al 1990). In this case heat exposure was long enough to instigate initial smouldering, but not prolonged enough to cause erythema or vesiculation, with possibly only slight reddening, oedema and stretching of the skin (Carvajal et al, 1975). These are indications of only mild first degree thermal burns, and as such was not a factor in the cause of the victim's death (Shepherd, 2003) and (Wang et al 2005).*

From the appearance of this and other photographs of the scene a conclusion may be drawn that the victim was a smoker, due to the presence of a spent match on the seat of the chair and a used cigarette end, along with a blood covered, tobacco packet to his left. The proximity of the roll-up papers could suggest that the victim was smoking some form of drug or cannabis. The victim, in a dazed, intoxicated state may have inadvertently dropped a red hot piece of burning cannabis, 'Hot rock', from a lit 'joint' whilst smoking (Duckworth, 1996). This could have produced a hole and the scorch marks on the trousers.

Also in this view, to the right of the sofa there appeared to be a broad, slightly concave, white coloured material, assuming the appearance of a fragment of the calvarium (Martini, 2004). From comparison with the size of the heal it appeared to be around 8 centimetres in diameter. It was also surrounded by other smaller, some triangular, splinters of skull. This would be conducive with the victim sustaining a craniocerebral trauma and skull fracture, either from high velocity blunt or acceleration-deceleration force (Morrison et al, 1998).

Summary of conclusions

In conclusion the death of the victim probably occurred as a result of the massive blunt force trauma impact in the left occipital region of the skull. There could have been a further impact in the right temporal region or one impact with contre-coup fractures, the force exuding further cerebral matter. The severing in the cervical region occurred post mortem, possibly as a means of disposing of the body, and the charring could have occurred as a result of intoxification and cigarette burns ante-mortem or by radiant heat from an electric fire post-mortem.

Feedback *from* learners was that they valued receiving feedback in good time to allow reflection on their performance, and to offer guidance on how they could improve for further case studies. A diverse cohort was involved in the module, and all were comfortable with the medium chosen for feedback.

Discussion

Problem based learning is supposed to enhance the integration of student's knowledge. Problems are used as a starting point for the learning process and learners define their own learning objectives in small groups. These learning objectives reflect basic science disciplines as well as 'specialist' disciplines and both fields are studied concurrently. Because learning takes place in a meaningful and authentic context, using cases, students learn to connect phenomena to underlying basic science concepts (Prince *et al*, 2003).

The learning resources provided should meet the needs of the learner and promote motivation. Problem-based learning is an approach to professional education that stresses the use of real-life problems as a stimulus for learning (Van Berkel and Schmidt, 2000). According to Race (2005), students should be able to directly relate the content to learning outcomes. This allows students to see the relevance of the subject content, and to take ownership of their own learning. The use of 'real' cases seems the ideal way to demonstrate the direct relevance of the subject content. The knowledge that the evidence offered has been taken from a situation that has actually occurred and where a case has been solved, provides a challenge to students, to evaluate the evidence and asses their own ability to 'solve' a crime. This offers greater motivation than a mock scenario. Clearly this has worked for our students who were highly motivated by the realism.

Various studies have demonstrated that traditional methods, such as lecturing, demonstrating techniques and setting repetitive exercises, encourage surface learning. Students taught through such methods have a high reliance on the tutor to assist with problem solving; fail to question information they are given; focus on producing a 'correct answer' rather than understanding issues and prefer to reproduce notes rather than offer a critical analysis or to reflect on relevant issues (Hockings, 2005).

In problem-based learning, students work in small tutorial groups on problems and in the course of discussing them, formulate goals for self directed learning (Van Berkel and Schmidt, 2000). This resulted in the learning achieved from these activities being considered constructive and contextually meaningful. Use of the problem-based learning approach requires students to become actively involved in their own learning, resulting in a movement towards more independent learning (Yeung *et al*, 2003).

Using this system, students worked through 5 cases, encompassing death by drowning, fire, road traffic incident, shooting and natural disease. In this way, students gained knowledge and skills in team-working, crime scene examination, forensic pathology, statement writing and presentation.

The *correct* findings from each Crime Scene were <u>not</u> the important consideration. The student learning centred on complex problems which need not have *one* correct answer. Students worked in a collaborative group to identify what they needed to learn in order to facilitate solving the problem (Hmelo-Silver, 2004). They engaged in self-directed learning and then applied their new knowledge to the problem and reflected on what they had learned and the effectiveness of the strategies employed. In this way we became facilitators to the learning process rather than simple providers of knowledge.

Race (2005) and others suggest that the opportunity for active learning is of paramount importance. Learners need opportunities to try things out and repeat tasks. Including an element of assessment, with timely feedback in our case allowed for such opportunity. In addition, learners should not be rapidly overloaded with information. The introduction of each case in a sequential manner, with timely feedback, allowed for the 'digestion' of information over the course of several weeks.

Jung *et al* (2002) stated that even for adult learners, social interaction with instructors and collaborative interaction with peers are important in enhancing learning. The inclusion of a presentation element for each case encouraged informal peer assessment and feedback, as well as information sharing between groups.

The use of 'MP3' audio technology allowed for an in-depth feedback of the crime and the forensic pathology associated with it. The asynchronous learning that this 'MP3' technology enabled allowed students to reflect on their performance and listen again, as required, to the feedback and make notes to improve their subsequent performances. Learners can feel comfortable in learning from their own mistakes in privacy.

Recording feedback in this way avoids the time constraints that are inherent in immediate feedback during a contact session, and discourages the domination of the session by a tutor. In this case, reports from all groups were evaluated by the tutors, and generic feedback on strengths and areas for improvement offered. The use of MP3 recordings allowed feedback to be given to the group and to the individual. With a little imagination, feedback can be made entertaining as well as informative. Feedback can be directly linked to learning outcomes, and can help learners to identify the level and depth of analysis that is required of them. Offering aural feedback is highly beneficial for learners with specific individual learning needs, such as visual impairment or dyslexia.

Berglund (2004) states that, 'to take the students' ways of experiencing the learning environment into account offers ways of designing well-functioning course. Changes in course design must be based on the learners' experiences if they are not to be counter-productive to the learning aims'. We routinely seek feedback from our learners relating to all aspects of their learning. Our experience was that learners *wanted* feedback, and were keen to use it constructively. The use of audio recording, allowing use of MP3 technology was valued amongst learners of all ages and backgrounds. The ongoing use of formative feedback, reflection and review empowered learners in their final assessment for the module.

This approach to learning has offered students the opportunity to develop collaborative teamwork skills through deep engagement in evaluating real cases. Learners are accessing professionally relevant experiences, whilst acquiring subject-specific knowledge. Importantly, such an approach encourages the development of desirable graduate qualities, such as competence in problem-solving, teamwork, and communication skills.

This system brings the crime-scene to the class-room and indeed the class-room to the crime-scene. Future developments include the use of 'MP4' technology to add video to this level of asynchronous feedback.

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[O26] Computer based assessment with short free responses and tailored feedback

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Keywords: computer based assessment, free text responses, feedback

Abstract

This paper describes the development of interactive computer marked assignments, providing students with instantaneous, targeted and relatively detailed feedback. Most of the questions are not multiple choice, but wherever possible the feedback given to students is tailored to their response to the question. Students are allowed three attempts at each question, thus enabling them to learn from the feedback provided. Questions are currently being developed that require free-text answers of around a sentence in length. These questions are authored with the help of a sophisticated linguistically based authoring tool, and early student responses are used to refine the answer matching. Challenges of designing, authoring, refining and providing feedback on suitable questions are described, along with early student reaction and reflections on the opportunities provided by assessment of this type.

It is widely recognised that feedback on assessment tasks has an important part to play in underpinning student learning, encouraging engagement and promoting retention (see for example Yorke, 2001). Gibbs and Simpson (2004) articulated eleven conditions 'under which assessment supports students' learning', and seven of these conditions relate to the provision of feedback. Online assessment provides an opportunity to give virtually instantaneous feedback, thus 'feedback is provided quickly enough to be useful to students' (Gibbs and Simpson condition 6). However, providing feedback which is targeted to an individual student's specific misunderstandings is more of a challenge for computer based assessment. Multiple choice questions enable specific feedback to be provided in response to predefined responses, but these questions narrowly constrain how students may respond (Sukkarieh and Pulman, 2005) and concern has been expressed over their reliability, especially when used for summative purposes (Lawson, 2001).

Throughout the UK Open University (OU)'s thirty-five year history, assessment has been seen as an integral part of the learning process. Tutor marked assignments (TMAs), although usually graded and thus having a summative function, also provide an opportunity for a student's tutor to give detailed and personalised feedback and a summary of points to assist with subsequent assignments. Feedback and 'feed forward' at this level is considered particularly important for students who are studying at a distance and have limited opportunities to participate in face-to-face or electronic tutorials. The OU also has a longstanding commitment to the use of appropriate media, including computers, to support student learning. Computer based assessment, initially in the form of batch-marked multiple choice computer marked assignments (CMAs), has been used since the early days, and since the 1990s, interactive formative questions of several types

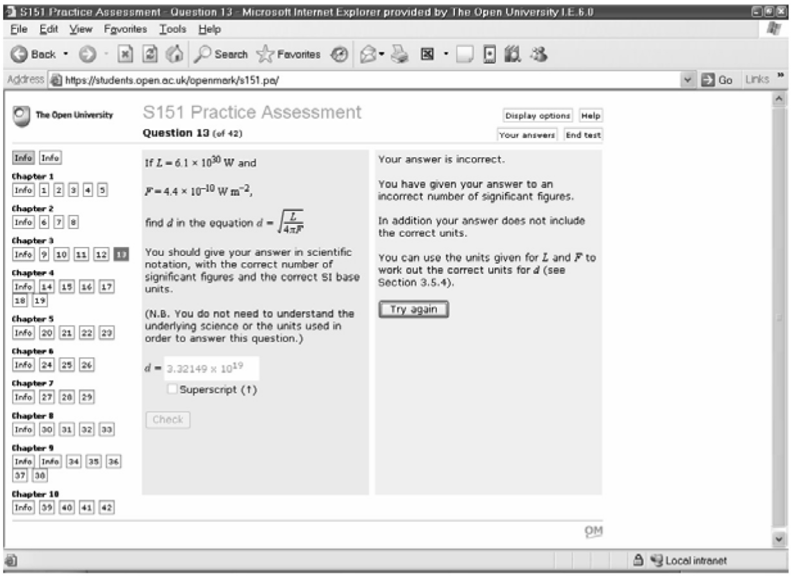

Figure 1: A question from the Maths for Science Practice Assessment, with targeted teaching feedback

(including drag and drop and numerical input) have been provided to Science Faculty students on CD-ROM and DVD-ROM.

In September 2002, a 10 CATS point course entitled 'Maths for Science' was presented to students for the first time. This course is studied over a relatively short time period (10 weeks – 3 months) and does not allow the opportunity for tutors to provide feedback to students via TMAs. However, the subject matter, and the fact that many of the students studying the course are lacking in mathematical confidence, meant that it was considered particularly important to provide rapid and meaningful feedback. It was therefore decided to use online interactive assessment for both formative and summative purposes. This enables students to be provided with instantaneous and targeted feedback on their responses to the questions, only about 25% of which are multiple choice (Jordan and Swithenby, 2005). **Figure 1** shows an example of the sort of teaching comment that may be provided, in this case in response to a student answer which is numerically correct but given to an unrealistic precision and without units. The feedback is targeted to the specific errors and includes a reference to the course material. The aim is to simulate 'a tutor at the student's elbow' (Ross *et al*, 2006), pointing out the student's error as specifically as possible, and providing a suggestion for how it might be corrected. The student is allowed three attempts at each question, with increasing amounts of teaching feedback provided after each attempt. The student is thus able to 'act upon the feedback to improve their work or their learning' (Gibbs and Simpson condition 6).

'Maths for Science' has now been studied by more than 7000 students and both the course and its assessment system have been well received. The technology underpinning the assessment system has been developed into the 'OpenMark' system, and OpenMark question types are being incorporated into the 'Quiz' function of the Moodle virtual learning environment. OpenMark is increasingly used for formative and diagnostic assessment by courses across the University.

Two new large population level 1 Science Faculty courses will be presented to students for the first time in 2007/2008, and both of these will use OpenMark questions in regular summative (but low stakes) iCMAs (interactive computer marked assignments). iCMAs will only form one part of the courses' assessment strategy (alongside conventional tutor marked assignments and, in one case, an end of course examination). The primary

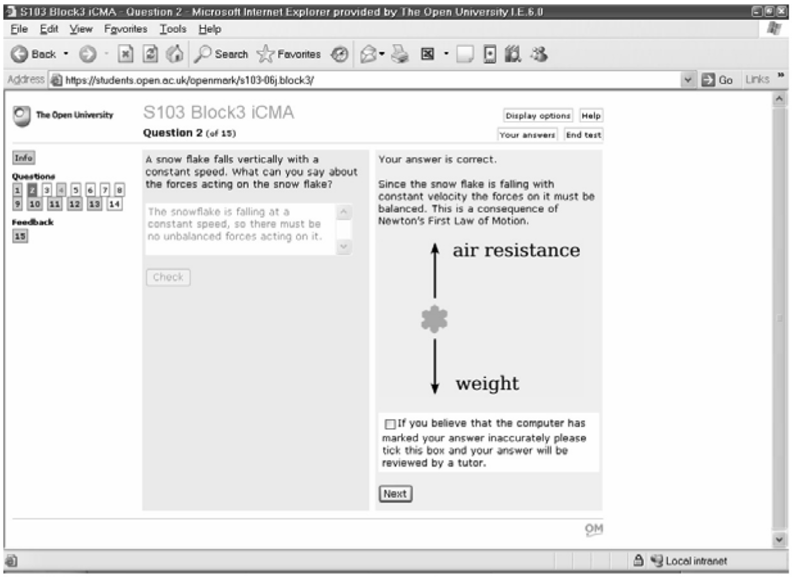

Figure 2: A typical (correct) student answer to a question requiring a short free-text answer

purpose of these assignments will be to encourage student engagement with the course material and to help students to pace their studies. However, the question types currently available mean that the tasks that can be assessed by OpenMark questions are limited, in particular questions requiring free-text answers are limited to those requiring numbers, symbols or answers to no more than a word or two.

In an attempt to explore other possible question types, a pilot study, jointly funded by the Centre for Open Learning of Mathematics, Science, Computing and Technology (COLMSCT) and the OU's VLE Project, is using an authoring tool supplied by Intelligent Assessment Technologies Ltd. (IAT) to write questions requiring free-text answers of up to around 20 words in length – typically a single sentence. The IAT authoring tool (Mitchell *et al*, 2003) is linguistically based, which means that an answer such as 'the dog bites the man' is recognised as being different to one such as 'the man bites the dog'. In the example shown in **Figure 2**, answers such as 'there are no unbalanced forces'. 'the resultant force is zero', 'the weight is equal and opposite to the air resistance', 'the forces are balanced' should all be marked as correct, but 'the forces are unbalanced', 'there are no forces' and the 'forces act in opposite directions' are incorrect or incomplete. The sophistication of the authoring tool means that these responses are indeed correctly matched, as are the vast majority of incorrectly spelt responses, responses in poorly written English, and many those which are expressed unexpected ways.

The Open University's pilot use of the IAT software has two major differences from that of most users of this software and other linguistically based short answer free-text systems (e.g. Sukkarieh and Pulman, 2005). Previous users have used student responses to paper-based questions in order to provide appropriate answer matching for the computer based version. The OU pilot recognises that 'real' student responses are essential as part of the developmental process, but we were reluctant to use responses gathered in one medium to inform the development of questions for a different medium – we felt that students might give different answers when working online and also that the optimal assessment tasks might be different. In order to obtain a batch of questions of sufficient reliability and robustness, questions are being developed with the assistance of students and staff on one presentation of the course 'Discovering Science' before being released to students on the next presentation of the same course (4 months later) for more extensive evaluation. Responses to the developmental versions of the questions are monitored regularly and the

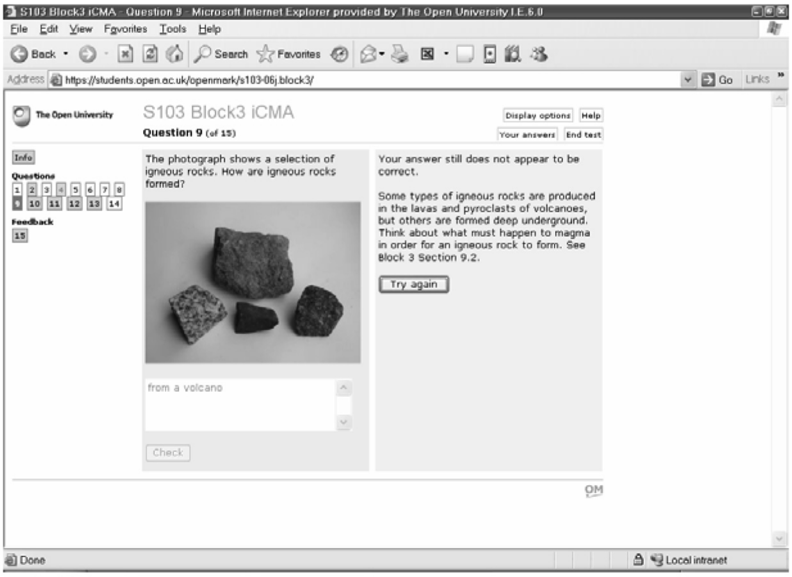

Figure 3: Targeted feedback on an incomplete student response to a question (Some igneous rocks are formed deep underground rather than being formed from lavas erupting from a volcano)

answer matching is amended whenever necessary (this can be done very quickly, whilst the system is live). The first batch of questions was released to students just before Christmas 2006 and by mid February 2007, the questions had been attempted by around 200 students, resulting in up to 277 responses per question for use in improving the answer matching. It is worth noting that, even in development, the questions have been very well received by students, with words such as 'fun' and 'addictive' being used quite commonly, and more than 75% of students reporting that they enjoyed answering the questions and found the feedback useful.

The second novel focus of the Open University's use of short answer free-text questions is the emphasis being placed on the provision of instantaneous teaching feedback. The IAT questions are currently being presented online to students via the OpenMark system, so a decision was made to replicate OpenMark's three stage feedback. At present the system attempts to recognise answers as correct or specifically or generally incorrect, and then to provide pre-written feedback including (as for conventional OpenMark questions) a reference to the relevant course material. Generic feedback is provided from OpenMark, but feedback targeted to specific student misunderstandings is generated within the IAT system. So, in **Figure 3**, the feedback in response to a student answer of 'from a volcano' (which is not considered a sufficiently complete response) has been generated from within the IAT system. Unfortunately the software used until February 2007 did not allow targeted feedback on many specifically incorrect student responses, and incomplete answers presented a particular difficulty. In the case of the question shown in **Figure 3**, it was not possible to provide targeted feedback on an incomplete answer such as 'they are formed from magma' because of interference with the correct answer 'they are formed from magma which has cooled and solidified'. However a new release of the software was supplied in February 2007 to enable the provision of targeted feedback whenever appropriate. For the present this feedback will continue to be written at the authoring stage, though it is recognised that there are other options for effective feedback on answers of this sort, for example letting students see which part of their answer 'matched'. A later stage of the project will compare the current system, based on computational linguistics, with a simple 'bag of words' system. This is likely to be less accurate in its marking, but may lend itself to different question types (including, paradoxically, those requiring longer answers) and the provision of different types of feedback.

The Open University's trial of online assessment questions requiring short free-text answers is in its very early stages, with four batches of questions released to students in their developmental phase, but only two of these batches released to students on the subsequent presentation of the course. An investigation has just begun into student perceptions of the questions and their use of the feedback provided. In addition, the effectiveness of the computer marking system will be compared against human markers.

Each time a student completes a question, they are provided with an opportunity to report if they think that the computer has marked their answer inaccurately. Most of the times this box is checked the student response has actually been marked correctly (and the student answer is usually wrong!). Questions which are relatively 'open' tend to generate the most uses of the 'inaccurately marked' box, perhaps because students fail to appreciate that they need to provide a precise answer (for example, if they are asked to compare intrusive and extrusive igneous rocks, they need to say *which* has bigger crystals). Framing appropriate questions, especially questions which assess understanding rather than simply recall, is, perhaps, a greater challenge for the question authors than using the authoring tool to generate appropriate answer matching. The time taken to write suitable questions and answer matching, and to modify this in the light of student responses, should not be underestimated. Using the IAT authoring tool to write questions of this type does not require any special linguistic abilities but it does require a logical approach to the authoring process.

The Open University's use of assessment of this sort is currently entirely formative; an 'add on' to a well established course. However, provided the questions prove sufficiently robust and student reactions are favourable, it is hoped to integrate a number of questions requiring short free-text responses into the regular summative assignments on the new level 1 course 'Exploring Science' from February 2008.

Monitoring student responses to interactive online assessment questions, essential in the development of sophisticated questions of the type described in this paper, can also be used to provide valuable feedback to academics about student misunderstandings. Analysis of student responses to the conventional OpenMark questions in summative 'Maths for Science' assignments has provided valuable insight into the mathematical misunderstandings of adult distance-learning science students (Jordan, in press). Even in the developmental phase, student responses to the short answer free-text questions has provided similar insight. For example, in answer to the question 'What does an object's velocity tell you that its speed does not?', a small but significant number of students gave the answer 'It tells you about a change in direction'. This answer was initially marked as correct (it is similar to the correct answer 'It tells you the direction in which the object is moving') but it is *not* a correct answer, and the source of the misunderstanding was tracked to an unfortunate section heading in the printed text. In both this case and the more systematic analysis of 'Maths for Science' questions, increasing understanding of student misconceptions has enabled changes to be made both to the assessment questions and to subsequent Open University teaching.

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[O27] Teaching biological science to blind students

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Abstract

A year's experience preparing and delivering teaching materials specially designed for visually impaired – including blind – students has shown that they are capable of achieving many of the learning outcomes expected of sighted students. Advances in information technology enable these students' access to written materials with or without personal helpers. Screen readers and software to present books and documents in auditory format mean that lectures, reading and tutorial work pose only resource problems. The main difficulty for students lacking full vision is participation in practical classes. Whilst many laboratory skills remain beyond the reach of these students, they can be helped to achieve a good level of understanding of many of the exercises presented in a laboratory setting if the learning outcomes are carefully considered, and bespoke learning materials constructed to enable them to be studied using non-visual modalities. For example, in a microscopy class, detailed consideration of what sighted students are expected to learn from the images they will see may allow the construction of substitute tactile diagrams. Bright colours help some students with residual vision, especially if they are made to a suitably large scale. Use of the tactile talking tablet (T3) allows students to study these diagrams with a measure of independence. This technology will be demonstrated, and some of the materials made for our students available for inspection. Three dimensional models made from a range of modelling materials, also brightly coloured, have been made for special purposes, for example to substitute for scanning electron micrographs. The evaluation of one severely and one moderately impaired student of our first year's work will be reported.

Introduction

This paper represents a work in progress: a steep learning curve in the teaching of biological material – specifically neuroscience – to visually impaired (VI) students. At the time of writing this represents barely six months' experience, but by the time the paper is delivered it will be a full academic year and we intend that the work will have been evaluated by the VI students.

Until this year students at Keele with a visual deficit have simply been provided with an amanuensis to help with taking notes, along with specialist computer software such as screen readers. Generally this meant that lecture and tutorial classes could be coped with, but little consideration had been given to laboratory classes and other types of practical work. The SENDA legislation (Special Educational Needs and Disabilities Act 2001) requires that an educational institution takes such reasonable steps as to ensure that disabled students are not at a substantial disadvantage. With two visually impaired students entering year two of a dual honours neuroscience course, we set ourselves the task of making the laboratory classes accessible to these students. At a later date we shall use our experience to convert all of our neuroscience and biology degree courses in the same way.

Our approach has been to consider each type of laboratory class in turn: macroscopic anatomy, microscopy, biochemical techniques, physiological recording, animal behaviour and (in biology) fieldwork. On first consideration it seemed to be impossible for students with severe visual deficits (bordering on complete blindness) to participate in most of these classes. This forced us into a more in depth analysis of the purposes of our lab classes: what was it we hoped that the sighted students would learn? What were the intended learning outcomes, and could they be achieved in other ways? We have had to accept that, for the moment at least, some laboratory skills are still out of the reach of students with limited vision, sometimes on safety grounds. But after the manipulations that VI students cannot perform, results are generated that need to be processed, and there is no reason why VI students should be excluded from this part of the exercise. Practical work in any case is often not concerned with acquiring manipulative skills, but about intellectual processes and illustrating concepts by the use of living or preserved material. It is on producing illustrations and results in a form that is accessible to the VI student that we have concentrated our efforts.

Technological Solutions

The tactile and auditory senses are the main modalities through which VI students can receive information useful in their studies, and these are brought together in a relatively new piece of equipment, the Tactile Talking Tablet (known also as the T3). The T3 is the European version of the Talking Tactile Tablet (TTT) owned by Touch Graphics, New York. It is marketed by the Royal National College for the Blind (RNCB) at Hereford and other companies. When the T3 is purchased from RNCB they provide additional invaluable information and training based on their vast experience of educating visually impaired students, and what follows owes much to them.

The T3 is an inexpensive touch-sensitive device producing immediate auditory information to the user on the object being touched. It consists of a touch-screen computer interface connected to a laptop or PC by means of a simple USB connector. A tactile paper overlay is placed on the touch screen, located precisely and held in place by a hinged metal frame. On touching the overlay at any location the user first hears a set of simple instructions telling him or her to press lightly on raised bumps in two diagonally opposite corners of the screen to ensure that the overlay is properly located. Next s/he runs a finger along horizontal lines at the top of the screen pressing lightly on three more raised bumps on these lines. Each gives a tone indicating successful location: the unique combination of these three bumps identifies the overlay, and the student is now ready to begin. The following words are heard: 'Feel the shape of the image with your fingers. Press down lightly with one finger to hear the name of the object you are touching. Pressing a second time will give you further information. You can interrupt speech at any time either by moving to a different object or by pressing on the background of the page outside any object.' The image in one of our neuroscience modules might be, for example a diagram of a motor neurone. In this case the spoken text will identify key structures such as the cell body, dendrites, axon hillock and axon, etc. So the student, having identified the axon hillock by touching it will touch it again, and this time will hear that this is where the nerve impulse is generated. Third and fourth layers of information may be added, going into as much detail as is thought appropriate.

The overlays are produced on special heat-sensitive 'swell' paper. A diagram of the learning object is drawn or printed onto the paper, which is compatible with standard ink-jet printers. The print needs to be very dry and the paper is then passed through a heating device that makes the paper swell wherever there is black ink. Thus a tactile diagram is produced. Other coloured inks do not induce swelling, but brightly coloured diagrams are useful for the majority of VI students who may have sufficient residual vision to detect them.

The next stage is to add the auditory information. The T3 comes with the necessary software for this. It is important to have text well planned, as when it is heard by the student it needs to be clear, with no hesitation or unwanted words or sounds. It is good practice to type out the text that is to be used so there can be no mistake. Speaking spontaneous sentences is likely to give a poor result. A reader with a clear, pleasing voice is an advantage, as the student is going to hear this a lot, and idiosyncrasies may become quite irritating.

Diagrams need to be relatively simple: it is important to realise that some of the detail that can be clearly seen in textbook diagrams may be too fine or detailed to be resolved by a fingertip on a tactile diagram. Use of artificial texture (cross-hatching or stippling) may be useful to distinguish structures, but the same considerations apply about fine grain shading and the differences that can be resolved by touch.

A very limited range of overlays is already available to purchase, but as yet few are available for HE level in any subject, and we have found that for specific classes we need to custom design our overlays. For example in a class in which the sighted students were learning about the ultrastructure of brain tissue and interpretation of transmission electron micrographs, it was possible to make T3 overlays to correspond with the illustrations being used by the rest of the class. However, transmission electron micrographs of brain tissue are very complex indeed, and difficult enough for sighted students to interpret, and a great deal of simplification was needed in the tactile diagrams. All but a few components that were the main study objects for the class – nerve terminals with synaptic structures - were removed. One of the tasks of the sighted students was to measure the diameter of a random selection of synaptic vesicles in two terminals and to do a statistical comparison of the vesicle populations to determine whether there was a difference between them. We tried hard to find a way for the VI students to make these measurements, even going to the lengths of constructing a 'clickable ruler' with 1 mm divisions. Such devices are available for purchase from the USA, but prohibitively expensive for a single exercise. In the event this task proved beyond our students at least with the equipment we were able to produce. So in this instance we settled for giving them the measurements and allowing them to do the statistics.

Other technologies

The T3 is a great advance in technology to support VI students, but it is not a universal panacea. RNCB provide a useful decision tree, originally attributed to the American Foundation for the Blind that gives guidance as to the appropriate conditions for its use. These include when the object in question is unavailable, too small, too large or to dangerous to examine by touch, and when the student needs the information to participate in classroom discussions or to answer questions. Even when these conditions are met other learning aids may be more useful. For example, when studying scanning electron micrographs in which the subjects were intact and damaged inner ear hair cells, it was judged that even a tactile diagram would be too flat to give a true impression of the structure. Three dimensional scale models were made from salt-dough, brightly painted and varnished and these proved useful for both our students.

Models of animals, plants and human organs are of course commercially available, but rather expensive, and often not quite appropriate for our specific lab classes. Ability to make good models is therefore a valuable skill: a wide variety of modelling clays and other materials is readily available. Wherever possible, however we are allowing our VI students to feel the real objects being studied. In an animal behaviour class being used, the students were able to handle live laboratory mice and, prior to a frog dissection, they handled the freshly killed animal. We have plans to prepare dried specimens of hard-bodied invertebrates such as large crustaceans, and to use living gastropod and bivalve molluscs. In this way, on our marine field course future VI students will at least be able to experience some of the range of organisms found on the shore.

For our student with some vision we have found the best approach is to use magnification and bold colours. The use of a visualiser (a video camera designed to project documents and other objects onto a screen) has been invaluable. To our surprise and delight a student who attempts to read normal text with his nose literally on the paper was able, using the visualiser, to dissect the sciatic nerve from a frog well enough for it to be used in physiological experiments. The nerve impulses subsequently recorded from this preparation and displayed on a computer screen were then printed out, transferred to swell paper and made into a tactile diagram.

In a developmental neuroscience class both our students were able to make a good attempt at removing a two – three day chick embryo from an egg. Tactile diagrams have been prepared to help them understand its anatomy.

Visually impaired students are not all alike

Accustomed to thinking of our sighted students as diverse in their needs and learning styles, we originally made the elementary mistake of assuming that visually impaired students would have so much in common that they could be treated as a homogeneous group. A short contact with our two students and some instruction from the professionals in helping sensory impaired students (Staffordshire ASSIST) soon disabused us of this fallacy. They are at least as varied in learning style as the rest of their class, and a one-size-fits-all approach is quite inappropriate. They vary from almost blind to possessing a useable amount of residual vision, and from the quiet, thoughtful and studious to the extrovert, outspoken and determined.

Another feature of VI students that has become apparent to us is the effort of concentration they need to make to follow a class of any kind. They need to work much harder than sighted students to achieve the same ends. Tiredness noticeably affects what they can do: even our most impaired student can see something on a computer screen when he is fresh, but this ability leaves him as fatigue sets in.

Examinations and other assessment

Naturally VI students require special examination arrangements, and for conventional exams the use of an amanuensis in a separate room is all that is required. However, some forms of in course assessment, particularly involving practical work need different tests. Although the learning outcomes (LOs) are kept as close as possible to those of sighted students, some changes are inevitable. It is necessary to remember that learning outcomes are what is assessed, so modified LOs require adjustments to the assessment. So far we have only provided help from an amanuensis when a test has involved graphics, but in principle there is no reason why the T3 should not be used to test as well as to teach.

Future plans

The first efforts described above have not been perfect, and we have asked our VI students to comment as they have done each exercise. Their different abilities and disabilities mean that their responses differ, and we have not felt able to impose on their time, as yet, to formalise their evaluations. We hope to be able to do this when their end of year examinations are over, and also to involve them in the design and evaluation of materials for modules they will not study. In this way we hope to be better prepared for future VI students, as Keele begins its Foundation Year for Visually Impaired students, and as they progress onto our principal degree courses.

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[O28] ACCESS (Audio Content Creation for Educational SuccesS)

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Background

Over the last two years, we have successfully rolled out the Blackboard Virtual Learning Environment within the School of Biological Sciences at the University of Leicester. Every undergraduate module is now represented on the VLE, providing supporting material and improving access for all students. Podcasting is currently focussing attention on the potential for audio teaching materials. In order to enhance accessibility for all students, the ACCESS project aimed to promote increased online use of audio teaching materials via the VLE, employing the same peer-to-peer strategy which was so successful in rapid adoption of the VLE initially. Funding was received from TechDis to support the purchase of equipment for this project.

Over the last two years, a programme of sustained promotion and training has embedded the use of the VLE, Blackboard, within the School of Biological Sciences. In 2003/4 only 51% of undergraduate modules were represented on Blackboard, since uptake was voluntary (Badge, et. al. 2005). Following the programme of peer-to-peer intervention, every undergraduate module is now represented on the VLE, providing supporting material and improving access for all students. However, we are concerned that this move to eLearning does not disadvantage any of our students, in particular those who may be dyslexic (the Faculty of Medicine and Biological Sciences has the highest number of students registered as dyslexic in the University). Recent research has shown that single format audio is superior to text plus images as it reduces cognitive overload in dyslexic students (Beacham and Alty 2006). Therefore our aim through the ACCESS project was to mirror the success with the uptake of the VLE to promote the use of audio on the VLE throughout the School. The pool of microphones was available to module staff to record narration for a variety of uses such as providing sound tracks for PowerPoint slides, breeze audio presentations and podcasting. The extra kit comprised two digital recording devices which allowed the direct recording of sound to mp3 files.

The ten microphones and two portable digital recorders have been used by 8 staff in the School of Biological Sciences in the first two months of the project and all the microphones will be used by a student group later this semester. Over 200 undergraduate and postgraduate students have had one or more of the audio projects in their courses during the first semester of 2006/7. This will be expanded to reach a further 500 students in the second semester.

All of the projects attempted to provide some alternative format for existing learning resource materials, in some cases to capture information that would be otherwise lost in discussion, in others to supplement visual material. This emphasis on the provision of audio material as supplemental and alternative resources was the main aim of the ACCESS project.

Evaluation of each instance of audio use was carried out through online surveys on our VLE. The students reported that the addition of audio increased their understanding of the topics concerned and allowed them to work at their own pace. Many reported that they would use the resources provided during revision for exams and they liked being to stop and start the recordings. Some cited the fact that they found concepts easier to understand in an online audio format.

Specific projects and sample materials

Weekly audio feedback for first years

A portable digital recorder was used to try to capture student voices during help sessions conducted in computer laboratories so as to provide an alternative means of feedback via audio podcasts for students on the module. Difficulties were experienced with this approach. Because of the noisy setting and the mobile nature of the staff helping students, it was difficult to get acceptable sound quality for the podcasts, even though the portable digital recorders performed well under more controlled circumstances (e.g. a quiet office environment where the speaker was static). Sound problems and continuous recording meant that editing the recording to produce a podcast took an unacceptable amount of staff time, and that the final result was technically disappointing. The informal, non-scripted nature of the source material would also pose difficulties for hearing-impaired students as no script-based transcript could be made available unless secretarial help was available to transcribe the recordings.

Student feedback indicated that the take-up of the podcasts was poor, and this was in part due to the poor audio quality. Comments included the following:

- The podcasts were useful. They are an interesting way of giving feedback to weeks assessments.

- I found the task using the university email system helpful, although learning was self-directed as there were no adequate notes explaining how to use it. I found podcast unnecessary but think it is a good way of learning and communicating specific ideas.

- Podcasts are a great idea, although I forgot about them (until now) after the first week – might be good idea to mention/refer to them again during lectures later through the course.

- Fairly helpful if had time to listen to them, e.g. when doing next assignment. But to help with problems, I felt it was just better to look through example answers afterwards.

- I didn't use the podcasts for feedback of this module because I didn't find them particularly interesting to listen to.

- As for the podcasts, I listened to about 1 minute of a podcast a few weeks ago. The person who was speaking seemed enthusiastic, although the need for such pod casting is questionable in the context of this particular module.

- It would be better if there was some feedback available in text on blackboard as I couldn't listen to the podcast on my computer. This meant that I missed out on all feedback all term due to a technical problem which was not under my control.

- Unfortunately I found it difficult to download the podcast for reasons that are still unknown so I am not able to comment on this.

- I don't have speakers on my computer so I didn't listen to podcasts.

In addition, the loss of visual information was a major problem for these computer-based sessions. The audio only approach has now been superseded by the provision of short online videos containing both audio and visual information from screen recordings.

Audio podcasts were used without student voices for the remainder of the course – see sample material for an example (week 2 podcast)

Figure 1: recording student questions during a help session using mp3 recorder for use in a feedback podcast

Recorded lectures (postgraduates)

The School of Biological Sciences runs four one year taught postgraduate MSc courses which have a high proportion of international students. A trial of providing a copy of a live lecture given to the Molecular Genetics postgraduate students was carried out in October. The lecture was recorded using the portable digital recorder and relatively good quality sound was obtained. This was then edited and synchronised to a powerpoint file using Macromedia Breeze (now called Adobe presenter **http://www.adobe.com/products/presenter/**) which converts the files to a flash presentation which can be hosted online. The recorded lecture can be viewed at: **https://breeze.le.ac.uk/p43913344/**

An online evaluation of student views on this format was carried out. A response rate of 29% gave only a small sample to gather data, but some of the general comments were informative. Students all listened to the presentation on their PC using Breeze, although mp3 files were also made available for downloading. Half of the students reported that they took notes whilst listening to the presentation (in addition to those already taken in the live lecture). All of the students said they would use the resource as a revision aid in the future.

- Sometimes when lectures are reviewed – even with the Powerpoint stuff – it can seem a little too detached; with the Breeze effects there is a stronger connection with the material.

- User-friendly interface.[the lecturer's] enthusiasm for the topic is almost tangible!
- The visuals are very well presented
- The audio description coincides very well with the content and scheme of each slide
- It's easier to remember the concepts, when they are explained, like having a personal tutor
- Occasionally the sound quality made it difficult to pick up the odd sentence, though this was more as a result of it being recorded in a lecture situation, rather than in an office.
- Sometimes the audio is more interesting than reading the actual words on the slide
- I'd like to be able to come up with some further constructive criticism, but I thought both the idea and the execution were laudable
- The fact that the slides from our lectures are presented on Blackboard is already a great help; with the addition of an audio record they are available in their entirety at our own leisure. However, this does not make the lectures redundant at all; rather it means that full concentration can be paid to the lecture itself, and there is a stronger connection to the material when the time comes for revision
- I think this is an excellent idea for remembering concepts that are not clearly depicted on some slides and explained verbally

Another lecturer is already planning to employ a similar technique to provide recorded lectures for third year undergraduate students.

Replacement of face to face lecture with online lecture
A second year undergraduate course with 42 students studying Bioinformatics employed a new strategy to replace a live lecture with an online one. The same macromedia breeze product was used to produce the online lecture as in example 2 above, however this time, the lecture was scripted and recorded in a quiet room and not captured from a live delivery. This gave the advantage of being able to display the script as written text as well as provide the audio track. The lecture was hosted on an open server and can be viewed at: **https://breeze.le.ac.uk/bs2064one/**

Students completed an online questionnaire to provide their feedback on the online lecture following the second lecture in the series, which was a traditional live lecture. Many students reported that being in control of the pace of the presentation aided their understanding of the topic:

- The pod cast lecture was very easy to use and did not pressurize me to stay focused onto the topic being talked about, it was very easy to pause it and read the side notes and replay the lecture till I understood. Most of the questions that came up in my mind were either answered in the voice file or by the notes. And being up close and in control of the presentation really helps.
- Could pause it while taking notes, and rewind to get bits that I had missed. Found it very useful, and I think my understanding was better than if I had been in a face-to-face lecture.

- I liked the fact that you could stop the slide presentation to enable you to write notes without falling behind and missing vital information.

- I liked the idea that the audio was written up too so that I could refer to it again.

Online software demonstration
Another one year taught postgraduate course in the School of Biological Sciences is the MSc in Molecular Genetics. Students were required to use a particular software package (Staden) to perform analysis to discover the evolutionary relationship between different organisms. This software was demonstrated in class and a written help guide produced to assist students. However, in previous years students had commented that this was still a difficult exercise so an audio guide was produced with screen movie demonstrating the use of the software. With a large proportion of international students on the course, these animated tutorials were very popular. An online survey was conducted to gain feedback on the tutorial. The survey was completed by all 21 students on the course. Over 70% of the students agreed or strongly agreed that that the animated tutorials were helpful to their studies and a quarter used the tutorial for more than 20 minutes. Students liked the fact that they could access the tutorial at their convenience and listen to it more than once if they did not understand a particular element. Students were asked to comment on what they liked about the tutorial:

- [I liked] the fact that the message was recorded and so we could play it back and listen to it again.

- It got us acquainted with the programme, was well described and was easy to understand.

- It helped with recognising the icons.

Recorded discussions on the ethics of science
Discussion from a two day workshop ‘Genetics, Science and Society – A Multi-faith Perspective’ was recorded in October 2006. The workshop, organised by the GENIE CETL (Genetics Education Networking for Innovation and Excellence) addressed social, legal and ethical issues of genetics. These recordings will be made available for student use online and will serve as primers on various ethical discussion topics.

Individual audio feedback to undergraduates
Providing timely, individualised feedback to our large first year cohort is challenging. We will trial a system of using the microphones for staff to record individual audio comments for each student to be returned to them as a file embedded in their original word document (to take place towards then end of semester two 2007).

Undergraduate use of microphones
First year undergraduate medical students will be using the microphones to record the audio to a short PowerPoint presentation within the Membranes and Receptors module. In previous years, students have made oral presentations live to study groups of 40 students. Feedback from these sessions over several years indicated that many students felt that they were unable to obtain the complete information set they required during the student presentation sessions. To respond to this feedback, the use of student podcasts of

presentations uploaded to the module pages of the Medical School VLE is being explored in a pilot project this year. This will permit presentations to be revisited and information to be re-accessed at a latter date. It is proposed to carry out this pilot with a minimum of four student study groups, resulting in a minimum of eight podcasts. All students (~320) will be encouraged to take part in this pilot and it is hoped that take-up will be much greater. If this pilot is successful, one of two required presentations for all students will be made via a podcast in future years. To ensure that all students have access to appropriate software, student podcasts will be recorded as narrated PowerPoint presentations in 2007. These will be uploaded on module pages within the Medical School VLE. The possible future use of Audacity (**http://audacity.sourceforge.net/**), which allows more interactive editing, will be explored with keen students. All ten microphones from the ACCESS project will be used for this activity (to take place in March 2007).

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[O29] Using debates to develop and assess critical reasoning abilities in first year bioscience students

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Introduction

The knowledge base of the Biosciences is no longer the domain of professionals in the field but has invaded contemporary culture with discourse around issues such as the implications of developments in reproductive technologies, genetic engineering and the genome project aired routinely in the mass media. Arguably the wider dissemination of this continually and rapidly developing knowledge base and the popularisation of science drives a greater not lesser need for professionals in the Biosciences, particularly in Biomedicine and Health, to have an in depth grasp of core concepts. They also need to have the competency to use those core concepts to counteract media spin around issues in science and health. Presenting such an argument also requires them to be able to critically evaluate the manner in which the knowledge base was acquired and therefore the extent to which it can be a valid explanation of phenomena.

Although there seems to be little disagreement about the importance of critical thinking and reasoning in Bioscience education, and in other science subjects (Garrett, J. *et al*.1999 and 2000), the use of critical reasoning abilities is usual only stated as a learning outcome for final year undergraduate or postgraduate modules and courses (Pearce, R. S. 2006). Debates are used as a learning tool for the development of critical reasoning but they are rarely summatively assessed. In addition the development of those abilities progressively throughout a three year degree course is often implicitly rather than explicitly addressed. (Fisher, A. 2001 pg1). We often assume that our students understand that this is what we expect them to do when we direct them to the evidence base and this isn't really good enough in a student centred ethos. Students have to know what they are meant to be learning from each task and need to be able to evaluate the extent of their learning. Learning outcomes need to be both explicit and transparent especially when linked to the assessment process. (Race, P. 1999, Biggs, J. B. 2003).

This article describes and evaluates the use of a summatively assessed debate as an assessment and learning strategy to develop critical reasoning skills and stimulate learning through assessment in first year Biomedical Science and Public Health students.

Engaging first year students in verbal debate is a challenge. Their conceptual thinking about the nature of science itself is an important factor to consider here (Eflin, J. T. *et al*.1999), as there is evidence that Bioscience students view new knowledge uncritically as an addition to a body of factual information rather than the outcome of a particular methodological approach to enquiry. Consequently their response to conflicting information was generally to ask the lecturer 'which is right' rather than making any attempt to understand why differing information might be presented. (Watters, D. J. and Watters, J. J. 2007)

Moving students away from an epistemological view of science as factual knowledge passively received to one that centralizes critical thinking about the nature of that knowledge, the quality of the evidence base for believing it and the implications of that knowledge, is a complex task (Edmondson, K. M. and Novak, J. D. 1993). Watters and Watters (2007), emphasize the need to understand students' beliefs and approaches to learning in addition to their view of science in order to develop appropriate strategies that facilitate change.

Deconstructing what is meant by critical reasoning is a much debated issue with its roots in a philosophical tradition dating back to John Dewey (1909) Edward Glaser (1941) and continued by Ennis (1989, 1996) amongst others, but for me it is relatively straight forward; I want my students to observe the world around them, ask questions about what might be going on, consider possible answers and explanations (that may be self generated through the research process) and determine which ones, on the evidence available, seem most plausible. In other words I want them to think things through before they express opinions.

Critical reasoning is also central to reflective practice – it is about holding self beliefs up for scrutiny in the light of new evidence and experience. Constructing a reasoned argument either verbally or in writing also necessitates 'the ability to use language with clarity and discrimination' (Thomson, 2002 p2).

Additionally, a fundamental requirement of assessment, learning and teaching (ALT) strategies in H.E. should be to empower adult learners to take responsibility for their own learning and to become self directed and reflective so that they develop the skills and competencies needed to continue their learning after graduating according to the demands of novel situations they are confronted with.

Undoubtedly the ALT methodologies and strategies that could be effective for empowering our students to be self directed learners are as diverse as the student population but all include the need to affect concepts of self efficacy (Bandura 1977, 1997). They would also have to involve a major shift in power relationships in learning towards increasing levels of student involvement in the process, culminating in students taking full ownership of some learning situations. This approach is exemplified by Finkel (2000) in his book on 'Teaching with your mouth shut' where he challenges didactic transmission models of teaching of the sort that predominate in Bioscience degrees (Hughes and Wood 2003) and where he instead suggests that 'the teachers task is to set up conditions that promote thinking'.

Opportunities abound on Science and Health courses to think about radically opposite viewpoints as ethical dilemmas present themselves almost daily in the popular media. Further examples here include end of life decisions; where the 'blame' lies for lifestyle induced illnesses; ecological ethics and the nature of doctor/patient relationships.

Many of these dilemmas are played out in TV medical and courtroom dramas and in novels (e.g. see Jodi Picoult, *My Sisters Keeper* and *Mercy*). Molecular biology techniques are utilised routinely in forensic investigation in crime thrillers such as CSI, and are therefore increasingly familiar territory to our students. This may be a double edged sword as students may expect the same 'content' in lectures and become dismayed when engagement at way more depth is expected! Alternatively, familiarity with the application of the knowledge base from popular culture may help to overcome barriers to learning that potentially arise when confronted with new and conceptually difficult subject material in a lecture theatre setting. It is this familiarity with contemporary culture that is exploited to stimulate learning by National Teaching Fellow Kirsten Hardie of the Arts Institute at

Bournemouth in her 'On Trial : Teaching without talking' role play work with students – developing Finkel's ideas. (Hardie, 2007)

Consideration of issues in medical, scientific and health care ethics often begin with 'should we because we can'. They can therefore provide a valuable learning opportunity for students to engage in critical examination of both sides of the argument whilst raising their awareness of the social responsibility of scientists and the impact of scientific developments. Because of its currency, debating ethics in Bioscience also has the potential for motivating students to engage in the possibility that science can be transformative as a philosophical approach to making sense of the world and their experience of it.

Teaching Strategy

In the Faculty of Health here at Leeds Met University, on our Health Sciences and Public Health courses, we deliver a first year, first semester module, Concepts of Science and Health, that was designed to explore definitions and views of both of those terms and to discuss moral and ethical frameworks such as utilitarianism, deontology and the medical ethics of Beauchamp and Childress that may help to evaluate and construct reasoned arguments around contested issues. Principles of critical reasoning are also introduced.

The module was also designed as an action research case study to evaluate qualitatively the tutor and student experience of stimulating learning by debating contemporary issues. The bioscience knowledge base needed to do this is only partially delivered in lectures. It is the students themselves who work out the information they need in order to argue their case, so it is a problem based learning methodology. For example in order to present arguments either for or against designer babies they need to find out what stem cells are, why they have the properties they do and they need to research and describe the methodology of IVF treatment. Understanding of this knowledge base is consolidated during the planning process for the summative assessment within small group tutorials.

60% of the module assessment is for the production of a group report that sets out the arguments that either support or refute an ethical standpoint followed by a debate with their opposing group based on the written reports. The remaining 40% is for an individual assignment that profiles a famous scientist, describes what they are famous for, reflects on the quality of the science and evaluates the impact of their work on our present thinking about science and health.

Module structure

- The first year cohort is large and includes over 140 students studying Biomedical Sciences, Public Health and Complementary Therapies.
- Because of logistical and resource constraints some teaching sessions (2hrs per week for 10 weeks) are lecture theatre based but are planned to be very interactive using moral and ethical dilemmas as scenarios for debate.
- My teaching style in these large group situations is to be controversial, play devils advocate and occasionally to be confrontational with an aim to stimulate discussion.

I often find myself able to stand back for extended periods of time as students converse with each other throughout the room, learning from each other. However, whilst it is not just the usual suspects that take part here, some students, for a variety of reasons may not feel comfortable enough to able to contribute in this arena.

- These large group sessions are therefore supported by course cohort group tutorials. In these smaller sessions the quality of the arguments I hear in the larger sessions is evaluated drawing out the principles of critical reasoning and further ethical problems are considered as formative work.

- For the summative assessment students are divided randomly – by alphabetically order of surnames - into groups typically of 5 students. Topics for debate are determined by the whole student cohort based on their current interests, though each group are randomly allocated both the topic and whether they have either the ‘for’ or the ‘against’ argument to prepare. They may therefore find themselves having to uphold a position that they themselves do not presently support. The intention here is that they will then take a more systematic approach to the construction of a reasoned argument.

- Assessment criteria for the report and the debate, are developed by the students, with minimal tutor guidance in tutorials. The criteria for the report typically focus on the integrated quality of the arguments and the evidence used to support them and the ability to demonstrate familiarity with the relevant underlying ethical theories.

- Completed reports are swapped between opposing groups and they are asked to prepare a series of questions, usually four, that they wish to pose based on issues arising from their reading and interpretation of the arguments in the report.

This year (2006-2007) topics were:

- Reproductive Technologies/designer babies
- End of life decisions/Euthanasia
- The treatment of lifestyle induced illnesses
- Drug companies
- Ecological ethics
- Animal Rights

The Debate

- The assessment criteria typically include the necessity for everyone to contribute, though not necessarily equally and for debates to be reasoned and evidence based rather than purely emotive! Clarity and quality of both the questions and the primary answers are also assessed.

- Each criterion is marked on a scale of 1 – 5 (which correspond to degree classification scales), to allow for mark allocation, but additionally has space for feedforward comment.

- The role of the tutor is to direct proceedings, time keep and retain order! The module tutor is present for all debates with a second tutor for moderation.

- Opposing groups come together and ask their predetermined questions in order. After each question the opposing group completes their reply (approx 1min) and there is then the opportunity for open debate (approx 3 mins).

- When all questions have been asked, each group self evaluates their performance against each of the criteria and the tutors give instant formative feedback based on their observations. In addition each group is asked to share their reflections on the whole assessment process, particularly on the extent to which their research impacted on their own views of the topic. This ensured that all students were engaged in feedback and evaluation.

- Marks are allocated within 24hrs after tutor consultation.

Student evaluation of both the module and the assessment is extremely positive with many specifically commenting that their views were changed as a result.

- ‘At first I thought I was never going to able to argue for it (euthanasia) but reading up about the people who have asked for permission to do it made me think about how I would feel in that position’.

- ‘Doing the research for the report made me realise that I didn’t really know anything about how drug companies worked. I had always thought they were just money mad but some of them do lots of good things’.

- ‘I have always thought that there was no problem with testing things on animals and although I do still think that, it should only be allowed if they can prove it can’t be done any other way’.

They also commented mainly favourably on the process as a stimulus to learning.

- ‘There was loads of information on it on the net so we really had to work out which bits were the best to use by looking at where the info came from’.

- ‘The other team were really difficult to argue against because they had really good reasons for everything – we just hadn’t done enough to cover everything’.

- ‘I wasn’t looking forward to the debate but when they were speaking I just thought but that’s not right and had to say something – and what I said floored them! I didn’t know I could do that!’

- ‘Our topic (global warming) was really interesting. Because we wanted to win I did loads of reading about it and I never read up about a topic after a lecture’.

Group self evaluation was routinely 1 grade less overall than the tutor grade. The main drawback commented on by students is that which is inherent in any largely self directed group work, namely how to manage dysfunctional groups and the extent to which any allocated marks reflect an equitable contribution by all group members. The students themselves decided on a strategy to deal with this but it still impacted negatively on their experience. They felt that the debate assessment criteria developed by themselves were valid and robust but needed to allow for a wider range of individual differences in mark allocation.

Conclusion

The aim of the ALT strategy described here was to help to develop critical reasoning skills in Bioscience and Health first year student using a summatively assessed debate on an ethical dilemma in science and health. Student evaluation of both the module and the assessment provides evidence that they rated the learning opportunities provided by this module as both highly effective and enjoyable confirming the experiences of other educators (Bond, 2005).

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[O30] Towards sustainable teaching of biosciences: integrating sustainable approaches into undergraduate teaching in higher education

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Abstract

In response to the report by the Higher Education Academy 'Sustainable Development in Higher Education, Current Practice and Future Developments' the Institute of Biological Sciences (IBS) at the University of Wales, Aberystwyth (UWA) proposed the implementation of sustainability into the curriculum and delivery of education across the Biological Science sector. In this preliminary investigation four case studies were undertaken. In the first, a survey revealed a high level of undergraduate support for the incorporation of sustainability into the curriculum. Year 1 and 2 of study were highlighted as the key target groups for sustainability education. A further three practical case studies addressed sustainability issues in organic waste management, laboratory classes and field trips. Factors limiting progress towards sustainability teaching of bioscience were identified and solutions are proposed.

Introduction

The concept of sustainability has become central to environmental debates around the world and has been taken up by all sectors including government, business and non governmental organizations. The 1987 Brundtland report first defined sustainable development as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (WCED, 1987). This report set out the guiding principles for sustainable development as it is generally understood today (Dresner, 2004). In order to achieve a sustainable world and minimise environmental degradation, a transition in resource use and waste management must occur locally, nationally and globally. Reducing carbon dioxide and other greenhouse gas emissions is now a high priority as global climate change has been conclusively linked to human activity (IPCC, 2007).

The future challenge of sustainability is set to dominate research and education. Universities will seek to educate the next generation of practitioners in sustainable methods. In addition science and technology will look for ways to identify environmental impacts and quantify and improve our aptitude for sustainability. The potential of educational institutions to lead the way in promoting sustainable education and research is now being recognised. The challenge for higher education is to provide all students with an in-depth understanding of sustainability and environmental issues; creating a new generation of 'sustainability literate' graduates (Dawe,*et al*. 2005). As well as teaching sustainability by theory, there is the opportunity for universities to 'walk the talk' by demonstrating sustainability through their practices. This will provide students with a platform to integrate sustainability into their own lives and future careers.

In response to the report by the Higher Education Academy 'Sustainable Development in Higher Education, Current Practice and Future Developments' (Dawe *et al*. 2005) the Institute of Biological Sciences (IBS) at the University of Wales, Aberystwyth (UWA) proposed the practical implementation of sustainability into the curriculum and delivery of education across the Biological Science sector. The preliminary investigation incorporates the following:

1. Student baseline survey on the demand for sustainable education and delivery within the Bioscience curriculum.

2. Practical laboratory based teaching – exploring ways to reducing the environmental impact.

3. Disposal of plant/soil material from the teaching glasshouses – minimizing landfill from plant based activities and projects and creating a resource.

4. Field studies – strategic planning of field trips to minimize environmental impact whilst maintaining or improving learning experience.

Methods

1. Baseline student survey: Undergraduate students in IBS were given a sustainability questionnaire in December 2006. Of 183 student participants in the questionnaire, 118, 40 and 25 were classified as being in years 1, 2 and 3, respectively. 77 (42%) provided information on gender; 36 and 41 were males and females respectively. Any analyses including gender as a factor related to the questionnaires only. The following questions were analysed in the current study:

a. Would you like to have more information available about sustainability in your degree course? Select one or more of the following statements: i) Integrated into all aspects of studying; ii) as a separate module; iii) included in relevant existing modules; iv) Online or written guidelines to sustainable living; v) I am not interested in learning more about sustainability.

b. How do you rate your awareness/understanding of the following issues? Rate your awareness/understanding from excellent (1) to (5) poor for the following issues: i) sustainability; ii) renewable energy; iii) climate change; iv) biodiversity; v) ecological footprint; vi) carbon footprint; vii) sustainable development; viii) environmental ix) sustainability; x) renewable resources; xi) recycling.

c. Where have you have gained knowledge of environmental issues? Rate the importance to your learning from important (1) to (5) unimportant for the following: i) family; ii) friends; iii) adverts; books; iv) television; v) newspapers; vi) environmental groups; vii) journals; viii) internet; ix) school; x)university; xi) employment.

d. What of the following would you be interested in getting involved with? Select one or more of the following activities: i) recycling on campus; ii) monitoring energy efficiency; iii) volunteer conservation work; calculating CO2 emissions; iv) visits to local environmental organizations.

Recycling 78%
Renewable resources 71%
Climate change 67%
Renewable energy 61%
Biodiversity 58%
Environmental sustainability 55%
Sustainability 52%
Sustainable development 50%
Carbon footprint 31%
Ecological footprint 30%

Figure 1: % of students rating their understanding/awareness of as 1-2 (above average to excellent)

2. Practical laboratory based teaching: structured interviews with fourteen academic and nine key technical staff at the Institute of Biological Sciences (IBS). Interviews were conducted from December 2006 to January 2007.

3. Disposal of organic material from the teaching glasshouses: the amount of soil/plant waste sent to landfill was calculated and various composting approaches were investigated as alternatives.

4. Field trip travel: for analyses of the environmental impacts of field courses carbon emissions were calculated for long haul (>3000 km) and short haul (0-3000 km) flights, car, bus/coaches. Calculations were based on official governmental figures (DEFRA, 2005).

Statistical Analysis

Kruskal-Wallis test for non-parametric data was used to determine year or gender differences in student perceptions pertaining to overall environmental/sustainability awareness. Willingness of students to become involved in sustainability activities was also analysed using a Kruskal-Wallis test. Spearman's Rank Correlation was used to examine the relationship between participant awareness/understanding and involvement in environmental activities.

Results

Undergraduate survey

92% of students requested more information about sustainability in their degree program. The majority of first and second year students, with 67% and 68% respectively, wanted to see sustainability integrated into relevant modules. However, the majority of third year students opted for online resources (56%).

Year of biological degree had no significant effect on student awareness of sustainability ($H = 2.59$, D.F = 2, $P = 0.274$). Separate analyses were conducted to examine the effect of gender on awareness of sustainability. Awareness of sustainability was not found to be significantly different between males and females ($H = 0.07$, D.F = 1, $P = 0.79$). Student understanding/awareness was found to be highest for recycling, renewable resources and climate change. Less than half of the students were confident with the issues of sustainable development, carbon and ecological footprinting (**Figure 1**). The role of the

FIRST	SECOND	THIRD
School 69%	University 85%	TV 62%
TV 65%	Newspapers	School 62%
Newspapers 60%	Internet 64%	Newspapers
Internet 60%	TV 61%	Internet 57%
Books 57%	Env. grps. 61%	University 52%
University 57%	Books 58%	Books 48%
Env. grps. 39%	Journals 58%	Adverts 43%
Journals 39%	School 58%	Journals 43%
Family 26%	Friends 48%	Family 33%
Friends 23%	Employment	Friends 19%
Adverts 36%	Family 27%	Env. grps. 19%
Employment 19%	Adverts 15%	Employment

Table 1: Ranked data according to year of study. % rating option as 1-2 (above average – important).

University in learning about environmental issues revealed interest in the mid range for students in year 1 and 3 and was the top priority in year 2 (**Table 1**).

Year of study had a significant effect on the willingness of the participant to become involved in sustainability activities, with year 3 being least likely to become involved (H = 6.24, D.F = 2, P = 0.044). However, there was not a significant effect of gender on willingness to become involved in sustainability issues (H = 0.41, D.F = 1, P = 0.524). Irrespective of year of degree, there was no significant correlation between participant awareness/understanding and involvement in environmental activities (year 1: rs = 0.105; P = 0.203; year 2: rs = 0.134; P = 0.421; rs = 0.197; P = 0.355).

Discussion

Student interest in sustainability is high, with 92% of the students surveyed indicating a desire to have more information available in their Bioscience degree programs. This level of enthusiasm for sustainability initiative is further supported by the student lobby universities to take on comprehensive environmental policy in with the 'go green' campaign (People and Planet, 2007).

From the data it was clear that certain issues of sustainability were not yet being covered as effectively as topics such as recycling, renewable resources or climate change (**Figure 1**). A program targeted at sustainable development and carbon calculating could redress this balance and move students towards 'sustainability literacy' (Dawe, *et al*. 2005). Students gain knowledge of sustainability and environmental issues through a range of media. The relative importance that students give to the different sources of information changes between the years. Year 2 students were shown to be more willing to become involved in environmental activities than year 3 and, in addition, year 2 tended to rank university education most highly as a means of learning about sustainability (**Table 1**). It is proposed that year 3 students would be under greater academic pressures from their degree; this may reflect their preference for resources online rather than having them added to the existing curriculum. The aim of the undergraduate student survey was to find target groups for sustainability educational programs. It could therefore be tentatively suggested that first and second year students could benefit most from having additional sustainability teaching incorporated into the degree program.

Case Study 1: *Sustainability principles applied to undergraduate practical classes*

Teaching students to be efficient and minimize waste in their practical training is essential. Consultation with teaching and technical staff led to the following areas being highlighted:

- Use of non-disposable plastics/glassware
- Wash and re-use wherever possible
- Turn off non-essential equipment if not in use
- Choose energy efficient equipment when replacing
- Source local materials
- Recovery of solvents (re-distil)
- Making solutions and buffers in-house in bulk
- Preferential use of least toxic materials
- Signage to reduce waste through confusion
- Plastic, paper, glass and organic recycling in lab
- Engage students in tidying and recycling activities

An explanation of sustainability practices can often be incorporated into standard health and safety guidelines and training.

Case Study 2: From landfill to compost for UWA staff

The department is looking at alternative ways of "disposing" of the plant/soil material. The procedure for safe disposal is to autoclave all experimental material at 126ºC for 3 hours. All material goes into a skip along with all other waste for landfill. By on-site recycling of organic and soil waste, estimated at half the total waste, there is a potential saving of 50% on skip hire each year.

The autoclaved material needs to be left for a period of several months to be repopulated by micro-organisms and to re-aerate (Zipperlen, 2006). The plant/soil material is piled up in bays constructed from recycled palettes. By using a cool composting method only minimal effort is needed, the work is done by micro-organisms, worms and fungi. Staff at the University have expressed interest in collecting and using the compost on their domestic gardens.

Case Studies 1 and **2**

Tackling a change of teaching methods in order to facilitate a move towards sustainable teaching of biosciences then raises many other issues. Information about sustainability does not necessarily lead to behavioural change (Collins, *et al*. 2003). An integrated approach is needed that tackles the reasons for unsustainable behaviour (Velazques *et al*. 2005). Some of the problems that teachers and technicians have cited as limiting their ability to work sustainably are summarised in **Table 2**.

It is important to target behaviour and awareness of waste and resource use at an early stage of a scientist's career. Scientific laboratories are complex environments and consume high quantities of resources. Energy requirements can be ten times higher per m2 than in an office space (James *et al*. 2007). The use of disposable plastics and experimental kits leads to high wastage and it is unfeasible to reuse much of this due to contamination with potentially dangerous substances. Solutions and reagents are often wasted due to inappropriate labelling or lack of communication. Re-use and recycling of chemical wastes from laboratories has been implemented in certain institutions along with an awareness campaign and suitable labelling (Serra *et al*. 2003). Many of the waste streams are inbuilt into the laboratory environment but there are others that can be improved through behavioural changes and small alterations in infrastructure (**Case Study 1 and 2**). Financial restraints can be a catalyst in a shift towards sustainability through the implementation of increased efficiency, resource minimization and waste reduction measures throughout the University (Comm and Mathaisel, 2005).

Field trips are often the most rewarding and inspiring part of learning. However, the impact of field trips does need to be considered in terms of sustainability. The human impact of students and researchers on fragile ecosystems can be minimized by limiting access to particular areas and carefully choosing 'sacrifice areas' for the highest level of activity (Tejedo *et al*. 2005). Environmental impacts of travel to study sites should be considered in terms of greenhouse gas emissions. According to the latest IPCC report continued

LIMITATIONS	POSSIBLE SOLUTIONS
Time - implementing new structures and practices difficult when added to a full workload. *Resources* - financial constraints often limit new developments. *Tradition* - there can be strong resistance to changing teaching practices. *Information* - there is a lack of easy to use guidelines for sustainable practice *Motivation* - sustainability issues may not seem relevant to the individual, or they may feel that it is not their role to be teaching it. *Curriculum* - there are particular constraints in teaching biosciences, students need to be taught methods relevant to future employment.	• Online resources • Best practice guidelines • "Green Laboratories Manual" • Review of staff workloads • Evaluation of the curriculum • Secure funding • Sustainability training for staff • Support from management • Sustainability group • Permanent member of staff to facilitate the transition to sustainable teaching.

Table 2: Factors limiting progress towards sustainability teaching of bioscience at the Institute of Biological Science at UWA

greenhouse gas emissions at or above current rates would induce many changes to global climate systems over the next century (IPCC, 2007). The amount of greenhouse gasses that we are putting into the atmosphere need to be 'capped' at a safe level to prevent further temperature increases.

Case Study 3 shows the travel carbon footprint of two field trips with equivalent content held at two different locations. The first, located in Indonesia and the second will be held in Pembrokeshire, south Wales. The second option is 200 times more efficient in terms of carbon dioxide emissions than travelling to Indonesia. Changing the location of the field trip to Pembrokeshire saved time, cost and considerably reduced environmental impact. In addition tutors on this course felt that an equivalent learning experience could be gained locally, further student feedback will be needed to assess impact on student satisfaction.

Following on from these preliminary case studies, several areas that need further investigation have been highlighted:

- Identifying best practices in terms of sustainability and student learning outcomes.
- A sustainability audit of the content, design and delivery of a range of modules.
- The relationship between sustainability and different modes of delivery in terms of their impact on student learning experiences.
- Engaging with students to determine the impact of the project in terms of content and delivery as assessed above.
- Collating information on suppliers assessing their environmental principles and consideration of sustainability in product design and operations.
- The development of easy to follow guidelines for academics, technicians and laboratory managers.

Developing more sustainable teaching will provide significant benefits in terms of increasing the efficiency of provision (time, cost and environmental benefits). This will also

Case Study 3: *Environmental Management Field trip goes local to reduce carbon footprint*

2005 Indonesia and back	**2007 Pembrokeshire and back**
Total distance travelled: **16,344** miles Aberystwyth – Manchester by **car** 280 miles x 0.29 kg CO_2 = 81.2kg CO_2 Manchester – Jakarta by **long haul flight** 14,658 x 0.18 kg CO_2 = 2638.44 kg CO_2 Jakarta - Makassar by **short haul flight** 1406 x 0.24 kg CO_2 = 337.44 kg CO_2 CO_2 emissions *per person*: **3057.08** kg CO_2	Total distance travelled: **168** miles Aberystwyth to Dale Fort, Pembrokeshire by **bus** 168 miles x 0.09 kg CO_2 = 15.12 kg CO_2 CO_2 emissions *per person*: : **15.12** kg CO_2

Travel assumptions (DEFRA, 2005)

have direct and indirect positive benefits to departments and their staff by providing a structured, user friendly methodology in which to assess opportunities and implement sustainable practices.

Conclusion

To move towards sustainable teaching in bioscience, strategies that involve students and university staff at all levels are required. There is potential for the department to lead by example by implementing a strong environmental policy that guides the University towards a low impact learning environment. From the student perspective there is support for a transition towards sustainability. The first two years of study are potential target groups for sustainability education, thus increasing the level of 'sustainability literacy'. A move towards sustainability will require some behavioural adjustments and alterations in infrastructure. Education, training and support for teaching and technical staff is needed in order to implement any change. With escalating energy costs, and forthcoming regulatory requirements, it is essential that higher education rises to meet these challenges.

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[O31] Threshold concepts, misconceptions and common issues

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Context

In every area of science there are some ideas that many students find difficult to grasp. Such difficult but key ideas has been recently termed *Threshold Concepts* by Meyer and Land, (Meyer and Land, 2006). They define a *Threshold Concept* as:

- Core to understanding the subject;
- *Seismic*: 'getting it' brings about a significant shift in perception of the subject;
- *Irreversible*: the change in perspective that comes with understanding;
- *Integrative*: understanding it exposes interrelatedness (previously hidden);
- *Bounded*: has distinct edges and affects other new concept areas;

Meyer and Land also describe the allied idea of *Troublesome Knowledge* areas which are major barriers to learning, where they are central to the subject and are often characterised by behaviours such as:

- *Ritual knowledge* – students are able to perform superficial tasks and techniques to get a result, but fail to understand the complexity that lies behind it.
- *Inert knowledge* – concepts are understood but not actively used or connected to the 'real world', a failure to see the 'big picture';
- *Conceptually difficult or Alien* – counter-intuitive, alien or incoherent e.g. mass, weight and gravity; i.e. the strangeness and complexity of scientists' views of the matter.
- *Troublesome language* – when are 'familiar' concepts are rendered strange and subsequently conceptually difficult?

Summing up Meyer and Land

> *'Failure to understand threshold concepts leaves the learner in a suspended state where understanding is mimicked or lacks authenticity.'*

In the sciences, there have been a small number of studies in area of university science – work by Taylor and Prosser (Taylor, 2006), but the majority of previous work in this area has focused at pre-university level e.g. work by Keith Taber (Taber, 2002) and Vanessa Barker, (Barker, 2005)). In her review '*Beyond Appearances: Students' misconceptions about basic chemical ideas*', Barker describes a number of chemical misconceptions. In one example, with 16+ students she identifies as a key factor the limits of the students' ability to wear 'molecular spectacles', when examining chemical concepts.

> *'When students cannot "see" particles they cannot really understand chemical reactions and so the fabric of chemistry is lost to them in a haze of impenetrable events completely at odds with their every day experiences of a "continuous" world.'* (Barker, 2005)

Taber considers several different concept types and the problems that arise when *natural* concepts (everyday life) appear inconsistent with *scientific (new)* concepts, as well as issues to do with language. For example, a student who has just learnt the idea of a covalent bond in a limited context does not share the same meaning of the term as their lecturer. The lecturer's meaning is very much more in-depth and sophisticated and is integrated into an extensive framework of chemical ideas, (so called *elaborated learning*). Taber identified both obstacles and impediments to a students learning. Some of these ideas resonate with initial findings from our studies.

Impediments can occur on two levels: firstly, *null learning impediments* where students fail to make sense of our teaching - either because they have prior knowledge gaps or because they fail to integrate their new information into their existing framework. Secondly, Taber describes *substantive learning impediments* where a student has alternate but wrong conceptions or is taught in an inappropriate way.

In her higher education study, Taylor recounts that troublesome concepts in biosciences can arise from problems with both *process* concepts and *abstract* concepts and situations where students develop 'islands of knowledge' that are not integrated into the bigger picture. (Taylor, 2006)

The Research

Building on the work of these workers and others, our plans were to firstly understand the nature of the problem:

- Discover what the common misconceptions are? (Staff and student perspective)
- Explore students' understanding with work in class or in focus groups
- Use questioning to explore understanding – diagnostic tests, questionnaires
- Identify knowledge gaps?
- Track which misconceptions persist from pre-university days?
- Examine which misconceptions are perceived to be maths related?

Having collected this data then the next step is to develop materials and approaches that help both with knowledge gaps and misconceptions, e.g. by considering the language used to teach and by setting things in context.

Qualitative Studies

Focus Groups

A number of students were interviewed and asked questions to find out:

- *What are the concepts students find difficult or troublesome?*
- *What concepts have transformed their understanding?*
- *What are the gaps they perceive in their knowledge?*
- *What are the concepts they are most keen to understand and why?*

Initial groups interviewed were Forensic Science students. On this interdisciplinary programme, students have to deal with concepts from biological sciences, chemistry, physics and forensic science itself. In addition they have mixed entry profiles of A2 and AS-levels in different subjects. This will affect their prior knowledge, and hence is likely to affect their ability to acquire both knowledge and understanding of concepts.

Topics they identified as causing problems included:

In chemistry:

> *Electrochemistry; chromatography; bonding; functional groups; spectroscopy, radiochemistry; Arrhenius equation; chemical equations, analytical science; crystal field theory, formulas and equations, dilution factors, structural formulas; calibration of instruments*

In biology:

> *Energy chains; electrophoresis of proteins and nucleic acid immunodetection; many types of chromatography (e.g. size exclusion);*

In physics:

> *Microscopy; waves; photography and image processing; ballistics; complexities caused by different theories, equations and functions*

In general:

> *Equation manipulation;*

Some of their reflections on learning:

On the perils of oversimplification and its consequences

> *'. . . but they teach you one thing and then you get to the next level and they say forget everything you learned in GCSE, it's not like that, it's like this and it's the same when you get to the degree, they say forget everything you learned at 'A' level, this is how it is and you have to keep resorting back to what you learned in the first place and it just confuses you'.*

On maths issues

> *'I agree with X about having the grasp of maths and rearranging equations, stuff like that, that would be good.'*

On the value of contextualising

> *'. . . why do you need to know that? If you are using a microscope you don't need to know that the light is behaving as a particle, all you need to know is that you have to adjust the thing to get it into focus and that's the thing I would rather have learned, rather than looking how the light bends this way?'*

On the use of language

> *'I find a lot of the technical words are difficult to grasp . . . it's like anything that you are working with, if you use it all the time, they become part of your everyday language and you don't realise that people don't understand it. I worked with the police force for eight years and they use loads of acronyms etc.'*

Chemistry survey

The survey asked fifty first year students to rate their understanding of topics in a core chemistry module, which covers aspects of the three main branches of chemistry. The survey asked students to rate their understanding of each topic on a 5 point Lickert scale from None to All, for example 'Half: I understand some of the facts/theories and can relate them to/solve straightforward problems; to All: 'I understand all of the facts/theories and can relate them to new problems.'

Students who indicated their understanding as 'none' or 'little' for any topic were also asked to suggest reasons as to why they found it difficult. In addition, we asked for information on their types of entry qualification and the grades they had achieved.

Topics which had low understanding ratings included:

> *Markovnikoff's rule; MO theory; VSEPR theory; Arrhenius Equation; Inductive effects; Alkyl halides (SN1, SN2 reactions); pH; dissociation constants and SI units*

Where given, student reasons for their difficulties included comments on:

> *'A lack of prior knowledge of some topics'; 'difficulty in understanding'; 'uncertainty over meaning of terms'; 'books were 'confusing'; 'insufficient examples to demonstrate the purpose of required field of knowledge' i.e. a lack of context.*

There is an implication in these comments that a lack of familiarity brings a lack of confidence in how to solve problems in, or apply, 'new' areas of knowledge.

Staff Surveys

As learning involves both teacher and student, it was felt important to ask teaching staff for their perceptions of students' difficulties with scientific concepts. Two groups of staff have been surveyed so far: academic staff teaching science at Nottingham Trent University; and secondary science teachers. It was intended to help identify those areas of the post-16 curricula where conceptual difficulties are carried through into undergraduate study.

18 Academic staff from a range of sciences, who responded to our survey, listed the following as difficult/troublesome concepts for their students:

> *Genetics; differences between viruses, bacteria and fungi; biomechanics; statistics in final year projects; anything that involves a formula; biochemical*

> *pathways (e.g. Kreb's cycle); molecular biochemistry (DNA); moles, ionic and covalent bonding; cellular respiration; cloning; transgenics; rearranging equations.*

We also asked for suggestions from staff as to why these concepts were troublesome. They suggested:

> *'Abstract concepts'; 'mathematical formulae phobia'; 'lack of prior knowledge'; 'difficult for them to conceptualise'; 'not well taught at school'.*

18 Science Teachers stated the following issues for their students:

> *Biochemistry – structure of macromolecules; DNA and protein synthesis; quantitative chemistry; electron structure; bonding; qualitative chemistry; valency; writing formulae and equations; electrolysis; systematic nomenclature; polymers; fuels; catalytic converters; how chemistry relates to the real world; inter-molecular forces; balancing equations and stoichiometry; relating properties to structure; photoelectric effect; nuclear particle families; nuclear reactions; calculations*.

Quantitative Studies

Diagnostic testing in Physics

Further factors for analysis were supplied by diagnostic testing with both first year physics and chemistry students. The physics test is part of a process begun in 1998, which has run every year for 8 years in the initial weeks of the programme, using the same test material. The test papers are in 5 sections, which cover: scientific notation, graphs and units; Motion; DC electricity; Atoms and radioactive decay; and Waves. Students are allowed up to 2 hours to complete the 23 questions, which are then peer assessed. The results are collected anonymously and the results tabulated by the member of staff. The students get their test paper back, common areas of weakness are identified and students then referred to appropriate units in the Open University Flexible Learning Approach to Physics (FLAP) materials. Students have persistently valued this approach highly. Results for these studies clearly show that the sections on *Waves* and *DC Electricity* persistently have poorer scores. A three year sample reveals that those getting 3 or more questions right in each section were usually 75-80% for sections on scientific notation, 60-76% on motion and 60-64% on radioactivity but only 13-21% on DC and 0-24% on waves. Further studies are therefore indicated to explore why these two topics are persistently difficult.

Diagnostic Testing in Chemistry

To compliment this physics data we began an investigation to obtain similar data about first year chemists. Fifty first year students were asked to complete a diagnostic test to check where there were conceptual difficulties.

The test involved 31 questions and question types included multiple choice, multiple completion and pairing. The questions were derived in part from an earlier diagnostic test (based on the RSC Question Bank). These were updated by the student running this investigation to reflect changes in syllabi at A-level on the advice of a highly experienced school teacher. The idea was to access levels of understanding with questions that started with A-level knowledge.

The poorest performances in the test were for questions on the following topics:

Trends in the Periodic Table; Electronegativity; Metal complexes; Isomerism; Electrophiles; Rates and Arrhenius

Conflicts of test and survey data

The first year group undertaking the test also did the survey. In some areas, students' test performances fitted their perception of their lack of understanding e.g. the Arrhenius equation. More interestingly, there were some discrepancies. The majority of students stated that they understood most aspects of *Trends in Periodic Table*, yet questions in this area produced the lowest scores of any in the test. This does raise some questions about how valid are students' perceptions of their own understanding and the relative outcomes of qualitative surveys versus quantitative testing. To what extent does self perception affect approaches to learning and perceptions of difficulty especially, for example, where mathematical ideas are concerned?

For all this work participants gave informed consent, data was anonymised and all research was conducted in accordance with British Educational Research Association guidelines (Furlong, 2004)

Conclusions and further work

From these initial studies, more detailed work is being carried out to explore why the concepts students and staff identified in our study are troublesome. Other subject groups are also being investigated e.g. sports science and bioscience and physics students.

Amongst our developing data, some common themes are beginning to emerge:

- Staff and students, at both school and university level, identify concepts involving the molecular but invisible, as causing problems: whether in biochemistry, molecular biology, or chemistry (e.g. DNA, structure and bonding)
- Mathematical issues, at all levels, from the manipulation of equations to statistics
- A perceived lack of teaching materials that relate scientific concepts to the real world
- Anything to do with the behaviour of electrons – from electrolysis, to DC to electrophoresis, is troublesome

Research, from Piaget onwards, indicates that it is not just about what is taught, but how it is taught that matters. Teaching needs to include activities and hand-on experiences, (McNally, 1973). It is about going beyond *Instruction to Intervention* where an experience maximises the learner's cognitive processing capability or development, (Adey and Shayer, 1994). As a result of these investigations, we are developing resources to support learning of some of these threshold concepts and troublesome knowledge – from VSEPR, and statistics, to protein purification and mole calculations, with a focus on the interactive, the visual and opportunities for repeated interventions. There's a lot more to do!

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[O32] Do students form, norm, storm and perform? What if they don't: exploring the realities of student project groups

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Introduction

A common assertion in study skills textbooks is that student coming together to work as a group will go through a predictable set of stages – from uncertainty and confusion through conflict and on to stability and productivity – the model of 'form, norm, storm and perform' (Tuckman 1965). This model is also routinely applied to all workgroups and has become almost a 'taken for granted' description of how a group of strangers might become over time an effective working team. The model's ubiquity can be demonstrated by a Google search – all the top ten links in response to a search for models of group development specifically described the model as outlined by Tuckman (e.g. Smith, 2005) or offered variations and minor updates (e.g. Atherton, 2003). Other similar models have been described in the literature with varying degrees of empirical support (e.g. Wheelan, 2004, 2005a and 2005b) and there have been various attempts to synthesise different approaches (e.g. Chidambaram and Bostrom, 1997).

So can we accept this model as the best prediction we have of the way student groups are likely to behave? In fact, there may be some good reasons as to why student groups do not follow this process, including familiarity with their peers, substantial experience in working in groups and a very task oriented approach to their work. We must be wary of assuming that groups or teams operate in similar ways in different contexts – for example, there is debate on the similarities and differences between student groups and the types of group and team that exist in the workplace (Hartley, 2005).

However, the way that student groups behave within their group is important because it can affect the way the tutor should monitor the group and intervene to help the group along. If we do accept Tuckman's model then what does this mean for the tutor? The model does suggest certain steps for the tutor as **Table 1** overleaf illustrates.

But what if Tuckman's model is not the most appropriate description of contemporary student behaviour? It is also worth remembering that Tuckman based his ideas not on his own original research but on an amalgamation of all the published studies he could find at the time. These studies did not include a representative sample of student groups and this was also true in his later follow-up review.

Systematic studies of student group development are relatively scarce so there is not much evidence to help tutors decide which interventions are appropriate. To complicate the issue further, there are other models of group development which do have some empirical support and which offer different advice to tutors. For example, some authors have suggested that groups may move through the stages in a less predictable sequence than Tuckman so the job for group leaders/tutors is identifying the stage and taking appropriate

Tuckman's stage	What happens in the group	On this basis, the good tutor should …
Form	Members are confused and hesitant, both about the task and interpersonally; state of dependence	• Not expect much productive behaviour • Support social blending
Storm	Conflict over 'what' the group should do and 'how' the members should act towards each other	• Make sure that the conflict remains within manageable limits • Intervene if it looks like the group is going our of control or in danger of splitting up
Norm	Norms and roles develop	• Check that the group is on track regarding the task • Make sure there is no aftermath from the conflict stage
Perform	Group performs to capacity	• Provide expert advice and support

Table 1: Advice to tutors following Tuckman's model

Alternative models	What happens	Tutors should …
Punctuated equilibrium	Start straight away Mid-point crisis	• Check first few days/week to make sure that the group really does understand the task and has adopted an effective approach • Halfway review to make sure group is still on the right track
Alternating stages	Groups flip between stages in no set order	• Monitor continuously • Intervene relative to state of the group

Table 2: Alternative Models of group development

steps. For this study we used descriptions of group types based on common theories of group dynamics: the detached group where apathy is the dominant aspect; the defensive group where the members seem to focus on self-protection and avoiding criticism; the dependent group which is looking to the leader figure to 'get it right'; the dramatic group which seems to be responding over-emotionally; and the performing group.

Another theory which has been specifically tested on student groups suggests that groups are likely to start seriously engaging with the task much earlier than Tuckman's model allows. Connie Gersick's model of 'punctuated equilibrium' suggests that groups start in their first meeting by establishing a 'framework of givens' (Gersick, 1988). This may not be explicitly discussed (assumptions may rule and these may be incorrect or misleading!) but the group develops a shared approach to the task (and their understanding of it) and settles into fairly stable patterns of interaction. These patterns are likely to continue for the first half of the group's life cycle. In studies with both student and work teams, Gersick found that, at the halfway point, there was often a critical moment for the group. There was a transition point – often a meeting which was 'different' in character from the ones that had gone before – preceded by a break in momentum. This led to the group re-assessing its progress and moving into a second phase with new ways of working and often a change of leader.

These different models have very different implications for tutors, as **Table 2** summarises.

This study aimed to investigate how student groups see themselves behaving over time to see if this offered a useful mechanism to support tutor intervention and to see if any of the models described above can offer reliable guidance to tutors. Our long-term aim is to repeat this form of study on a broad range of student groups and to incorporate some observational measures to check the reliability of student self-reports.

Methods

The group exercise chosen for this was a level 3 poster exercise that one of the authors (NJL) has run for several years. The exercise runs over a single semester and contributes 25% of the module mark of which 15% is for the group component and 10% is for an individual summary of the poster. The students are randomly divided in to groups of 5 and assigned a topic by the tutor.

There were three timetabled contacts with the tutors responsible for the exercise.

Week 2

- All students were briefed as to the nature of the exercise the aims and learning objectives. They were also informed as to the rationale behind the structure of the exercise. In order to facilitate communication within the groups they were instructed that there should be a minimum of at least 3 group meetings and minutes of each meeting should be taken. These had to be handed in but did not contribute to the assessment.

Week 7

- A formative meeting was held with one of the two members of staff who were to mark their poster. As a result of this meeting the group had to produce an action plan to demonstrate how they would incorporate the formative feedback. This had to be handed in but did not contribute to the assessment

Week 12

- Poster assessed by two members of staff in a day long poster presentation session

Group communication was facilitated by the formation of Blackboard E-Mail groups for the students and the tutor.

A 30 question questionnaire (examples of the items are shown in **appendix 1**) was given to all students at the start of the exercise. They were asked to fill in their responses to this questionnaire at two week intervals throughout the semester. All groups submitted responses with all members of the majority of groups submitting a response. This high level of response was facilitated by regular e-mail reminders. The questions were designed to reflect three separate descriptions of group behaviour – based on Tuckman, based on the similar model by Wheelan, and using a typology of groups based on work by Sparks - and to allow for the self-reporting of how the students perceived their performance in this exercise.

Data was analysed using ANOVA with SPSS.

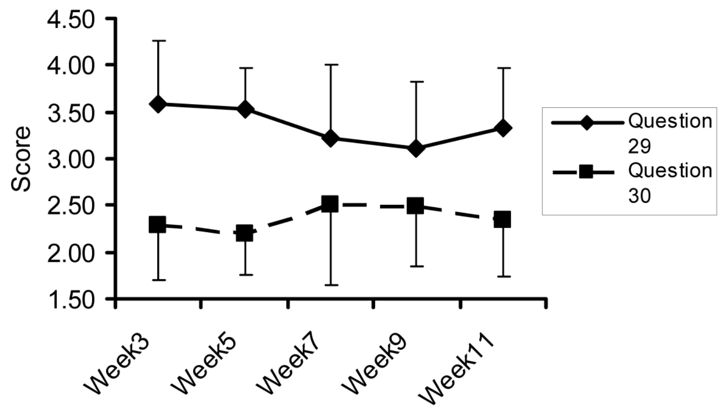

Figure 1: Comparison of responses to Q29 and 30

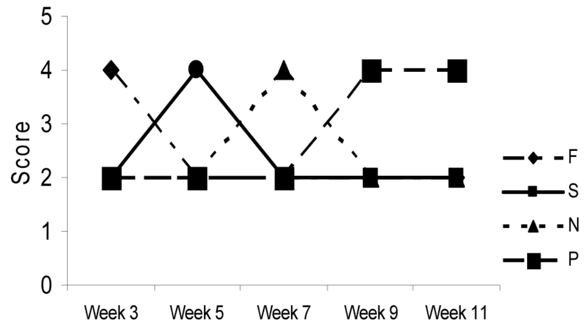

Figure 2: Predicted Tuckman response

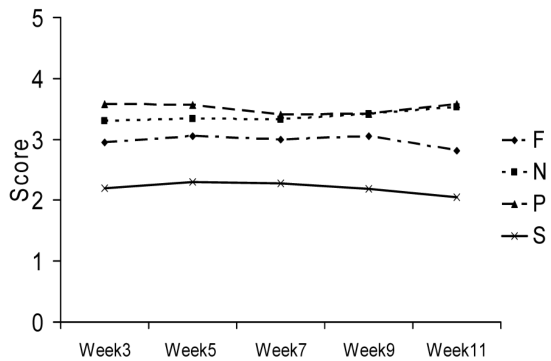

Figure 3: Actual Tuckman response

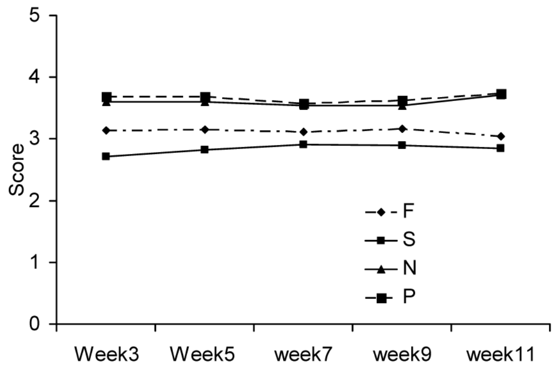

Figure 4: Wheelan response

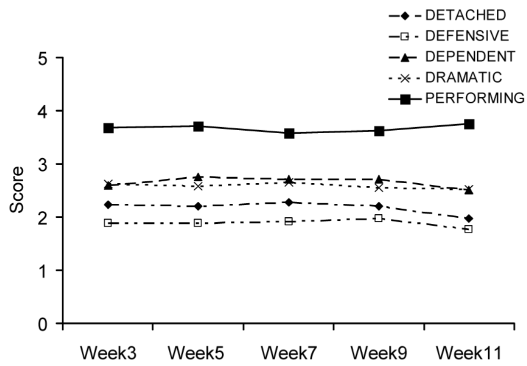

Figure 5: Sparks response

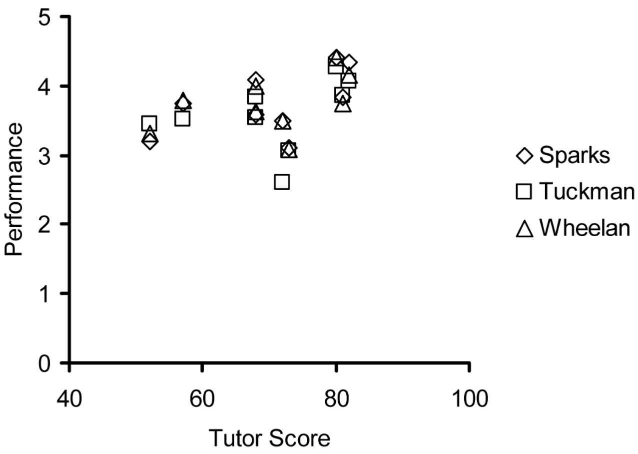

Figure 6: Correlation between perception of performance and real performance

Results

Initial analysis of the data examined the evidence for punctuated equilibria by comparing the responses to questions 29 and 30 with the results being shown on **Figure 1**. Whilst there was a slight decline in agreement with the question 'We decided what we needed to do at our first meeting and we have stuck to it' (Question 29) and a concomitant increase in agreement with the question 'We have just had a crisis where we reconsidered what we were doing and changed direction' (Question 30) these changes are slight and not statistically significant. It is also to be noted that overall students are more in agreement with question 29 than question 30.

If the Tuckman model of group behaviour applied to student groups then we would expect a sequential peaking of the various group attributes as shown in **Figure 2**. However no evidence of peaking of the self-perception of any of the group behaviour traits was seen (**Figure 3**). These values were typically seen in each group, however two groups showed an effect after intervention; one showing a positive benefit the other an apparent negative effect.

When the scores for forming, storming, norming and performing based on Wheelan's model are analysed no real evidence of peaking of the self-perception of any of the group behaviour traits is seen (**Figure 4**). These values were typically seen in each group, however two groups showed an effect after intervention; one showing a positive benefit the other an apparent negative effect.

The pooled results for the group type scores (**Figure 5**) show high performing scores but low scores for the detached and defensive scores; the latter two characteristics are those that would be expected of dysfunctional groups. These values were typically seen in each group, however two groups showed an effect after intervention; one showing a positive benefit the other an apparent negative effect.

Figure 6 shows the correlation between the perception of performance and the outcome of the assessment. Higher performing scores appear to correlate with increased mark. The only exception is a group whose questionnaire responses suggest an apparently poor effect of intervention.

Discussion

These results provide little support for the idea that the dominant model of group behaviour, forming storming norming and performing, applies to the behaviour of these student groups. A number of factors may affect this: firstly these groups form for a short period of time to achieve a specific task; secondly the student cohort, although randomly formed into groups, have undertaken many such exercises and should have become skilled in the rapid formation of groups to achieve specific tasks; and thirdly that the groups never function as teams with a high degree of interdependence, although anecdotally this does not appear to be the case.

However this study does not provide substantial evidence to support the alternative model of punctuated equilibrium. At week 7 there is a dip in the agreement with the question 'We decided what we needed to do at our first meeting and we have stuck to it' and an increase in the response to the question 'We have just had a crisis where we reconsidered what we were doing and changed direction'; overall these are slight, although individual groups showed marked responses. All groups had a formative session in week 7 which raises the possibility that the mid-point crisis is tutor-induced.

Again the data shows little evidence of significant change in group type. The groups generally class themselves as high for performing and low for dysfunctional characteristics suggesting that they come together early to concentrate on the task and that their self perception of the group is that they are functioning well as a group. The correlation between outcome of the assessment and the self-perception of performance suggests that students have a realistic perception of their performance.

Conclusions

From the theoretical point of view, this study suggests that the dominant models of group development do not look very robust when applied to specific student groups. But we must be wary of the limitations of self-report (and this is an area for our future research).

This raises significant practical issues for tutors associated with substantial student group projects. If there is no really reliable model of student group behaviour, then how can tutors plan their interventions and support? We suggest that the best strategy is 'play it safe' and use a schedule and style of tutor contact which accommodates the very different pattern of responses we observed. This would include:

- Early monitoring of group assumptions and progress, as this is essential if groups are following the 'punctuated equilibrium' sequence

- Halfway review, to check on groups which might be experiencing a transition and to check on groups who are making more gradual progress (but also do some follow-up as this halfway meeting can have negative impact)

- Intervention based on an appropriate diagnosis of the particular group's progress and position

Items based on Tuckman	CATEGORY
We communicate in tentative and polite ways	F
We do not have very clear goals but we have not tried very hard to clarify them	F
There is very little disagreement or conflict in the group	F
Members wait to be told what to do	F
We appeal to our leader for direction	F
We allow our leader to do most of the work	F
We seem to be getting clearer about what we have to do	N
Members of the group are becoming more active	N
We are getting much clearer on what we have to achieve	N
We are working to build a group structure that will help us	
to achieve our goals	N
We are becoming more trusting of each other	N
Each of us is highly committed to the group goals and tasks	P
We effectively manage our time	P
Members communicate directly and honestly	P
Members tend to stay focused on the task	P
We can resolve any conflict effectively and quickly	P
The leader is being challenged	S
We often interrupt each other	S
We often engage in open conflict	S

Appendix 1: Examples of items from the questionnaire

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[K2] Teaching undergraduates to think: from parrots to professionals

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Keywords: skills, problem solving, context based learning, critical thinking, case studies

Abstract

There is a need in chemical education to provide students with open ended, creative problem solving activities. Critical thinking exercises and problem solving case studies have being developed in order to provide students with a 'real' context to extend their knowledge of chemistry, to develop intellectual or 'thinking' skills and practise a range of transferable skills. The nature of the activities involved ensures that, in order to complete the case study, students must use a variety of subject specific and transferable skills.

Introduction

Employers have long been urging the Higher Education sector to produce graduates with a range of key skills that would make them more immediately effective in the world of work. Several reports (e.g. Finer, 1996) have highlighted particularly communication skills, team working, numeracy, use of IT and learning to learn as highly desirable qualities in a graduate. This view has also been highlighted as being particularly important in a report by the LGC (Fleming, 1994). Following a comprehensive survey carried out by the LGC (Milgrom, 1993), the report states that employers' overwhelming concern was with the graduates' ability to apply appropriate theory and laboratory techniques to practical problems. In particular, graduates should be able to evaluate a specific problem, identify appropriate theory, methods and techniques that can provide a cost-effective and reliable solution, and ensure that this solution is implemented in accordance with rigorous quality or regulatory regimes. Good interpersonal skills were identified as being crucial to allow analysts to work effectively in a team and to evaluate problems jointly with clients.

So, in order to produce graduates who can operate in the workplace as professionals we need to go much further than just ensuring that they have a sound knowledge of their discipline. We must produce graduates who can think critically, have an analytical approach, can interpret data and information, tackle unfamiliar and open-ended problems and apply all that chemical knowledge that they have acquired. In addition, the modern graduate must master a range of 'professional' or key skills. These include communication, team working skills, time management, information management and independent learning.

The Challenge

What is missing from the traditional approach to the chemistry curriculum that would enable students to develop these intellectual and personal skills and capabilities? In order to enhance the qualities of the chemistry graduate we need to provide opportunities to develop advanced problem solving skills, a range of key skills and an appreciation of the range of applications within which the professional chemist works. Problem solving activities can provide the vehicle for achieving this. Students should begin to tackle unfamiliar and open-ended activities that allow some degree of flexibility and creativity.

Johnstone (1993) has categorised problem solving activities and identified their characteristics according to whether the problem is familiar, has well defined aims and has a complete data set. Most of the problems that students encounter during traditional chemistry teaching and learning activities are firmly rooted in the lowest type of problems. An attempt was made to produce novel problems for chemistry undergraduates in the 1999 publication ‘A Question of Chemistry’ (Garratt *et al*, 1999). In this book problems of several different types were presented. The categories used were: ‘understanding argument’, ‘constructing argument’, ‘critical reading’, ‘using judgement’ and ‘reference trails’. The nature of the problems meant that their styles would be unfamiliar to most students as they were generally non-numerical, open-ended and without a single correct solution.

An example of a problem from the ‘using judgement’ chapter is given here. It is based on the requirement to carry out a ‘back of the envelope’ calculation in order to obtain a rough answer that gives the student some insight into analytical processes and scale of analyses.

> *The proverbial expression ‘looking for a needle in a haystack’ might be used by scientists trying to detect or identify traces of compounds. If there is one needle in a haystack, estimate its concentration in parts per 10^n on a weight or volume basis.*

When problems of this type are used in classes of students, in addition to developing their range of thinking and problem solving skills, it is immediately obvious that other ‘key’ skills and competencies are being developed. The students have to formulate and defend ideas, communicate their ideas to each other clearly, and they have something to discuss for which they are entitled to hold and defend an opinion that may differ from that of the tutor. There is no longer a single correct answer, so students have to realise that answers are not always right or wrong.

I have become convinced that the best way to address the skills development agenda is through problem solving activities. Those in ‘A Question of Chemistry’ are fairly short, so they can be worked on within a tutorial session. If the problem-solving activities were extended so that they required students to learn some chemistry content in order to make progress and, if the problems were carefully developed, these should then stimulate students to expand their knowledge and develop a wide range of professional skills. This reasoning has led to the development of problem solving case studies. They are related to applications or real contexts, provide incomplete or excessive data, require independent learning, evaluation of data and information and do not lead to a single ‘correct’ answer.

Case studies have a long history in many subject areas and their value within chemistry has long been recognised (Belt *et al*, 1998, and Overton, 2001).

A case study should:

- involve the learning of chemistry either by building on and showing the relevance of prior learning or by requiring students to learn independently in order to tackle the case

- be active in style
- involve a work-related context
- involve the development of personal skills
- encourage reflective learning
- have clear learning objectives for students

Case studies require students to work both individually and as part of a team to solve an extended problem. Each case study is flexible enough to be used in a variety of different teaching situations and each has been designed to encourage the development of different transferable skills. For each case study, students work in small groups and the contact time is ca. 4-6 hours with students usually spend 6-12 hours in associated independent study. The case studies offer a number of opportunities for assessment depending on the learning outcomes set by the tutor.

The Titan Project

For this case study (Summerfield *et al*, 2002), students adopt the role of the management team of a titanium dioxide plant empowered to make recommendations on the future of the site. The case study encourages students to consider industrial chemistry in a broad context of the associated safety, environmental, economic and social issues. Some of the case studies are outlines here.

The Pale Horse

In this case (Overton *et al*, 2002), the students act as the investigation team for a (fictitious) suspicious death. The evidence is gradually presented in reports from attending police officers, an investigating officer, a forensic medical examiner, a scene of crimes officer (SOCO) and a forensic scientist. From these, students select samples for analysis together with the corresponding analytical methods. By consideration of the results from these analyses, the students are able to identify the cause of death, the manner in which the poison was administered, and the role of analytical chemistry in solving the case.

Conclusion

These case studies have been piloted with students ranging from undergraduate to masters level study at over a dozen UK universities. The staff and student feedback has been very positive. It is noteworthy that the enthusiasm and engagement of the students swiftly increases as the case studies progress, presumably due to an increased familiarity with the approach and perhaps due to a greater involvement in decision-making processes. Additional feedback from students shows that the case studies not only provide them with the opportunity to develop their knowledge of analytical chemistry, but serve to increase their awareness of their transferable skills and capabilities.

Acknowledgements

I thank Simon Belt for his fruitful collaboration on authoring the case studies. We thank the Royal Society of Chemistry Analytical Trust Fund for funding and the encouragement of the UK Analytical Partnership.

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[P1] The use of 'webquests' to enhance blended learning environments

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Introduction

In the modern Higher Education environment increasing emphasis is placed on 'electronic learning' (e-learning) (Su *et al*., 2005). This basically involves the use of information technology (IT) facilities to deliver learning material. Effective use of e-learning has been focused on distance learning with less information available for relating e-learning to a blended learning approach (Ellis *et al*., 2006). The authors felt that previously e-learning was simply 'bolted on' to existing practice, rather than being fully integrated. This 'bolting on' approach has never been entirely successful, as students do not perceive where On-line Learning Tasks (OLTs) fit in with the module and do not take the tasks seriously (Hassanien, 2006). Instead students continue to rely heavily on receiving information from more traditional forms of delivery, such as lectures, workshops and tutorials.

The aim of this study was to harmonise e-learning with the more traditional styles of teaching that occur in the classroom or lecture theatre. This was to be done by trying to integrate information obtained from an OLT, which was completed during a period of student self-directed learning, with classroom activities.

Method

In a second year undergraduate pharmacology module, students normally receive three hours of taught classes each week, is supported by on-line access to lecture notes and workshops. In order to increase the effectiveness of the module's on-line facility towards the objectives of the course, two hours of the class that occurred in week five of the semester was dedicated to an unsupervised on-line task (OLT). This task was constructed in a way as to consolidate prior learning as well as to act as a preview to subsequent classes. The OLT was designed as a 'webquest' in which various medicinal drugs were concealed within a written scenario. The scenario did, however, contain hyperlinks to high quality pharmaceutical Internet sites and during the OLT, students were encouraged to study these sites and to apply the pharmacological knowledge they had already obtained from the module to the medications mentioned in the scenario. In addition to this, several of the drugs in the scenario were unfamiliar to the students, as they had not yet been covered on the module.

On completion of this OLT, students were expected to submit an electronic document that consisted of the names the concealed scenario medications, along with supplementary information on their use, mode of action and adverse reactions, all of which could be derived from the hyperlinked web-sites. Such documents enabled the module teaching team to monitor student engagement, as well as to encourage the students in producing a report that could prove to be a useful aid to learning key pharmacological principles covered in this and subsequent pharmacology modules. On completion of the module,

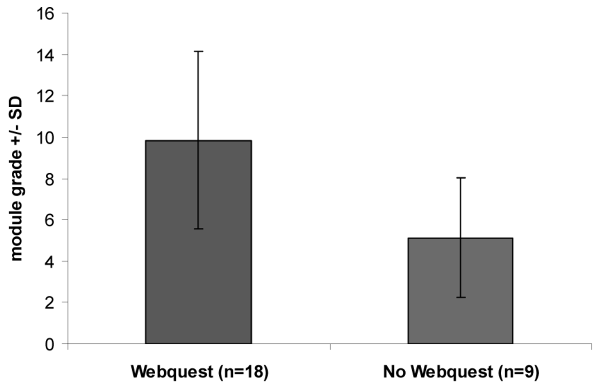

Figure 1: mean module grade +/- SD for self-selected student groups, one group engaging with the webquest activity and the other not engaging

students were asked to complete a reflective questionnaire about the effectiveness of the OLT as an aid to understanding the key principles of the module.

Results

As this was a student-directed activity, students could select whether or not they engaged with the OLT and as a consequence two independent groups were formed: students who engaged with the 'webquest' (n=18) and those who elected not to engage (n=9). Comparison of the assessment performance as shown by the mean module grade (**Figure 1**) was carried out using an independent T-test. A significantly higher mean module grade was noted for those students engaging with the 'webquest' when compared to those who elected not to engage ($p<0.05$).

Discussion

This OLT uses a scenario from which students were expected to seek pharmacological information that reinforces the knowledge they have already obtained from the module. It also serves as an introduction to new learning material that is set to follow. The scenario itself was deliberately written in an approachable style to make it accessible for a diverse student cohort. It was set in a non-scientific context, ensuring that it contained no off putting technical or biomedical terminology so as not to dissuade even the least able students from approaching the OLT. In addition to this, such a scenario emphasises the concept that the subject of pharmacology is not just restricted to the classroom or laboratory, but that it routinely occurs in everyday life. Engagement with the 'webquest' is associated with improved assessment performance (**Figure 1**) with students who engaged with the 'webquest' achieving on average a higher module grade ($p<0.05$).

This 'webquest' was designed to provide a thorough self-directed learning experience into the fundamentals of pharmacodynamics by explaining and integrating the interaction of drugs at the different levels of cellular and tissue organisation. On completion of the 'webquest' students had been given the opportunity to explore the relationship between the actions of drugs at their molecular targets and their efficacy in achieving pharmacological effects. Students encountered the quantitative analysis required to relate the way in which drugs may lead to therapeutic or toxic responses. In accomplishing this work, the OLT has been converted from merely gathering information into a more challenging exercise. To meet the goal of having to produce a document that relates all the underlying principles of pharmacology to the way in which medicinal drugs are used, students are required to apply newly acquired knowledge to formulate their own opinions on unfamiliar classes of drugs. In this way students are guided towards the qualitative phases of relational and maybe even extended abstract thinking of Biggs' SOLO taxonomy (Biggs, 2004 p48). Further to this, since student responses to the 'webquest' are expected to come in the form of reasoned written descriptions, this will encourage students to transform declarative knowledge to functioning knowledge, underpinning the qualitative stages of learning.

Conclusion

This OLT has been designed to create a student-centred on-line learning environment that is constructively aligned (Biggs, 2002) with the learning outcomes of the module. By setting a series of progressive targets within this task, starting simply and increasing in complexity, it is envisaged that the work being set was something that could be approached by all students on the module. By integrating an OLT with face-to-face activities, students engaged more fully with e-learning within a blended learning environment. As a result e-learning can be used effectively as a method for stimulating the acquisition and transformation of knowledge by students. The results from this OLT were positive, suggesting that this form of e-learning can be used as an integral support tool within a blended learning environment.

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[P2] Piloting forum activities into a nutrition and fitness module to support and enhance learning

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Keywords: virtual learning environment (VLE), forum, technology-supported learning (TSL)

Background

To support the learning process of level two undergraduates in a nutrition-based module, the teaching team employed VLE forum activities relevant to the lecture topics. This study incorporates a 2006 cohort of learners who were unable to commit to lecture attendance and an ongoing 2007 group with frequent class attendance.

The E-learning scene

E-learning provides a strategy to widen participation, facilitate learning, enable logistical and sequential flexibility, increase enjoyment, improve communication and equip the learner with skills relevant for professional practice (DfES, 2003; Challis *et al*, 2003; Oblinger and Hawkins, 2005).

It has been proposed that discussion and sharing of experiences are considered two of the most effectual modes for adult learning (Brookfield, 1990; Brown and Duguid, 2000). This is particularly effective when applied contextually to a subject area that requires critical thinking hence incorporating Schon's (1983) ideas of restructuring 'what we believe, know and do'. With these ideas in mind, we utilised the university VLE forum and designed a setting with consideration of Salmon's (2002) vital features for online activities:

- 'spark' or stimulus
- an activity for individual participation
- interactivity such as response to another's post
- feedback from the moderator
- all necessary instruction to take part (Muirhead, 2002)

The 2006 pilot group explored the implementation of a carefully scaffolded forum into a conventional module to alleviate feelings of module detachment associated with distance

	Excellent	Good	Satisfactory	Poor
Usefulness of the forum	100	0	0	0
Ease of use	33	66	0	0
Support to learning process	20	80	0	0
Usefulness of interaction with peers	33	66	0	0

Table 1: the evaluation of the forum by distance learners (expressed as a percentage of 6 learners)

learning. Owing to the success of the pilot, we have felt it impelling to employ the forum in the current year's group of full-time attendees.

Outcomes for 2006 group: the distance learners

For the 2006 group, forum activities were posted on a weekly basis (relevant to the content of the week's lectures) over a period of nine weeks. The forum tasks were discontinued after seven days and tutor feedback was provided along with the subsequent task.

The outcomes of the study were evaluated by the quality of the forum posts, the weekly progress of interactivity and discussion, and the content of student feedback via e-mail and questionnaire (**table 1**).

100% of the distance learners expressed a benefit from shared knowledge and collaborative learning. The study also supported Schon's theories of learning since the learners agreed to their use of reflective skills and of how their thoughts/ideas had been restructured by virtue of the forum debate. The quality of the posts demonstrated knowledge construction, application of Higher Order Thinking Skills (HOTS) and personable changes within the learner. The distance learners also provided qualitative feedback such as '*I am finding the work really constructive and interesting*' and by the close of the module 80% conveyed an interest in using forum activities in future modules.

Preliminary results for 2007 group: week 4 of module

With regards to the preliminary results of our ongoing forum study, levels of participation have increased from 50% in week 1 (which accounts for latecomers and a 'settling-in' period) to 56% in week 3. When comparing the responses of the 2006 and 2007 groups, it is evident that 100% of the distance learners rate the usefulness of the forum as excellent (**table 1**) where as at the early stages of forum use in 2007, only 17% of the

	Excellent	Good	Satisfactory	Poor
Usefulness of the forum	17	58	17	0
Ease of use	45	36	9	9
Support to learning process	27	55	18	0
Usefulness of interaction with peers	20	30	40	10

Table 2: the evaluation of the forum by full attendance learners (expressed as a percentage of 16 learners)

group consider the usefulness as excellent with 58% opting for good (**table 2**). Overall findings demonstrate that the distance learners selected only the categories excellent and good for all comments and full attendees distributed their responses in all four of the categories.

Feedback taken at week 4 in the module also informs us that nearly 63% of the 2007 group feel that they would be more likely to participate in the forum if they were undertaking a distance learning programme yet a significant 85% of the group assented to an interest in using forum activities in other modules.

Quality of forum debates

By collaborating with peers in a supported virtual learning environment, the learner has the benefit of collective critical reflections, an outcome that would be difficult to achieve without the use of a discussion-based activity (Naidu and Oliver, 1996). E-learning proffers an alternative learning route in constructivism, by allowing students to reflect on experience and undergo the resulting cognitive processing. The forum activities instigated the learner actively constructing new knowledge via perspectives, context given and peer interaction (Vygotsky, 1978 in Oliver and Herrington, 2003). By observing both the quality of the posts and responses provided, there was apparent active and constructive processing and it certainly seemed that learning was taking place.

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[P3] Creating questions for learning

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This poster was not submitted in time for inclusion in the Proceedings.

[P4] Multimedia tools and their accessibility

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Keywords: accessibility, multimedia, user testing, audio, e-learning resources

A wide range of tools that enable instructors to add a variety of different digital media to their presentations such as audio and animation to produce multimedia resources are now available. Given the dangers of simply 'putting notes on the web' (Evans *et al*. 2004) and the shallow use of virtual learning environments by many academics (Badge *et al*. 2005), promotion of tools to provide a fast introduction to creating multimedia resources is to be welcomed. Multimedia can itself become an assistive technology simply by providing alternative formats such as audio, diagrams and images to long sections of unbroken text that can be inaccessible to users with learning disabilities or other disadvantaged groups such as those with English as a second language (Sloan *et al*. 2006). Successful teaching of biological sciences encompasses the use of good illustrations, three dimensional representations, research images and other visual media which lends itself to a multimedia presentation. The University of Leicester recently offered the use of two tools, which transform PowerPoint presentations into online resources, Adobe Presenter (formerly Macromedia Breeze **http://www.adobe.com/products/presenter/**) and Impatica (**http://www. impatica.com/imp4ppt/**). A third widely used tool for presentation of rich media online, is Adobe Macromedia Flash (**http://www.adobe.com/products/flash/flashpro/**).

This pilot project aimed to evaluate and compare these three products in terms of the possible benefits for a small test group of biological sciences students with registered accessibility issues by employing usability testing. The subjects tested comprised two groups of ten students. The first group of volunteers were students with disabilities including dyslexia, hearing and visual impairments and the second group was a matched set of volunteers by gender, course and year of study. PowerPoint materials were transformed into Macromedia Flash, Adobe Presenter and Impatica resources with animation and audio narrative. Our findings show that there were statistically significant differences between the two groups tested in their use control of and interaction with the resources.

Acknowledgements

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[P5] Can you repeat that last bit, please? Using talking books to support student learning in science

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Keywords: accessibility, student support

Accessibility is no longer an issue solely for students with additional learning needs: diversity of learning styles requires a diversity of delivery options to enable students to take ownership of their learning and to access materials in the way which suits their needs and preferences.

Our exploratory work with 'DAISY[1] Talking Books' suggested these could be a useful adjunct to traditional delivery methods and an initial trial was instituted on a Level 2 year long Biomedical Science module – *Integrated Physiology and Metabolism.*

This is a team taught module presented as a series of cognate themes supported by various resources. A group of volunteers were recruited to use a 'talking book' version of the section in the prescribed textbook[2] dealing with the '*Renal Section*' of the module.

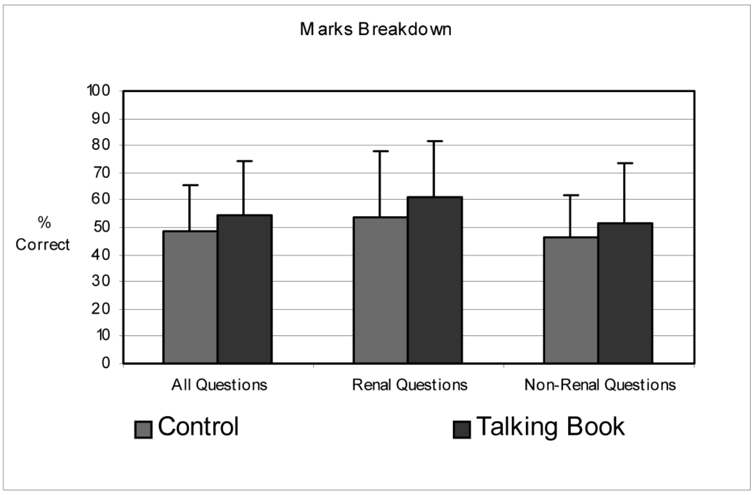
Electronic files of the text and graphics were provided by the publisher and were converted to 'Daisy talking book format. The 'talking chapter' was burnt to a CD together with a restricted version of the reader software[3]; the students were given a copy of this CD with a single sheet of installation and running instructions and left to install the book on their home computers.

Reader screen View	Bookmark screen view	Search screen view

The principal feature of the reader is the 'preferences' capability which enables students to set their background colour, font size and style and other parameters, and where synchronisation of audio and text highlighting is maintained if the viewing speed is either slowed or speeded up. This option permits users to select a pace which suits their preference or needs. Other options set the play back features, for example 'remember last book position' and the play back speed. Sections or sentences can be 'bookmarked' for subsequent review or revision whilst the search feature permits the locating of particular words or phrases.

At the end of the trial period the participants completed a simple questionnaire on their experiences with the book and the software, and subsequently undertook the standard assessment with the non participating group. The results of the participants were compared with those of the control group both in terms of the section supported by the project as well as the remaining standard delivered sections.

Participants who completed questionnaires expressed positive views as to the utility of the system and expressed a desire to have other materials in ‘talking book’ form but as an addition to and not as a replacement for a traditional text book.



The chart demonstrates that the talking book users scored better in the ‘renal questions’ than the non-user group. They also scored better in the non renal questions section but not to the same extent.

These preliminary results suggest that ‘talking books’ may provide another option in meeting the personal learning styles of some users and may serve to support reinforcement and will be the basis for a repeat of this exercise with another student cohort.

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[1]DAISY (Digital Accessible Information System) Consortium format is a recognised international standard which was created in 1996. **www.daisy.org**

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[3]EasyReader – Dolphin Computer Access Ltd **http://www.yourdolphin.com/dolphin.asp**

[P6] Maintaining quality feedback in the face of increasing student numbers

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Keywords: feedback to students, peer assessment, self assessment, tutor assessment, formative assessment

Introduction

This study sought to use new and more effective methods of formative feedback to students within the context of Chemistry teaching in order to facilitate student learning. Emphasis was placed on the use of student directed assessment, and in particular, the use of student self- and peer-assessment. During semester 2 of the 2005-06 academic year, a cohort of some 100 Chemistry students and 33 Natural Sciences students attended a series of problem-based workshops designed to test self- and peer- assessment methods.

The number of students in Higher Education in the UK has greatly increased over the last decade. The present government has set a target to continue this growth, requiring a further 17,000 lecturers to be employed by the year 2010 to teach the extra students (Ratchford, 2006). In the current academic context, it is widely accepted that feedback is an essential component in the process of learning and in a student's development (Weaver, 2006). Although in the recent past it has not always been seen this way (Fritz 2000). Unfortunately, despite the best efforts to retain a level of consistency in the quality and amount of feedback given to students, recent surveys carried out on students have highlighted their dissatisfaction with the feedback they receive.

The National Student Survey in 2005 provided a snapshot of one year within the Higher Education sector. The Survey showed that whilst most students were overwhelmingly satisfied with the quality of courses, there was a general dissatisfaction in many Higher Education institutions with the provision of assessment and feedback. Responses to the 'Assessment and Feedback' section of the survey gave 86 out of 128 (67%) participating institutions their lowest score. At the University of Bath, dissatisfaction with feedback amongst students was highlighted by the Student Satisfaction Survey in 2003. A suggested cause of the problem was the increasing student-staff ratio, which has resulted in the decline of feedback to students (Macaskill, 2006).

Method

The students were divided into four independent teaching groups for their workshops, which were timetabled across consecutive weeks; this allowed for consistency in the investigation. These timetabled workshops placed emphasis on improving skills in drawing reaction mechanisms, rather than the frequent format of using knowledge from lectures to answer problems. This in turn made the workshops ideal to investigate both the students' reactions to different methods of feedback.

Two problem papers were designed, the questions on the first paper sought to guide the students through practice in drawing reaction mechanisms with the aim to help them to practise these important skills. It was also essential to allow enough time during the workshop for assessment and feedback to the students and also feedback to be received from the students about the process undertaken.

Four groups of students containing roughly equal numbers (~35) took part in the investigation (three groups of Chemistry students and one group of Natural Sciences students); they each had a different form of assessment method as follows: Group 1 – Peer assessment workshop; Group 2 – Control workshop; Group 3 – Tutor assessed workshop; Group 4 – (Natural Sciences students) – Self assessed workshop.

The control workshop was included for comparison. This was run as a 'normal' workshop in that, as in general departmental workshops, it did not involve any aspect of feedback other than a tutor being available to answer questions, and to go over general group problems on the board.

The Tutor-assessed workshop was given so that comparisons could be made between the groups of the level of satisfaction with the feedback they received. The students received feedback on their answer sheets from the tutor, which they received a week later. This allowed us to investigate how much the students valued a fast feedback response, as received by groups 1 and 4.

Discussion

Tutor comments were not preferred to self or peer-assessment by the students. A perhaps surprising finding from the data collected was that students overwhelmingly felt that they would not like to have a tutor annotate their work individually. This was especially clear for several reasons:

The observed reaction of the students in the tutor-assessed workshop could have been due to the fact that they had to hand in their worksheets at the end. Those students who had not completed the work would be reluctant to hand it in.

All students in the Self and Peer Assessment workshops agreed that they would not like to have a tutor mark their work, but would instead prefer receiving an answer sheet and marking their own work. The students marked the worksheets during the workshop, which meant that they also received fast feedback from the peer and self assessment mechanisms.

Another reason could be that the thought of handing work in to be commented on unsettled the students, as there seemed to be a belief that tutors will think less of them if they did not do well. This perception concerning the tutor-assessed workshop may be linked to the 'fear of failing' as described by Stiggins (1999), who goes on to say that '*the trick is to help students understand that failure holds the seeds of later success*.'

The tutor's feedback in these tutorials was generally in the form of a verbal feedback with no peer assessment involved. Self-assessment may have occurred, but this would have been at the discretion of the individual tutors and the way that they chose to run their feedback tutorials. The interview analysis with our students indicated that they would rate tutor feedback very highly. When probed further, it seemed that there is a difference in the minds of the students between having annotated comments from a tutor and having face-to-face feedback with a tutor. Students claim they would prefer to have either feedback from a peer or the opportunity to go through their own work with a view to self critique and learn from their mistakes, rather than receive written feedback on their work from a tutor.

Thus the ranking in order of preference for written feedback from the results seems to be *Peer Assessment, followed by Self Assessment, followed by Tutor Assessment*. This observation is largely based on how the students would like the procedure to run in future workshops. This is a very interesting result as it suggests that there is great value in exploring peer- and self-assessment as a method of feedback to students and in doing so to move away from the more conventional use of tutor written feedback.

Conclusion

The study of peer- and self-assessment workshops has shown convincingly that students valued this fast feedback approach and that they appreciated the quality of feedback received from their peers or from the self assessment exercise. Interestingly, the study also revealed that students viewed feedback from peer- and self-assessment more favourably than tutor feedback. Thus the dual aim of giving quality feedback to students, but without adding more time pressures on to tutors was achieved. This will lead to greater enhancement of feedback mechanisms within the programmes of study offered by the Department of Chemistry at the University of Bath.

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[P7] Examining possible links between student perceptions, expectations and their final grades

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Keywords: action research, expectations, grades, perceptions, self-assessment

Introduction

In discussing student success, emphasis is often placed on facilities, teacher skills, teacher expectations, student abilities and curriculum issues but not much effort is directed toward student perceptions and expectations. This action research attempted to investigate some of the perceptions and expectations of a select group of students in order to aid the understanding of their views of facilities, mentor/facilitator support and expectations and perceptions of themselves which might be influencing their performance and final grade. The project arose out of listening to students voicing varied perceptions, and expectations from their university programmes during tutorials.

Method

Questionnaires were used to collect data from student volunteers of two second year biology courses for one term only. The questionnaires were completed early in the term to get participants' perceptions before there were opportunities to be influenced by factors such as lecturer feedback. Data was collected after two weeks into the course.

Assistance was obtained to help with maintaining anonymity in matching grades with questionnaires of participants. Discussions were held with colleagues regarding the validity, effectiveness and sensitivity of the items in the questionnaire to be used. In this type of research it is difficult to exclude the perceptions, beliefs and values of the researcher; however, it is possible with collaborative effort to achieve the collection of useful material (Beach *et al*., 2006).

Questions provided information on programmes being studied, expected qualifications, reasons for taking the course, expected grades, participants' view of some facilities necessary for their course, mentor/facilitator support and participants' self assessment of their effort, ability and enthusiasm. There was a free response section used to determine whether the participant appeared to be an active or passive learner. This assessment was based on a brief statement, if any, given by the participant and thus the determination would be influenced by the subjectivity of the researcher.

Results and Evaluation

The total number of participants in the survey was twenty-five. Seventy two percent participated in the matching of grades with perception. Just over half of the participants

(52%) indicated that they were taking their course for general interest or self improvement. 64% of participants said that their effort in the course was good to excellent whilst 36% rated their effort as only satisfactory to poor. 60% rated their enthusiasm as good to excellent whilst 40% rated their enthusiasm as satisfactory to poor. When self assessment was compared with grades, 64% rated their effort as A/B, 72% rated their ability as A/B, 60% rated their enthusiasm as A/B, however 80% expected to achieve grades of A/B. The actual A/B grades were 44% (there were 40% non participants). When views of mentor/facilitator and lecturer support were compared with grades, 36% rated their mentor support as A/B, 72% rated the approachability of the lecturer and the lecturer's interest in their learning as A/B.

Discussion

The results may be considered only one loop of the spiral of reflective action research, with more questions arising and ideas for further investigations. It was difficult to assess how closely the actual grades linked with effort and enthusiasm as not everyone participated in the grade comparison. When only A grades were considered, the factor which matched closest with expected grades (12%) was effort (12%), but matching closest with actual grades (28%) was views on enthusiasm (16%) and approachability of the lecturer (24%). It was also interesting to note that 8% of participants rated their effort as D and there were 8% of actual D grades although no one had put an expected grade of D. The overall view of facilities rated as A/B was 48%, actual grades matched closely with this by giving results of 44% of participants achieving grades A/B. This is not precise, however, as there were 40% non participants. Further investigations of mentor/facilitator support could examine what scaffolding participants expected of their mentors to improve their views of the support to aid success. A question which emerged was - are students relying to some extent on lecturer approachability and interest in their learning as a measure of how well they will perform whilst underestimating the importance of effort and enthusiasm?

Based on their free response participants were divided into types of learners. Only 24% appear to be active learners whereas 56% were assessed to be passive. 20% gave no response and were also categorized as passive, giving a total of 76% passive learners. The active learner is more likely to engage in the exploratory nature of learning (Rowland, 2000) which is a fundamental part of studying scientific subjects. Hypothetical deductive thinking patterns (Lawson, 1995) continue to develop when students actively seek explanations for occurrences. Active learners, instead of just passively hoping to 'gain knowledge' will want to search for 'new experience from the practicals' or 'broaden . . . course' by in-depth research. Active learners who engage in hypothetical deductive thinking are usually more conscious and critical of their own thinking patterns (Lawson, 1995) and will want to investigate the validity of their own conclusions.

Conclusion

There appear to be some trends towards links between perceptions, expectations and achievements, however, much more research and analyses need to be carried out. It is difficult to make inferences with this limited data; however the enquiry has revealed students' willingness to share their perceptions and expectations. This also taps into the broader debate as to what students ascribe their successes and failures.

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[P8] Student-centred problem-based group exercises in molecular biology

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Keywords: molecular biology, problem-based learning, blended learning, experimental design

One challenge when teaching molecular biology is to effectively link the theoretical and practical aspects so that students can gain the skills of experimental design. In these exercises, students work together in groups to design an experimental strategy to solve a particular problem. They work independently from the tutor, who undertakes the role of facilitator for several groups at the same time. Sessions have been run with one tutor facilitating up to eight groups of eight students. This is an added benefit of the exercises; small group teaching in large groups! Students are given a 'real' problem to solve which relates the application of practical techniques to actual situations encountered in industry, medicine or academic science.

Examples include:

> *'How would you use recombinant DNA techniques to produce therapeutic quantities of a medically important protein?'*
>
> *'How would you develop a test to be used in genetic screening for a single gene disorder'*
>
> *'How would you clone a gene involved in the control of the eukaryotic cell cycle'*

Students are presented with an extensive set of researched options at each stage in the experimental design. The sets of researched options are presented as packs of cards. Some of the cards are decision-making and some provide information. Right and wrong decisions can be taken and there is more than one solution to the problem. At the end of the sessions the groups present their final strategies to each other and the tutor facilitates discussions about the approaches chosen. Therefore these exercises not only give students an opportunity to develop their awareness of practical molecular genetics, but also develop interpersonal, analytical and presentation skills. This approach has been used and adapted for all levels of undergraduate and taught postgraduate programmes as well as Adult Education short courses.

In questionnaire feedback both students and staff seemed to enjoy the exercise *'I found the tutorial really helpful. For the first time I really understand gene cloning'* (2nd year Medical Genetics student) *'We need more of these types of sessions'*(student from the MSc in Molecular Genetics programme) *'I had effective small group teaching but with 40 students*' (2nd year module convenor).

In addition to the hard copy packs of cards, we are developing electronic versions which

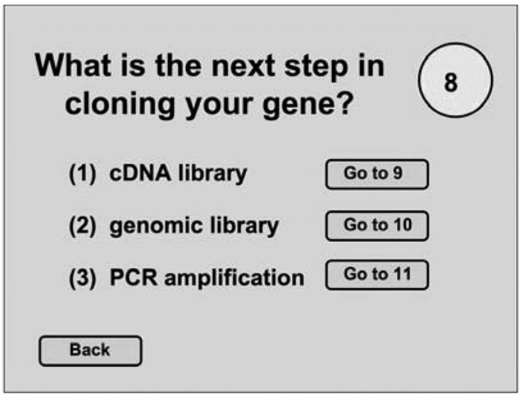

Figure 1: Example of a decision-making card. When students have made their decision they can use the buttons which will give them some brief information before guiding them to the next 'card'.

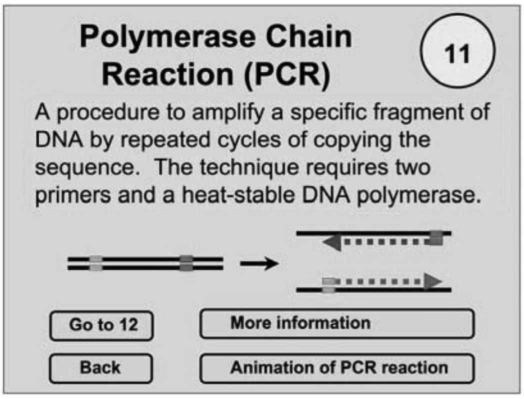

Figure 2: Example of an information card. Taking the example of PCR, in the on-line version there are possibilities for more detailed information or viewing an animation of the reaction before moving to the next 'card'.

enable the students to work on-line through the exercises. Examples of the 'cards' in the electronic versions are shown in **figures 1 and 2**. The on-line versions are good revision aids but can also be used as an alternative approach to presenting the exercises.

We are comparing the effectiveness of the two approaches in improving the students' ability to answer factual questions and to write a short summary of their final experimental strategy. In a pilot study a group of 36 students were split and half the students used the exercises on-line and half worked in groups with the hard copy packs of cards. We gave formative tests to the students before and after carrying out the exercises. On each occasion the students had to answer a series of multiple choice questions and write a brief summary of the experimental design which was marked to set criteria. The students who had worked on-line showed a marked improvement in their scores for the MCQs but little or no improvement in their ability to describe the experimental strategy. The opposite was observed for the students who worked in groups.

The on-line versions do contain more possible options for gaining information and, in interviews with the students, it was interesting to note that more than half the students that were carrying out the exercise on-line had used the internet as a source of information in addition to the information given within the exercise itself. The students using the hard copy versions did not have all of this information available but this approach did seem to be better at helping them to produce a coherent experimental strategy. We are carrying out the same tests with larger cohorts of both biological sciences and medical students to further compare the impact of the two approaches on the student learning experience.

[P9] A learning package to develop and assess employability of bioscience students taking work placements

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Keywords: placement, employability, reflective practice, biomedical sciences

Employability of graduates can be regarded as extending beyond the acquisition of a job to encompass a set of achievements (skills, understandings and personal attributes) which makes graduates more likely to gain and be successful in their employment (Yorke, 2004). A common approach to developing these achievements is the inclusion of work-experience components in higher education courses. These can develop not only specific vocational/professional skills but also the generic or transferable skills valued by employers such as self-confidence, political awareness, communication, team-working and interpersonal skills (Yorke and Knight, 2004). Reflective practice is increasingly recognised as a skill which enhances good quality academic achievements including many of those which underpin employability. This may be of particular value in the professional environment involving complex activities where situations are relatively unpredictable, and reflective practice has become a significant component across a range of professions including teaching and the health professions (Moon, 2004).

Work experience in a NHS pathology laboratory is offered in many BSc Biomedical Sciences courses as a placement year or multiple placement periods throughout the course. This can allow completion of a programme of education and training that provides graduates with eligibility to register as Biomedical Scientist with the Health Professions Council. Assessment of this professional training programme in many courses is by a portfolio which, while containing a strong element of competency attainment, also encourages a range of generic skills including reflection (IBMS). Although this new approach may contain elements unfamiliar to many professional training staff, practitioners are now being encouraged to develop new learning skills, for example in reflective practice (Ajeneye, 2005). We have developed a learning package which is aimed at extending the range of learning and teaching tools which can be used both for academic and professional portfolio learning and assessment. The learning and assessment exercises incorporate reflective practice and include specific outcomes of enhancing academic achievement and employability afforded by the student workplace experience. This has been developed, trialled and evaluated by collaboration between four HEIs offering BSc Biomedical Sciences courses that include appropriate work placements.

The package consists of exercises for level 3/4 students and level 5/6 students; these include an investigation into the relevant career pathway and evaluation of staff perceptions and opinions by arranged interviews with professional staff in the placement laboratory and a structured reflective document based on a ‘SWAIN’ analysis to assess generic employability skills developed by students. The project, funded by the HEA Centre for Bioscience Teaching Development Fund, is being carried out over the academic year 2006-07 and the learning package will be evaluated by student outcomes and questionnaire data from students and placement supervisory staff. As well as providing a larger data set for analysis, this collaboration benefits from the pooled experience from four HE centres of Biomedical Science in the project design, and by the inclusion of a number of workplace settings which can show some variation in the quality of student experience and presentation of unpredictable situations. The reflective document is structured so that the employability skills section can be used for any bioscience subject area while the biomedical science discipline-specific section is adaptable to a range of bioscience-based subjects or disciplines. As part of the evaluation, the views of senior team members for a range of courses with work placements will be sought, with a view to assessing transferability of the learning package across the biosciences.

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[P10] Development and implementation of a policy for delivering effective feedback to students

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Keywords: VLE, assignments, skills, assessment, proforma

Introduction

Provision of timely, high quality feedback on assessments has been identified as supporting student learning (Gibbs and Simpson, 2004; Juwah *et al*, 2004). The National Student Satisfaction Survey of level 3 students, which was conducted in 2005, indicated student feedback as an area which could be improved in clarity and detail of comments and in timeliness. Local surveys of level 2 students at MMU have produced similar findings.

A number of developments within MMU relevant to the teaching of Biology and Chemistry have provided an ideal opportunity to reflect on mechanisms for providing feedback to students. These developments have included the recent formation of the School of Biology, Chemistry and Health Science from the merger of the Departments of Biological Sciences and Chemistry, and the subsequent review of all programmes within the School. In addition, the School has piloted the move of the MMU Virtual Learning Environment (VLE) from WebCT Campus to Blackboard Vista. Currently all modules within the former department of Biological Sciences are delivered within a VLE and this will, next year, apply to all modules across the School. The project reported here is on-going and has been supported by a Departmental Teaching Enhancement grant from the HEA Bioscience.

The aims of the project are to develop, evaluate and embed a School procedure for delivering effective, relevant and high quality feedback on assignments. The objectives are to:

a) survey the extent of use and primary purpose of feedback proformas used within the School;

b) devise, trial and evaluate the use of feedback proformas which are explicitly linked to the learning outcomes of different types of assignments.

c) transmit feedback proformas to the students through the VLE.

d) embed the use of feedback proformas, if deemed successful, within all modules in the School.

Methods

1. A survey of existing proformas/marking schedules has taken place (objective ‘a’.)

2. Academic staff (eleven in total) took part in a structured interview in order to clarify current practice regarding the use of feedback proformas. Questions used are bulleted below:

- Do you use a proforma when marking student assignments?
- What is the primary purpose of the proforma that you use? Is it to make marking easier, more consistent, to provide useful feedback to students on their assignments or to provide evidence for audit purposes?
- Do you provide generic feedback on assignments? If yes, do you use templates
- Do you provide an assignment brief? If yes does this brief make clear to students the learning outcomes of the assignment, the mark allocation, the skills being tested and the link to grade descriptors?
- During the interview staff were also asked to consider what would be their expectations of the learning outcomes for different types of assignment at different levels of the programme.

Results and discussion

More than thirty individual proformas are currently in use within the School of Biology, Chemistry and Health Science at MMU. However, there is considerable overlap between them. There is, therefore, scope for using proforma templates, which can be adapted to suit individual tutor need.

The structured interviews of academic staff showed that, often, assessment proformas are used to make marking easier, more consistent and to provide evidence for audit, though most staff agreed that the primary use of proformas should be to provide useful feedback for students. The survey of the proformas frequently demonstrated that the language of the proformas was not ‘student friendly’ and may, indeed, be confusing. This exercise has raised awareness amongst staff of the need to simplify proformas so that students can readily access their message, rather than simply register a mark.

Staff have identified generic learning outcomes for different assignments at different levels. One example is shown in **Table 1**.

Three modules were selected from each of levels 1, 2 and 3 within the Bioscience undergraduate programmes offered by the School of Biology, Chemistry and Health Science. The modules were selected so as to cover a range of assignments across the programmes. Unit teams have identified a maximum of four learning outcomes that will be assessed in this assignment. Proforma templates have been devised for the different assignments. These proformas will be given to students with the assignment brief so that the learning outcomes and marking schemes are explicit. Since the School has now moved to Blackboard Vista, use will also be made of the Vista Grade tool for designing feedback proformas. Thus, we will build several feedback proformas into the new Vista templates and assess their use. Generic feedback will be given electronically via the VLE.

Assignment	Level 1	Level 2	Level 3
Essay/report	o Structure an essay/report o Search for information from appropriate sources o Report facts in own words o Correct use of bibliography: list references correctly in appropriate format	o Source appropriate information o Use appropriate scientific terminology o Appreciate the value of the scientific integrity of the information o Use in-text referencing o Appropriate use of IT to present information	o Critically appraise information sourced o Give a balanced and reasoned account o Use appropriate texts/sources o Evidence of original and creative thought o Appropriate referencing in-text using a defined style

Table 1: Examples of learning outcomes identified at each level of study for an essay or report

It is hoped that, as the project continues, students will receive more rapid feedback on their assignments, especially if staff confine their feedback to those learning outcomes explicitly stated in the assignment brief and in the proforma.

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[P11] Using problem-based learning to enhance the student experience in sports and exercise biomechanics

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Keywords: constructivism, problem solving, module development, curriculum

Problem-based learning (PBL) has long been used within teaching in Higher Education in a range of subjects as a means to encourage student interaction and independent learning (Savin-Baden, 2003). A PBL approach has several advantages compared to other teaching methods. This is possibly due to the ability to build on previous knowledge, the immediate application of knowledge to construct solutions to specific problems and to the team based learning environment that facilitates student learning and independent thinking (Camp, 1996). However, there has been limited investigation of the impact of PBL on students' learning experience within sports biomechanics and while there is an expectation that PBL can make a difference in students' learning, the reality of these differences has not yet been investigated. The aim of this paper is to outline the development, and student experience of, PBL in a second year undergraduate, biomechanics module within a Sports Science degree.

The impact of PBL on students' learning experience was examined using a single module approach. The module was designed using the McMaster model whereby the students engaged with one problem at a time and met two/three times with the tutor to discuss the problem (Savin-Baden, 2003). The module format was modelled on a successful PBL module in Sports Studies (Duncan and Al-Nakeeb, 2006) and was designed to highlight a series of problems with a particular focus on competencies and issues related to biomechanical testing in sports. Problem scenarios were the central component of the module and other modes of delivery including laboratory practicals and workshops were designed to feed into the problem scenarios at an appropriate time. Two forms of assessment were utilised within the module: a written report and an examination.

Focus group interviews were conducted at the end of the module. The results from these along with end module questionnaires revealed a number of themes within the student experience of PBL. It was quite clear that the students who had taken this module had not experienced the type of delivery involved with PBL. Although many found this a change to begin with, the delivery of the module was perceived to be more enjoyable and effective. The students noted that PBL delivery allowed them more autonomy to explore problems the way they wanted to and develop skills that might be useful later in their course or in employment. For example, student B noted:

> 'Its taught me how to set out my own project and things like structure and how to research and it's a different idea, you are out on your own and you have to do it rather than being in a class and just listening'

A number of students reported that they felt 'more engaged', more 'inquisitive', that the approach allowed 'more freedom to play to our strengths and think about issues'. It was clear from a number of student comments that simply presenting a problem and asking them to resolve it can provide a stimulus for greater critical thinking and independent thought that does not normally occur with traditional didactic delivery. Student G commented:

> 'If you have lectures first you kinda don't know what going on sometimes, you can switch off but having the problems first you sometimes don't know what going on too but then you have to work it out yourself so you have to think more about it and you can't switch off'

Overall, the student experience of this PBL module is positive and no student made negative comments about the module delivery or content. However, the results from the focus group interviews did provide some insight into barriers to learning within the module. The module was delivered over 2 terms (approximately 20 teaching weeks) with a 12 week break in between to accommodate the institution's generic work placement module. This appeared to be a particular barrier within the module and was raised by a number of students. For example: Student H stated:

> 'I feel I learnt a lot of stuff before placement, went on placement, forgot some stuff and then have had to come and pick it up again this term'

These points may be important considerations for future practice within problem-based learning. This particular module was the first module the students had undertaken that used problem-based learning. It may be that on first presentation of PBL, particularly where the initial onus is on the student to investigate an issue, the tutor may need to structure the module into a more compact and cohesive timescale.

In this specific instance, the use of a problem-based learning approach appears to offer advantages in terms of student enjoyment, engagement and development of criticality compared to traditional, lecture led, delivery in Sports Science. However, care may need to be taken in terms of timing of delivery and access to specific resources, particularly with groups who have no experience of problem-based learning.

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[P12] Incorporating formative feed-forward feedback into summative tutor marked assignments and setting targets for student achievement of learning outcomes

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Assessment at the Open University is predominantly summative. However tutor marked assignments (TMAs) also provide the major, and sometimes the sole source of personalised teaching within the University. Previous research has shown that students do not necessarily build on feedback to improve and further develop study skills within the course, and are probably not taking forward acquired skills into future courses. Student perception was that feedback is only related to a specific assignment, and that skills are not particularly transferable between assignments.

The aim of this project was to determine whether formative feedback built into summative TMAs can help tutors provide students with the means to become more effective learners. Students should then be able to improve their skills and take them forward through the current and future courses. By setting targets the tutor should be able to focus the student towards more self-directed learning.

The project involved use of a tick sheet of skills, devised to accommodate the limited time which tutors have available for marking. The sheet focused on the course-wide learning outcomes, and students were assessed as to whether they had 'well demonstrated', 'adequately demonstrated' or 'not adequately demonstrated' each skill. Students were also given a target to meet by the next or a subsequent TMA, and advice as to how that target might be met.

It is hoped that students will benefit from increased awareness of what effective study entails, will have specific support aimed at increasing those skills, and will be able to monitor their own progress. They will have a greater understanding of how they are learning and be better able to recognize that TMAs provide a progression of feed forward support as well as a method of assessment. Tutors will benefit by being able to monitor progress of their students' skills more effectively by checking targets.

[P13] Implementation of new teaching materials for an introductory chemistry course in a further education college

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Keywords: chemistry, applications-led curricula, information processing, further education.

Students at one Further Education (FE) college in Scotland undertake a one year pre university nursing course. As part of successful completion of this course, students are required to complete an 18 week introductory chemistry course. The background knowledge of students entering the course is varied and some may not have any formal chemistry education at all.

It is known that some students may find chemistry difficult to learn, complicated and find the relevance of chemistry problematic. This is especially the case for nursing or non science major students (e.g. Hall and Evans, 2006; Herron, 1975; Mahaffy, 2004).

At the outset, previous groups of students found the incorporation of chemistry in the curriculum as being largely irrelevant when compared with other classes in the curriculum. Various changes were made to the chemistry module in which the applications-led approach (Reid, 2000) and an understanding of the Information Processing Model (Johnstone, 2006) were the key underpinning principles.

In looking at the applications-led approach, a change in direction from the original 'logical' approach was implemented.

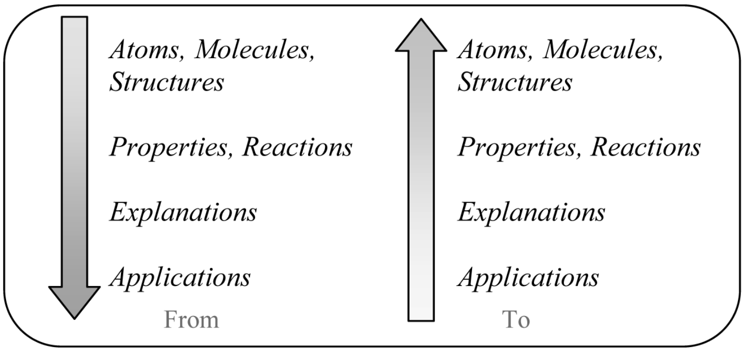

Figure 1: A change of direction

The course content, which was nationally set, was not altered in any way: only the order, presentation and sequencing of materials were changed. The importance and relevance of the material were illustrated, whenever possible, by presenting the chemistry to be taught from real life situations and to previously held knowledge. In this manner, learning chemistry can fit with what we already know about human psychology. By taking account of information processing capacities (illustrated in poster), material was presented in such a manner that reduced the load on the working memory, which is a rate determining step for learning. If the working memory is overloaded, learning (defined as understanding) will more or less cease.

New teaching materials were developed with these features in mind and distributed to a small sample of pre university nursing students. It was hoped to make the new materials accessible, achievable and relevant in the context of the learners.

The effectiveness of the programme was evaluated primarily by interviews with 18 participating students. The learners (mean age 36) were interviewed in two groups of 8 and 10 students. In addition, an informal discussion with the delivering FE lecturer also took place at the end of the course. Questionnaire data was also obtained regarding students views on learning and their intentions of studying more chemistry at university.

Although the sample size was small and no statistical significance can be made, the participating lecturer and students gave universal support to the new materials. The interviews showed very clearly that the students were very positive about the different approach. In addition, it was clear that a positive attitude change to learning chemistry had occurred. Further discussions revealed that it was extremely important that students could see the context of chemistry within nursing studies. Indeed the view was expressed that they would have liked the new materials from the very beginning of the course.

The study indicates key factors influencing the design of introductory chemistry courses and in promoting intentions of studying chemistry at university. By preparing the mind for learning, a positive chemistry experience at the introductory level allows students to view future opportunities to learn chemistry in a more positive light.

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[P14] From principles of science to publishing: a new interactive resource for bioscience undergraduates

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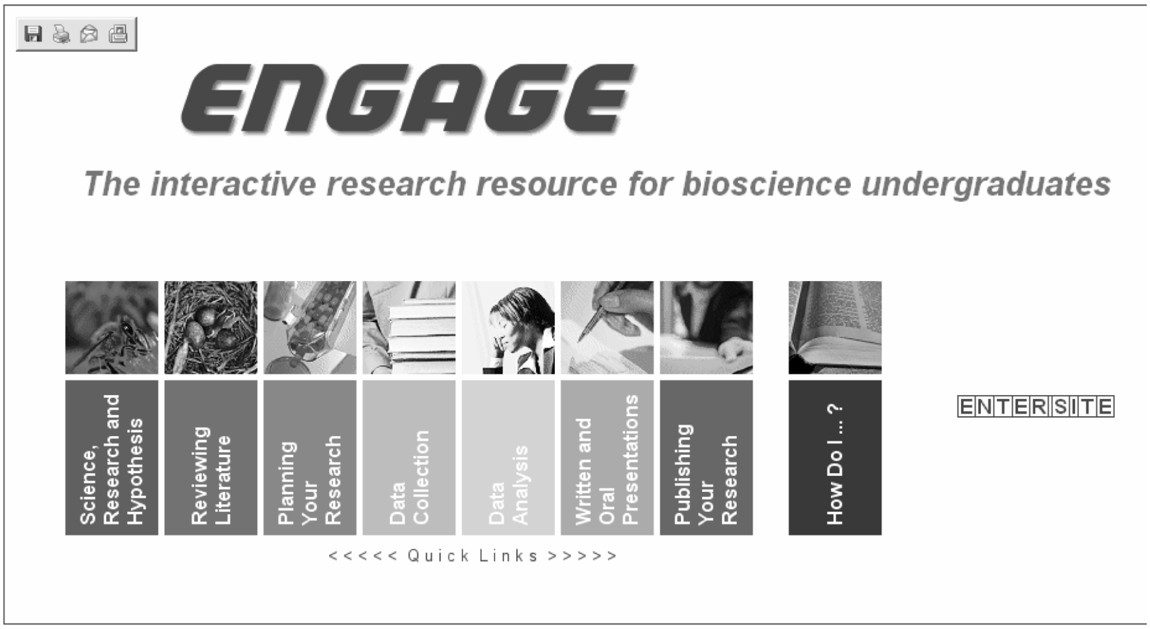
This poster outlines the new 'ENGAGE' research skills website for bioscience undergraduates. The aim of the website is to provide an interactive resource for undergraduate students to support them in their research from first principles through to publication.



ENGAGE has been designed and developed as a resource to encourage active learning through the inclusion of interactive activities. It is envisaged that students will variously use the website for example:

- If they have an interest in scientific research and wish to find out more information about the research process or

- If they need information about a specific topic, for example they may have been asked to write a literature review on a topic and they want to know how to get started.

We anticipate that ENGAGE will primarily be used by undergraduates as an 'external' resource, although we would welcome colleagues to consider embedding it as a resource within their courses/modules, where appropriate.

ENGAGE will provide generic information on a range of topics relevant to undergraduate research in the biosciences, and will include the following sections:

- Getting Started in Science: What is research; what is a research topic/question and how can I develop these; what are hypotheses?

- Reviewing Literature: What is a literature review; where can I find sources of information; how do I reference correctly?

- Planning your Investigation: Is my research experimental, observational or opinion-based?; important aspects of experimental design; essentials of data collection; how to effectively manage your time.

- Step by Step Statistics: Basic statistics (mean, probabilities etc.); testing for differences; testing for relationships; what analysis should I use?

- Writing Scientifically: What's expected of field reports, lab reports and final year projects?; how to write scientifically: how to use scientific language.

- Presenting Science: Where can I present my work?; what should I include in an oral presentation?; dealing with questions from the audience; creating poster presentations; how to survive a viva.

- Going Professional: Can I publish my research?; which journal should I submit my work to?; who decides if my paper gets published?

As well as providing detailed information, each section will contain a series of worked examples, formative exercises with answers and 'quick quizzes' for students to work through at their own pace. We have developed these resources to be used by students as an aid to learning but all materials can also be downloaded by staff to be used as in-class teaching resources.

In addition, undergraduate students and colleagues at Reading have recorded a series of Podcasts, which are embedded within ENGAGE, and which offer advice and 'top tips' to students on a wide range of research-related topics. These range from a member of staff discussing the reliability of information sources, to a final year student, discussing how she chose the research topic and question for her final year dissertation. We also plan to incorporate video footage of undergraduate students engaged in research activities as the website develops.

In addition, ENGAGE also has a 'Quick Tips' section, which provides downloadable (pdf) sheets on topics such as referencing, oral presentations and writing laboratory reports.

ENGAGE will be piloted in mid 2007 by staff and students at the University of Reading, after which time it will be available nationally.

[P15] Design of flyers as a stimulating and non-threatening means of introducing undergraduate students to controversial issues arising in society from bioscience/biotechnology

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Keywords: flyers; controversial issues; bioscience/biotechnology

Introduction

There is currently the expectation that bioscience students are introduced not only to controversial issues raised in society by bioscience and biotechnology (for example, Willmott *et al*., 2005; QAA, 2007), but also varied and innovative forms of assessment that promote development of employability skills, including skills in communication (QAA, 2007; HEA, 2007). At the same time, there is the expectation that students should find such LTA activities stimulating and non-threatening and that assessments should ideally be based on 'real world' situations (Rust, 2002).

In order to match all these desirable LTA attributes with consideration of controversial issues raised in society by bioscience/biotechnology, an exercise has been developed in which students are presented with a proposition related to a relevant controversial issue and are required to design two flyers for distribution to lay persons; one intended to persuade readers to accept the proposition, and another intended to persuade readers to reject the proposition.

The Exercise

The exercise was aimed at two groups of students: i) students in year 2 of the 4-year BSc Biological Sciences full-time course, studying at a level equivalent to the Level 8 in the Scottish system, and ii) students in year 3 of the 4-year interdisciplinary full-time sandwich course, Science with Management Studies, opting to take Biology as a science specialism, and studying at a level equivalent to Level 9 in the Scottish system.

Propositions given to students reflected topics being studied. The topic *Brewers and distillers should be held responsible, wholly or in part, for the social and economic harm caused by alcohol consumption* linked to studies on production of alcoholic beverages (industrial microbiology). The topics *Society needs genetic engineering and Genetic engineering is a good thing for society* linked to studies on gene manipulation (molecular biology).

Assessment and marking criteria set for the exercise were discussed with students at the time they were introduced to the exercise. The criteria used in assessment of flyers were that flyers should be eye-catching, interesting, easy to read, easy to understand and relevant to the proposition and should contain reliable facts and figures. Each criterion was given equal weighting. The exercise contributed approximately 15% to the overall mark for the modules, and equated to approximately 20 hours working time.

Students' evaluation of the exercise

Feedback from students was obtained by questionnaire after the exercise had been completed and students had received their marks and feedback. Students' responses were supportive of the exercise. The majority of respondents considered that the exercise was enjoyable, was challenging, was an interesting way of considering the propositions, did not cause them more anxiety than other continuous assessment exercises, and developed their communication skills. Nearly one third of students considered that the exercise would help them to consider such issues from opposing angles in the future, although the majority of students expressed uncertainty about this.

Students' performance in the exercise

When examined with cohorts of 12-18 students, the exercise resulted in marks from the low 50s to the 80s. With pooled data from several cohorts from both degrees (86 students in total), the mean mark for the exercise was significantly higher than the mean mark for the exam component of the same module (mean for exercise = 64.5 %, mean for formal exam component = 58.4%, $p<0.01$ by t-test).

When examining an individual student's mark in the exercise against their mark in the formal examination component of the same module there was little correlation (correlation coefficient for these data = 0.21), suggesting the exercise did assess different skills from those used in examinations.

Conclusions

The results show that production of flyers can be an interesting and non-threatening way of prompting students to examine from opposing positions a controversial issue arising in society from bioscience/biotechnology, while also developing communication skills. In contrast to use of posters, widely used as a means of developing communication skills, the exercise presented here is designed to stimulate the student into considering controversial issues from opposing positions, and the target group is lay individuals rather than peers and lecturers. Also this exercise actively engages each student in the process of developing opposing arguments, which may not be the case in debates held amongst a group of students. The exercise can be linked to essays, discussions or debates on students' own positions with respect to the proposition, or on the broader scientific, social, economic, ethical and moral issues raised by bioscience in society.

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[P16] Feedback (feedforward) on exams: are specimen answers from previous cohorts useful?

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Keywords: feedback, exams, specimen answers

Introduction

Feedback to students is important to us as it is on the quality enhancement agenda (QAA, 2007) and its quality is generally rated relatively poorly by our students (Mccune and Hounsell, 2005). There is little time in a crowded curriculum to give exams formatively, and giving feedback to students on exams poses logistical problems for us and may come too late for students sitting hour-long essay-type questions for the first time.

The Exercise

This exercise involved two cohorts of students in Hong Kong studying a distance learning programme. The students were direct entrants into the programme at degree stage (Level 9 in the Scottish system), having had little previous experience of the hour-long essay-type questions to be used in their exam. They had previously studied one module in this programme, for which there was no opportunity to give feedback on their exam. In the exercise students were given formative 'feedforward' by provision of specimen exam answers from previous cohorts via WebCT.

After studying a given topic, students were presented with the exam question on the topic from a previous exam, the solution to the question prepared for the External Examiner, and a range of students' answers (excellent to poor) to that question. Students were invited to rank these answers and award a mark to each. Subsequently for each answer I provided the mark awarded to the answer, and a detailed commentary on it with reference to the solution (commenting on both the positive and the negative aspects of the answer, and accuracy, scope and presentation style).

Students' evaluation of the exercise

Feedback from students was obtained using an online questionnaire, answered after the exam but before results were known to the students. The return rate was *ca.* 25%, representing 22 students.

All responding students considered that the exercise was worthwhile, helped them judge the quality of their own answers in the exam, helped them improve their performance in the exam, made them more confident in taking the exam, showed them how to avoid making mistakes when answering questions, helped them work out what they needed to do to produce a good answer, and helped them learn about the topics. All respondents agreed that the exercise should be repeated with subsequent cohorts. The majority (>70%) of respondents considered that the exercise did not take up too much of their time, and that it helped them with revision. 41% of respondents considered that the exercise was as useful as being given feedback on their previous exam would have been, but 45% were undecided about this.

Students' performance in the exercise

Compared to previous cohorts there was no obvious difference in mean mark in the exam or the range of marks, allaying concerns that the exercise might lead to mark inflation or restriction in the range of marks. In all cases pass rates exceeded 97%.

There was no correlation between the mean mark achieved by a student and the number of hits on the relevant WebCT pages (correlation coefficient = 0.249). However, the number of hits on the pages does not necessarily bear any relationship to the time a student spent interacting with the corresponding material. It might be of significance that the one student in the cohorts studied here who failed the exam was one of a small set of students (*ca.* 7% of the total) who failed to open the relevant WebCT pages.

Conclusions

The exercise was judged to be useful for at least a significant proportion of students, and the decision was taken to continue the exercise with future cohorts. The exercise should prove useful to any student entering our programmes without a background in answering the conventional exam questions we use (not only direct entrants at later stages of our programmes but also school leavers entering our programmes at Level 7). Our School is currently considering franchise agreements with universities in and elsewhere, and the exercise seems ideally suited to assist not only the students studying our programmes abroad but also the staff involved in delivering these programmes in judging the quality standards of our exams.

A study by Huxham (2007) showed students preferred personal feedback on exams over model feedback. However, students performed significantly better in exams when exposed to model answers. This suggested that the best approach might be a hybrid one, drawing on the strengths of both kinds of feedback. With the students involved in this study personal feedback on exams was judged not to be practical, and students' perceptions and the study by Huxham (2007) support the use of model answers with these students.

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[P17] Learning styles: is what students say what they do?

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Keywords: learning styles, e-learning, teaching, learning

Context and methods

Over recent years there has been much debate over the practicalities of learning style models, and whether there is a place for such analyses in the Higher Education environment (Reynolds, 1997, Robotham, 1995). Using the VARK© (Fleming, 2005), a learning preference questionnaire, the Centre for Effective Learning in Science (CELS) has conducted a preliminary piece of research to investigate whether learning preferences, as indicated by the VARK analysis, are reflected in student behaviour and approaches to work. The VARK questionnaire is designed to determine whether students prefer to learn using one of, or a combination of, the following modes; visual, aural, read/write or kinesthetic (active). Students who have a combination of learning preferences (eg VK, VARK or RA) are known as multimodal, where as those who have a preference for only one mode are known as having a single mode preference. The VARK questionnaire was selected for use in the study as we were primarily interested in how learners prefer to communicate, both when receiving and giving out information. We also wanted to investigate how their preferences for receiving new information affected their behaviour. As VARK focuses solely on communication preferences, we considered it appropriate for use in this research.

Our pilot study involved the use of an e-learning system, known as the Loreus Trainer, which works using a neural network; key features of this technology include its ability to interact with, and track the progress and commitment of the user. For the purpose of this research, the system was adapted to present information in visual, textual and active formats. The participating students were presented with tutorial material via the system, which logged their behaviour and interactions.

The objective of this study was to determine if students' learning preferences were reflected in their interactions with the e-learning system. We were interested in finding out if students actually approach new concepts and tasks in the ways they say they do.

By allowing students to navigate freely through the material – whilst tracking their movements – we were able to determine if the majority of their time was spent in the format (e.g. visual or textual) that corresponds most closely to their learning preference(s).

Initial findings

Initial analyses indicate there was a higher proportion of students in the group with multimodal preferences than with single mode preferences, this is illustrated in **figure 1**.

The findings also reveal an overall preference for visual information regardless of learning style, as identified by results from the VARK questionnaire. This was true for groups both

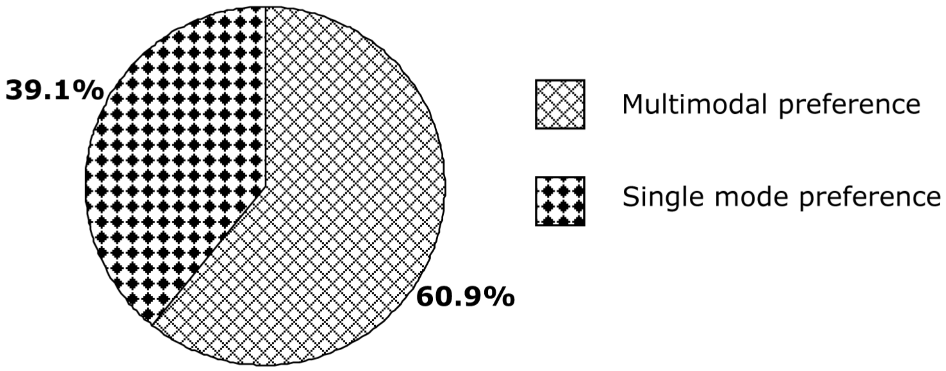

Figure 1: The proportion of students with singular and multimodal learning preferences

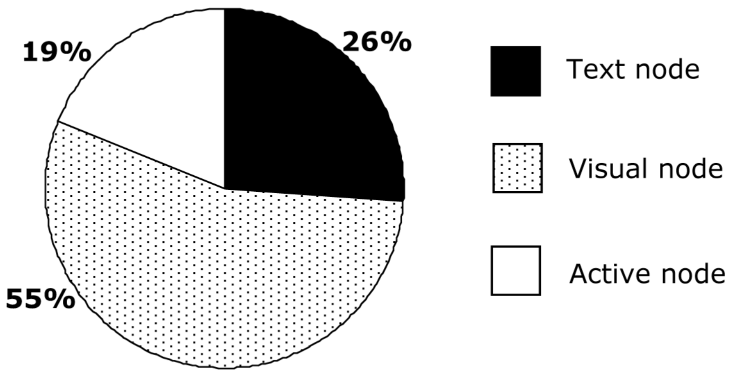

Figure 2: Total time spent in visual, text and active node

with and without visual learning preferences, which may suggest that learners have a preference for visual materials regardless of their learning preference as determined by VARK. The reasons behind students, who do not have the visual mode in their profile, preferring to access visual material rather than any other requires further investigation.

Future work

In future studies, we intend to increase the proportion of material covered in each of the three nodes – as in this study only 10% of the total material on the system was presented in each of the formats described; we are also looking at the possibility of adding auditory nodes.

We also intend to carryout a large scale survey across Nottingham Trent University to investigate if trends in learning styles differ across the schools.

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[P18] Exploring the concepts of challenging and straightforward in undergraduate research

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The research reported in this poster forms part of an ongoing study into the undergraduate final year Honours research project in the School of Biomolecular Sciences at Liverpool John Moores University. It derives from our recent survey of undergraduate students and undergraduate research project supervisors (academic staff) in which the factors influencing students' choice of project were investigated, by using a structured questionnaire[1]. The survey indicated that there was good agreement between staff perceptions of what students were looking for and what students claimed had influenced their project choices, with one main exception. Staff thought that most students wanted a 'straightforward' project, while most students claimed to be seeking a 'challenging' project.

We are currently using a number of different methodological approaches to explore the concepts of challenging and straightforward with respect to the Honours project, in order to explain what this difference means. For example, we have conducted semi-structured, open interviews with a selection of project tutors and project students, all of whom had responded to the questionnaire. In addition, we have surveyed students and staff from another School at LJMU, using a similar questionnaire to that of our previous study. Preliminary results will be reported.

However, to gain a broader perspective, we aim to canvass the views of delegates at this conference through an interactive poster. Accordingly, we will be requesting descriptors and any other comments for the terms 'challenging' and 'straightforward' from readers of this poster. 'Post-it' notes will be available to write definitions and post them on the poster board.

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[P19] NHS funded hospital-based clinical teaching sessions: pharmacy students' perceptions of their educational value and impact on career choice

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Keywords: teacher-practitioner, clinical teaching, hospital, pharmacy, careers

Introduction

Teacher-practitioner led hospital-based teaching has been incorporated in to undergraduate curricula to aid the development of skills such as problem solving, communication, application of knowledge, information retrieval and professionalism (Hanning, Price *et al*. 2002; Shah 2004). The potential advantages of appointing dedicated teams of hospital pharmacy teacher-practitioners include better planning and coordination of teaching and learning activities which are of a higher quality (Hanning, Price *et al*. 2002). Barriers to hospital pharmacy recruitment may be overcome by raising awareness of hospital pharmacy and introducing hospital-based clinical pharmacy teaching in to the undergraduate course (Hatfield, Marriott *et al* 2000; Silverthorn, Price *et al*. 2003). Traditionally, pharmacy undergraduates at Aston University have attended local hospitals within the West Midlands region to gain experience of the various aspects of hospital pharmacy careers and of clinical pharmacy practice. In 2003 the BBCWDD allocated funding for six half-time equivalent teacher-practitioner posts and one full-time lead post at West Midlands hospitals. The team's principal remit was to provide practice-based clinical pharmacy teaching to Aston University pharmacy students and to promote hospital pharmacy careers.

Objective

To evaluate how pharmacy students at one University perceive the effectiveness of the NHS funded hospital pharmacy teacher-practitioner team in their provision of practice-based teaching and the impact of this teaching on hospital pharmacy career aspirations.

Methods

A series of educational objectives relating to the successful attainment of skills, appreciation of the hospital pharmacist's role and relevance of hospital pharmacy to the undergraduate course were formulated. Groups of 4 to 6 students attended a series of three hour sessions. Each incorporated an initial interactive tutorial on a pre-determined topic, a student-led interview with one or more suitable patients, a group review of a selected patient's medical notes and a final plenary discussion. Topics were selected from those which had recently been covered during pharmacology lectures. Students were assessed using a variety of methodologies including the electronic submission of pharmaceutical care plans to their teacher-practitioner, completion of a case study (fourth year undergraduates) and group case presentations (third year undergraduates). Based on the educational objectives, a semi-structured evaluation form incorporating rating scales, tick boxes and open questions was devised. Questions relating to perceived satisfaction and the impact of the visits on career choice were also incorporated. Students were handed an evaluation form at the end of each hospital visit and were asked to complete the form before leaving. Second year students attending an introductory session on hospital pharmacy were not formally evaluated.

Results

During the 2004/2005 academic year 526 evaluation forms were completed by third and fourth year students over 120 teaching sessions. On a three point Likert scale, the majority of respondents believed that the length of the visit (91.1%) and the level of student input required (98.1%) were appropriate. The results of a four-point scale rating students' extent of agreement with a series of pre-determined statements about the session are shown in **Table 1**.

Evaluation statement/objective	% responses for each level of agreement			
	Strongly disagree	Disagree	Quite agree	Strongly agree
Pharmacist led session well	0.8	0	15.5	83.7
Visit was interesting	0.8	2.3	23.6	73.3
Improved confidence with patients	1.9	11.6	50.3	36.2
Improved communication skills	2.9	18.4	51.7	27.0
Improved awareness of multidisciplinary roles	2.7	18.5	49.4	29.4
Enabled visualisation of pharmacist's role	1.5	6.9	42.4	49.2
Enabled application of knowledge	0.4	3.3	36.5	59.8
Enhanced clinical knowledge	0.5	2.7	30.7	66.1
Work covered was easy	4.9	50.9	41.7	2.5

Table 1: Extent of student agreement with a series of statements about the session

On a three-point scale rating whether students viewed hospital pharmacy as a potential career option before and after each visit, the percentage of students who responded 'not at all' reduced from 15.7% to 9.4%. Similarly, the percentage of students who responded 'definitely' increased from 33.3% to 41.8%. The most commonly volunteered reasons related to a higher level of perceived interest, an increased awareness of hospital pharmacy and hospital pharmacist roles, increased clinical application and enhanced patient interaction.

Discussion

The sessions appeared to have generated much interest with the majority of students and were also perceived to be well conducted by the teacher-practitioners involved. The appropriateness of the ‘pitch’ of the sessions was confirmed by the apparent normal distribution of responses around the perceived level of difficulty. Most respondents agreed that the visits had enhanced their practical application and level of clinical knowledge. Students were more likely to disagree that their communication skills, confidence in talking to patients and appreciation of the roles of pharmacists and other health professionals had improved. The team has since restructured the second year visits to focus on developing communication and case notes interpretation skills and has supported these sessions with a series of pre-visit virtual learning environment mediated interactive quizzes. A previous study identified clinical pharmacy teaching programmes and previous work experience as the largest influencing factors on hospital career choices (Silverthorn, Price *et al*. 2003). The qualitative and quantitative data presented appears to confirm the value of teacher-practitioner led hospital-based clinical teaching sessions in contextualising university-based learning and in promoting hospital pharmacy careers. However, because the career evaluation questions were undertaken at the end of each visit and because the data collection tool has not been validated, the results should be viewed with caution.

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[P20] Blended learning redefined: facilitating student learning 'a la carte'

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Keywords: blended learning, learning styles

The findings of a study involving 2nd year UG-students in Biology will be presented during which learners use a 'pick-and-choose' approach to select their assignments from six different coursework options, all in the field of Microbial Genetics. Conceptually this study is based on a broader definition of blended learning taking into account the existence of different learning strategies of students.

An e-learning environment has been created from within which students were asked to choose a minimum of three coursework assignments out of a total of six, permitting free choice. In addition to the original single laboratory-based coursework assignment five non-laboratory based assignments were developed, with two of the new assignments consisting of group work. Calculation of the final coursework mark was based on the average of the best three submitted assignments providing students the opportunity to influence the assessment outcome by undertaking extra assignments to compensate for possible poor performance earlier on.

All source documentation was made available within the Virtual Learning Environment platform WebCT VISTA, as was the students' individual submissions and the provision of feedback.

Take-up of the options available to students was varied as was their performance across the different assignments. There was very little correlation between the popularity of a particular option and the performance of students therein. The workload for marking the various assignments was estimated to be the equivalent of two medium sized essays per student.

The class mean of the overall coursework marks showed a considerable improvement in comparison to the single assessment in previous years; there was also a large reduction in the number of failed coursework marks. Data obtained from an accompanying student survey suggested that students responded positively to the availability of choice and they also appear to engage more actively in their studies.

Some weaknesses of this scheme will be highlighted, and possible ameliorations will be proposed combined with suggestions of how this scheme may be extended to additional subject areas, other student groups and to modules with different credit ratings.

[P21] A national journal for undergraduate research in the biosciences

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Undergraduate research is commonly carried out as part of final year research projects. Some of this research is published in peer reviewed journals, however a considerable amount of high quality undergraduate research remains unpublished. There are good examples of institutional undergraduate journals in the Biosciences, such as Biolog-e[1] and Origin[2]. Following the success of these journals a working consortium met in 2005 to explore the possibility of launching a National Journal for Undergraduate Research in the Biosciences with the broad aim of strengthening teaching-research links within and across Universities.

Following this meeting a survey of Bioscience teaching staff was undertaken in June 2006 to which 63 people responded. A large majority thought the journal was a good idea, although there were some very negative views. Some colleagues were concerned about the actual details of submission and the practicalities of getting the journal up and running. Examples of positive comments included:

> *'This initiative is to be applauded. The opportunity for undergraduates to see their research in print should help to encourage the next generation of scientists, and raise the bar for existing projects.*
>
> *I think such a journal would inspire UG students carrying out their projects and act as a benchmark of quality for UG projects nationwide'*

On the basis of the support received from the survey and with support from Oxford University Press the first pilot on-line edition of the journal will be produced in the academic year 2007/08, the aim being to produce two on-line editions in the year with approximately 10 articles in each. The objectives of the journal are:

- To promote the link between teaching and research in Higher Education
- To provide a repository of high quality undergraduate research which will be useful to other students and staff
- To provide a forum for students, their supervisors and Universities, to showcase high quality undergraduate research work
- To illustrate the student skill base to prospective employers.

The journal editorial board, comprising representatives from a consortium of universities, is seeking contributions from Bioscience departments during the summer of 2007.

Departments will be encouraged to submit papers reflecting high quality assessed student research for inclusion in the journal. Submission must be approved by Departments in which undergraduates are studying (have studied), and the journal will not accept submissions directly from students without written approval from their Department. Detailed guidelines for authors will be available at the SLTC but is envisaged that Departments will effectively provide the first stage of the peer review process by submitting only high quality articles from assessed work. It is envisaged that the majority of submissions will be based on final year research projects, but that these will have been re-written by the student (with guidance from their supervisors) into concise research papers of no more that 3000 words (or 5 typeset pages). On receipt of submissions the journal editorial board will send suitable articles out for review prior to acceptance (or not) and publication.

The consortium recognise that there are still many issues to be resolved before the Journal becomes a reality but this pilot project with OUP will provide clear guidance as to whether a National Journal for Undergraduate Research in Biosciences is a sustainable proposition.

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[1]**http://www.biolog-e.leeds.ac.uk/**
[2]**http://www.chester.ac.uk/origin/**

[P22] Embedding ethics into the undergraduate and postgraduate curricula in biological sciences

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Introduction

Biological Sciences cover an enormous range of disciplines, many of which incorporate sensitive and contentious areas which have major ethical implications. Indeed, the Biosciences benchmark statement requires students '*to be confronted by some of the scientific, moral and ethical questions raised by their study discipline, to consider viewpoints other than their own, and to engage in critical assessment and intellectual argument*' (QAA, 2002). The provision of training in ethics is also a key requirement of the Research Councils'/AHRB joint statement on skills training for postgraduate students (Research Councils, 2001).

Whilst we provide some ethics teaching within individual undergraduate and postgraduate degree programmes offered by the Faculty of Biological Sciences, University of Leeds, it is not available to all students, nor is it provided in an integrated way. The award of a Centre for Excellence in Teaching and Learning in Interdisciplinary Ethics (IDEA CETL) to the University has provided a unique opportunity for biological scientists and ethicists grounded in philosophy to work in partnership to address this problem.

Our aim is to provide a comprehensive and progressive training in ethics throughout individual degree programmes within the Faculty, covering both discipline-specific issues and also generic issues that are applicable to all biological scientists. Given that the framework within which each graduate can make their own ethical decisions is often not presented to students, and the range and variety of values which underpin these decisions are not made explicit, we seek to remedy this situation. In addition, many biological sciences graduates take jobs outside the discipline and therefore we wish to equip our graduates with the ability to think through ethical issues which they may encounter in future employment, regardless of career chosen. In developing this new provision, we see no purpose in replicating case studies or teaching material in areas where these already existed, but would produce subject-specific materials in areas where these are not available in order to fulfil our objectives.

Implementation of new provision

A position audit of current provision and how individual module leaders and programme managers wished to develop ethics teaching within their respective modules and programmes was undertaken. Student opinion was also sought. As a result of these audits, the decision was taken to embed any new provision for Level 1 and 2 undergraduate students within existing professional skills, tutorial or practical modules rather than to develop specialist, 'stand alone' ethics modules for each programme/level. However, an optional ethics module would be developed for those Level 3 students who were interested in ethics and ethical issues and who wished to be provided with further training in this area. This process of the development and subsequent implementation of new ethics teaching and training throughout all of our undergraduate programmes has been greatly facilitated by the planned restructuring by the Faculty (2007/2008) of the curricula of all of these programmes. At postgraduate level, new provision would be imbedded into existing skills modules and training courses/workshops for taught masters and research students respectively. All of this new ethics provision will be delivered using predominantly case studies or role play, supplemented by the occasional lecture where appropriate.

For undergraduates, we aim to introduce students to ethics and ethical thinking at Level 1, with topics covering three non-discipline specific issues (*Life skills, Teamwork, Plagiarism*) and a discipline-specific issue which requires limited subject-specific knowledge (e.g. Drugs in the third world). In 2006-2207, one or more of these topics has been piloted in all degree programmes within the Faculty. At level 2, we wish to provide additional training in generic issues (e.g. *ownership and confidentiality; scientific integrity*), these topics designed to provide specific training prior to students undertaking research projects at Level 3. In addition, all students will be provided with discipline specific training relevant to their individual programmes. Thus, all students who use animals or animal tissue in the course of their studies will attend a seminar on '*the use of animals in scientific research*' whilst those who undertake studies involving humans will be provided with training in '*the use of human subjects and the principles of informed consent*'. Both of these seminars cover the relevant law and wider ethical implications of such studies. In 2006-2007, the '*animal studies*' seminar has been incorporated into all relevant degrees programmes, the '*informed consent*' lecture and seminar has been piloted in the BSc Physiology degree programme. We have also introduced a specialist level 3 module (BMSC3226 Ethical Issues in Biomedical Sciences) for students registered on the biomedical sciences group of programmes, this module covering topics relevant to these students e.g. '*Reproductive medicine*'; '*Organ transplantation*'. In 2007-2208, the range of topics will be expanded to encompass ethical issues spanning across the Biological sciences therefore making it suitable for all level 3 students across the Faculty.

Similarly, we wish to provide training in both generic and discipline specific issues for both our taught and research postgraduate students. Thus, in 2006-2007, all postgraduate students attended seminars on '*plagiarism*' and '*avoiding misconduct in biosciences research'*, an additional seminar on '*values in research: ethical issues concerning ownership*' was also provided for research students. The latter students also received discipline-specific training relevant to their research project e.g. '*the use of animals in scientific research*' or '*human subjects and the principles of informed consent*'. This discipline-specific provision will be incorporated into taught masters courses in 2007-2008.

Feedback from students and staff

After delivery of each new 'block' of ethics provision to individual programmes or levels, we have sought feedback from both staff and students. Feedback has been extremely positive, both with regard to methods of delivery and content. In additional, individual teaching sessions have increased student awareness of specific ethical issues, provided essential knowledge (e.g. current legislative or ethical requirements) and removed popular misconceptions (e.g. regarding the use of animals in scientific research). We will incorporate this feedback into the development and expansion of provision for the next academic year.

Acknowledgements

The authors wish to acknowledge the contributions made by the other members of the Biological Sciences Ethics Theme Team.

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Interdisciplinary Ethics Applied Centre of Excellence in Teaching and learning (IDEA CETL). **http://www.idea.leeds.ac.uk**

[P23] Establishing an undergraduate research journal: staff perceptions and pitfalls

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Undergraduates often do significant research work, as part of final year projects or dissertations. We consider this research to have intrinsic value and intellectual importance, to the student, to his/her supervisor and department and to the wider academic community. In most cases, it remains unpublished and unexploited. We have therefore sought to establish an appropriate and effective means for its publication.

Our goal was to establish a vehicle for the publication of the best u/g research work performed each year in our School. All our students carry out a final year research project. They produce a dissertation which is the product of a full year's exposure to a significant intellectual problem, involving considerable amounts of practical or theoretical work. Students work closely with a member of academic or research staff, often contributing to the efforts of a research team. Very occasionally, this work is published by traditional routes or has direct practical application, but in most cases even the best research receives no external exposure.

We were aware of two u/g research journals produced by UK bioscience departments (*Origin*, a paper-based publication by University College Chester; *Biolog-e*, an on-line journal at the University of Leeds) and of several examples in the US (covering a variety of disciplines). However, we could find no standard approach, nor any significant discussion of the difficulties which might attend such a venture.

We set out to establish an on-line publication, with the following aims: 1) to promote our School's u/g research, 2) to expose students to the disciplines of publication, 3) to provide a marketing tool for widening participation, 4) to enable students to promote themselves to employers. It was evident that to be acceptable to both students and academic colleagues, such a publication would have to be of high intellectual quality and would have to reflect well on the research and educational values of the School. It would also have to depend on minimal input of staff time and effort, and fit appropriately with the tight calendar of the final year of u/g study.

Initial discussions with colleagues elicited considerable support for the venture but also revealed some significant anxieties. Chief amongst these were issues related to prior publication, scientific integrity and intellectual responsibility. Even though direct publication of u/g work is currently rare, colleagues were concerned that this possibility might be pre-empted by publication in an u/g journal, especially where the student had contributed to the work of a group or had assisted in the analysis of data to be made use of later. Some colleagues considered that individual student project work would be too slight to justify full publication and that it would dilute the quality and value of other research being carried out in the School. Others felt that research supervisors would want to be involved in writing and editing submissions, so as to maintain quality and establish proper responsibility, but would be reluctant to devote the necessary time and effort. One colleague feared the elitism that might result from publishing some projects but not others.

Reflecting on these concerns, we identified a fundamental difficulty associated with the term ‘publication’. Whist we had envisaged the creation of a fully citable ‘journal’ with peer-reviewed content and an ISSN, it was evident that the implications of this approach within a research-intensive institution might make it impossible to achieve in practice. On the one hand, staff might be reluctant to recommend work for publication. On the other, editorial constraints and the need for institutional and academic responsibility might create too long a gap between the completion of the work and its eventual appearance in the journal. We felt strongly that to achieve the aims of the venture, student research articles would have to demonstrate immediacy and should properly reflect the efforts of the student authors themselves.

Given these considerations, we have created an online record of undergraduate research, called BURN (**http://www.nottingham.ac.uk/~sbzml/**), which we refer to as a ‘showcase’ rather than a journal. This is in the public domain and represents the University of Nottingham, but it has no ISSN. Staff in our teaching Divisions are asked to nominate students who have done the best research of the year, and they have the option of excluding any whose work might be published elsewhere. The recommended students are invited to submit manuscripts, under single authorship, as soon after the completion of their formal period of study as is practicable. The resulting articles undergo light editing but are not peer-reviewed: the quality and integrity of the published material are assumed on the basis of the rigorous assessment process to which all out u/g research projects and dissertations are exposed. Overall, staff involvement has been minimal and may be reduced even further in future by the use of postgraduate editors.

Response to this venture has been positive both inside and outside the University; we therefore believe that our showcase of u/g research is fulfilling its aims whilst addressing the concerns of colleagues. The showcase is selective but we reject the pejorative term ‘elitist’ on the grounds that it promotes an excellence attainable by all students and contributes to the promotion of u/g research across the School. Our longer term objective remains the achievement of full publication status, but it is not yet clear how this is to be accomplished given the research-intensive nature of the environment in which our students are educated.

Support by the University of Nottingham’s Centre for Integrative Learning (a CETL).

[P24] Creating a departmental web-based resource centre to support the teaching and learning of numerical techniques

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Keywords: biosciences, computer-assisted learning (CAL), numerical techniques, statistics, web-based resource

Introduction

This poster reports on a project designed to improve quantitative skills amongst bioscience students through the creation of a web-based resource centre containing technique specific ‘toolkits’. In the poster we will:

- Report issues raised during the project set up phase;
- Demonstrate the structure and appearance of the resource;
- Present the initial data on use of the resource centre by students and staff.

Problem being addressed

It is being increasingly recognised that many undergraduates in biosciences lack the knowledge and/or confidence to cope with quantitative aspects of their curriculum (Tariq 2004; Tariq *et al* 2005). Ways need to be found to address this problem while minimising the time diverted away from the teaching of biology.

Approach

The approach we are taking is to produce ‘toolkits’ for each technique that are accessible through a central Intranet access point. The resource provides contextual support across the breadth of the bioscience curriculum including behaviour, environment, biomedical and sports science. This context-specific approach is an outgrowth of a first year module on biostatistics run by staff in the Department of Life Sciences at Anglia Ruskin University which has recently been published as a textbook by Oxford University Press (Hawkins 2005).

The main sections of each toolkit are:

- **When to use**: A summary of when it is appropriate to use the technique

- **How to do**: Instructions on how to perform the technique
- **Example data sets**: Datasets explicitly supporting class work and assessment exercises involving the technique
- **More Information**: Links to other sources of information and support such as *Mathtutor* (2005)
- **Learning Check**: Self tests which can be used for formative or summative assessment

The key features of the toolkits are:

- Consistent and familiar environment to promote ease of use
- Emphasis on when and how to do the techniques rather than why they work to promote the idea of maths as a tool for biologists
- Specific subject specific examples to promote motivation to learn
- Explicit links to modules to promote integration of support of statistical and other numerical methodologies into the bioscience curriculum

Additional features include:

- The toolkits can be accessed via either an alphabetical list of techniques or a 'test selector' which helps students choose the appropriate statistical test. For statistical techniques the toolkits contain two options within the '**How to do section**'.

  1) An interactive calculation sheet into which data can be entered directly
  2) A helpsheet providing simply instructions on how to conduct the test using SPSS

Methods and monitoring

Our main activities are:

- Auditing our degree pathways in order to identify the range of numerical techniques requiring support
- Compiling/finding/generating material
- Building the web-based resource
- Monitoring use and effectiveness

Each of the toolkits is built as self-contained sites using XHTML. For the initial assessment, these are contained within a VLE (WebCT 4.1) in order to be able to track student usage. The final product will be wholly web-based. Monitoring will also be achieved through interviews and paper based surveys.

Acknowledgements

This project funded by the HEA Centre for Bioscience Departmental Teaching Enhancement Scheme.

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[P25] Supporting online learning using assistive software: an evaluation of ScreenRuler

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Keywords: assistive software, ScreenRuler, e-learning, dyslexia

Introduction

Assistive software is designed to enable access to a computer interface for people with a range of disabilities. At Newcastle University we currently have a range of assistive software available across the campus computer network but much of this software, such as screen-reading and text magnification packages, is complex and requires significant training before it can be used proficiently.

ScreenRuler, produced by Claro Software[1], is designed to be easy to use and with limited but specific function: an alternative to 'feature-rich' software packages that are too complex for the intended user group (Blenkhorn, 2005). ScreenRuler provides a x2 magnified movable ruler of changeable width across the screen to assist with on-screen reading. Text is only magnified in the vertical plane, increasing vertical mouse movement to traverse the screen, but not introducing additional horizontal movement. This distorts the text slightly but does not reduce readability. The magnified ruler can invert colours and the unmagnified screen above and below can be independently darkened to increase contrast against the ruler. TechDis and the HEA Bioscience Centre purchased five ScreenRuler licences to trial within the Faculty of Medical Sciences at Newcastle University.

The School of Medical Education Development delivers academic IT teaching to undergraduate and postgraduate students within the Faculty of Medical Sciences. Three courses are delivered using online tutorials which involve a lot of on-screen reading but also require interaction between different types of software including Word, Excel and an internet browser.

This trial originally aimed to identify the benefits of using ScreenRuler in conjunction with online tutorials to assist students to read the information in the courses. An investigation into attitudes towards this software and perceived benefits was also conducted, to gauge how successful uptake of this or similar software might be if used in e-learning.

Results and Discussion

The software was installed on one machine in each of the five main clusters within the Faculty building. Students working through online IT tutorials and completing their own work, in particular on-screen reading, were asked to participate in the study. 16 students provided feedback on the software.

Student opinion changed significantly as students became accustomed to viewing the slightly distorted text and moving the mouse to reveal text immediately above and below the magnified area. Most students using ScreenRuler for on-screen reading considered it helpful software; most students completing more varied tasks considered it a hindrance. 66% of students said they would use it again for on-screen reading and only one student considered that not being part of the target audience would discourage them from using the software.

Three key findings are prevalent from this research.

Users require time to adjust to ScreenRuler
The changes that ScreenRuler makes to the screen including the distorted text and hidden surrounding text, plus the additional mouse input required to operate it, require time to adjust to. The software is extremely easy to use and quick to load, but users need to adjust to the changes it enforces on the screen and with the input. This change does not take very long and users should be encouraged to persevere with the software whilst they adjust.

ScreenRuler is extremely beneficial for on-screen reading
On-screen reading is an activity which will increase as it continues to be routine to access journals and other academic work electronically. ScreenRuler is complicated to use for simultaneous activities, especially those that require much interaction with icons or require whole-screen visualisation (such as movies or pictures). However, it has great perceived (and actual) value for on-screen reading and therefore should be promoted on such merit. One student suggested that a 'hot key' to quickly turn the ruler on or off would increase the value of this software as it would enable discretionary use of the software during mixed tasks.

Unfortunately, the nature of the online tutorials delivered to Faculty of Medical Sciences students at Newcastle University negates the use of ScreenRuler because of the constant change of software environment and the switch between on-screen reading and completion of activities.

Being assistive software did not discourage users
It is encouraging that students were not inhibited from using the software if it demonstrated benefit to them, despite not considering themselves part of the target audience. This suggests that other assistive software packages that demonstrate benefits for a variety of disabled and non-disabled users, such as mind-mapping software and read-out-loud programs, may be well-used if promoted as aids to learning, for instance, rather than as assistive software.

Further work

The third finding from this project is worthy of greater investigation under two main areas. Firstly, whether the complexity of the software deters users and therefore whether highly usable software such as ScreenRuler and other Claro software packages would be of greater benefit to students than more complex but similar programs. Secondly, whether the way that software is promoted, either as an aid to learning or as assistive software, affects the uptake and perception of the software thereby leading to a change in software usage.

Conclusion

Software that is easy to use is likely to be used more frequently, and stigma associated with assistive software is likely to decrease if its use becomes more commonplace. Normalising the use of assistive software will improve the working environment for all users and will contribute to improving attitudes towards disability. It also has the potential for facilitating student interaction with electronic materials, thereby supporting the learning and teaching environment.

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[P26] In-course assessment using 'seen' class tests: evaluation of their feedback role and their influence on study patterns

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Keywords: assessment, feedback, engagement

Introduction

Part of the assessment of undergraduate Chemistry courses at Keele University involves the use of a 'seen' Class Test system that forms a component of the assessment of each module at levels 1 and 2. The 'seen' Class Test system (2003) replaced assessed 'assigned' problems, which students attempted in their own time and which suffered from a rather narrow focus on the curriculum, poor student engagement and plagiarism.

The 'seen' Class Test system was therefore originally designed with the aim of increasing student engagement across the breadth of the curriculum whilst seeking to achieve a more uniform distribution of student effort throughout the semester, rather than concentrating study effort in the weeks prior to the unseen exam. The 'seen' Class Test system therefore seeks to meet the following conditions of 'effective formative assessment' as specified by the FDTL4 FAST (Formative Assessment in Science Teaching) project (**http://www.open.ac.uk/science/fdtl/**, Gibbs and Simpson, 2004):

- Assessed tasks capture sufficient student time and effort.
- The tasks distribute student effort evenly across topics and weeks.
- The tasks engage students in productive learning activity.
- Feedback is provided quickly enough to be useful to students.
- Feedback is acted upon by students to improve their work or their learning.

The current operation of the 'seen' Class Test system is as follows: In each module two 1-hour tests account for 20% (2 x 10%) of the module mark. Each module has ~10 'seen' class test questions that are displayed on the modules sites within the VLE. Class tests take place at specified times throughout each semester and for each test the module tutor selects two questions. Students do not know in advance which questions will be used. Class tests are preceded by problem classes (usually 7 days prior to the class test), which employ different problems from those in the Class Tests, but which address the same curriculum material. The problem classes are intended to provide useful feedback to students on their grasp of the module material.

Assessment Experience Questionnaire Items	1st Year 2004-2005 41 Responses	2nd Year 2004-2005 16 Responses	1st Year 2006-2007 42 Responses
	% Agree/Strongly Agree		
I have to study regularly if I want to do well on these modules	74%	69%	83%
Tackling the Class Test problems really makes me think	93%	88%	86%
The feedback helps me to understand things better	78%	93%	81%
The feedback shows me how to do better next time.	78%	86%	81%

Table 1: Student feedback of the ‘seen’ class tests

Student Feedback

Student feedback on their experiences of the ‘seen’ Class Tests was obtained using an Assessment Experience Questionnaire (AEQ, Brown, Gibbs and Glover, 2003). A selection of this feedback is given in **Table 1** and in representative student comments.

Student Comments

‘The class tests force me to learn things in detail, to get the best marks I can for a given question, I then remember these details, even for questions that were never assessed by a class test. Details that would not otherwise be learned for an exam, or at least a memory of them are already in my mind when it comes to exam time. This makes exam questions relating to class test material more easy to recall’

‘The class test system encourages me to study the course material. The fact that the questions are “seen” means more of the course is revised and allows me to see what is needed for the exam’.

‘Makes you revise throughout the module instead of all at the end. Very useful, although we could do with going through them afterwards so we know the correct answer and why’

I believe it is a good system, forcing people to learn as you go along. It gives incentive to work at a time when there is usually not very much.

‘I like that it test understanding. It makes clear the material you need to go over again’.

‘It would be helpful to publish answers to all class test questions after the class test is over, i.e. for questions not on the test you don’t know whether you would have done well’.

‘The fact that they are ‘seen’ is helpful – allows more time to go back over things and understand topics more fully. A good system and ‘model answers’ are very helpful’.

'Very useful process – makes sure you keep revisiting/revising material – very good aid for learning'.

Conclusions and Future Developments

The evidence obtained from student feedback on the 'seen' Class Test system indicates a positive impact on the distribution of effort across the curriculum and throughout the semester (although there are clearly peaks in the vicinity of class tests). Students really do engage in tackling problems that they know may not appear in the Class Test. However, it is clear that whilst feedback on questions selected for tests (and therefore marked and returned) is rated quite highly by students, they generally don't receive sufficient feedback on questions that are not selected for the tests. Future developments may involve the use of more frequent, but shorter 'seen' class tests (see for example, Thin, 2006) with the use of peer-assessment to provide rapid and more effective feedback.

Acknowledgement

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[P27] The e-volution of teaching in the modern world

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This poster was not submitted in time for inclusion in the Proceedings.

[P28] Flexible delivery with *CeLLs*: collaborative e-learning in life sciences

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Project Background

The *CeLLs* project, funded by the Scottish Funding Council e-learning Transformation Programme, is a collaboration between the Scottish Colleges Biotechnology Consortium, Napier University, The University of Dundee, The Scottish Qualifications Authority (SQA) and The Interactive University Ltd (IU), a not-for-profit commercial company.

Project Aims

The major aim is to create and share core online materials for early-years learning and teaching in Life Sciences. Each academic institution is using the materials to further a more student-centred approach to learning and to enrich a blended approach to teaching. Partners are also each developing institution-specific materials that will help contextualize the core, online materials according to the specific learning needs and ethos of each institution (e.g. HNC, HND, degree streams).

Flexible Design

Core learning objectives common to all academic partners have been agreed in cell and molecular biology, microbiology, immunology, chemistry, biochemistry, metabolism, and genetics at SCQF Levels 7 and 8. The poster will illustrate the iterative process of design and quality assurance used to develop and produce e-learning objects (91 in total) to assist students to achieve the objectives.

Flexible Delivery

From November 2006, project outputs are being embedded in practice according to the needs and contexts of HN and Degree programmes e.g. metabolism objects used in HN Biotechnology, 1st and 2nd year BSc Life Sciences, 1st year medicine and dentistry programmes.

Evaluation of outputs

Staff and student feedback on ease of use and suitability for purpose is being collected, using existing evaluation tools where possible. The poster will illustrate the results.

Conclusion

If institutions share the load of core content creation instead of duplicating effort, staff time is freed for other student centred activities. This approach is possible only if the design, delivery and evaluation of the learning objects are sufficiently flexible to permit embedding into programmes within institutions of differing ethos.

[P29] Evaluation of a blended learning approach to embed ethics teaching

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Keywords: blended learning, on line resource, ethics

Introduction

A number of drivers require the dissemination of ethics, for example the 'Biosciences Benchmark' document states 'students should be expected to be confronted by some of the scientific, moral and ethical questions raised by their study discipline'. Thus it is paramount that students engage with ethics and that tutors are enabled to support this. Our experience in MMU is that students vary greatly in their understanding of ethics. The implementation of a managed learning environment via Blackboard Vista has offered the opportunity to evaluate the student learning experience using taught postgraduate modules linked to a 'self managed' on line resource. This project was funded by MMU 'BIDS' Faculty Learning and Teaching Scheme.

Aims and objectives

The aims of this study were to evaluate the student experience of a blended learning approach, to elucidate the barriers to learning, and to feedback these findings to staff and students via the MMU virtual learning environment (VLE). This was achieved by:

- Use of a questionnaire to evaluate student's experience of the Ethics module
- Recruiting and interviewing a focus group of students from each elective
- Analysing the questionnaires and findings from the focus group
- Analysing student usage of files and tools on the VLE

Methods

The structure of the MSc Biomedical Science involves a mix of traditional lectures for the electives and a 'self managed' Ethics module delivered via the VLE. The Ethics module is generic in content but involves assignments based on the study of electives. Students studied by mixed mode and have no prior ethics teaching.

A questionnaire to evaluate the student experience across 5 different electives was designed and made available to students (n = 41) enrolled on the MSc Biomedical Science within the School of Biology, Chemistry and Health Science at MMU, via the VLE. Completion of the questionnaire was optional. A volunteer student focus group (n= 12) underwent a structured interview (Krueger 1988) answering questions to record their experience of the blended learning approach used to teach the Ethics module. In addition, Blackboard Vista usage statistics were downloaded for analysis.

Results and discussion

Analysis of Blackboard Vista tools and files

Blackboard Vista enables the tutor to view and analyse student usage of the electronic learning material. The following data illustrate the student experience (n = 41) during a selected 8 week period. The end of the 8 week period coincided with an assignment hand in deadline. It was found that that the most accessed tools are the folders (49%) and files (30%). The majority of teaching and learning materials are housed in these folders and files. The least accessed tools were the mail and the media library (each <1%).

Usage of electronic files over 8 week period

The areas most accessed were the 2 examples of case studies (17% and 13%), the weblinks (13%) and the case study mark sheet (10%). The discussion board was accessed infrequently (7%). Analysis of usage showed that the Ethics on line resource was accessed at all times of the week and all hours of the day, although the pre-lunch period is most popular. The most active day was immediately prior to the coursework submission date.

Analysis of focus group interview

At the end of the module student volunteers were invited to discuss their experience of blended learning. The interview was based on 13 specific questions, and included general discussion of topics. A summary of responses follows:

- Distance learning/flexible mode of study was especially liked
- Access to the marking scheme was found to be useful
- Students were happy to access files randomly and to their own personal interests
- Traditional lectures would have been preferred by 2/12 students
- Access and choice of material was reported to be assignment and deadline driven
- Most students printed the handbook and teaching material (9/12)
- Sample case studies were considered the most useful files accessed
- Support sought with tutor was infrequent, support was sought via email or occasional tutorials. Some students experienced feedback from others via presentations on ethics topics within their specialism
- Use of the discussion board was limited, students felt there was nothing to discuss and initiation of discussion was lacking, they would use it if marks were assigned

Conclusion

Evaluation of the on line resource for teaching ethics has shown that the balance of e-learning and supported learning within the blended learning approach was appropriate for postgraduate students. Although embedding the ethical content within a structure based on lecture/tutorials for electives allowed for tutor support, few students felt the need for further support. The findings of this study have indicated mechanisms whereby tutors may embed ethics within individual modules by supplementing learning with an on line resource.

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[P30] The 'Animal Diversity CD-ROM': developing a multimedia learning resource to support a self-taught undergraduate zoology module

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Keywords: taxonomic skills, multimedia, hypermedia, formative assessment

At the University of Reading the Cole Museum of Zoology provides students studying the BSc. Zoology with a world-class educational opportunity (Trewavas, 1956) and following the Museums recent refurbishment and restoration, it is now used extensively to support undergraduate teaching in zoology.

In response to reports from employers that there is a widening 'skills gap' in the taxonomic skills of zoology and ecology graduates (British Ecological Society, 2004), academics in the School of Biological Sciences have developed a new self-taught, third year undergraduate module in 'Animal Diversity' for students studying zoology. The module is based entirely on the collections held within the Cole Museum of Zoology.

The Animal Diversity module is designed to support the further development of students' taxonomic skills, as well as enhancing their transferable skills and providing them with a unique opportunity to gain experience of working in a museum environment. Assessment of the module requires students to design virtual cases for the Cole Museum, based on taxonomic issues, and to prepare a written and an oral assignment on specific taxonomic groups. There is also a practical examination using specimens from the Cole Museum, which further assesses their taxonomic skills and understanding.

The Animal Diversity CD-ROM

To enhance the Animal Diversity module we have undertaken a collaborative project between the University's Division of Environmental Biology and the Centre for Excellence in Teaching and Learning in Applied Undergraduate Research Skills (CETL-AURS) to create an interactive CD-ROM that serves as an integral learning resource for the Animal Diversity module. The effective use of an interactive CD-ROM in the teaching of zoology and human biology has been reported previously (Coall, 2002).

The Animal Diversity CD-ROM was developed according to a seven stage multimedia development model and was designed according to the latest pedagogical theories (Meyer, 2005) and accessibility information relating to the use of multimedia in higher education. Information derived from student questionnaires was also used to inform the technical and user-interface design process. The first edition of the CD-ROM contains over 1000 individual multimedia pages, 1,100 images, 102 diagrams/graphics and 50 formative learning multiple choice quiz questions.

Pedagogic Design

The CD-ROM is comprised of four main sections, which are each designed to provide a different type of learning support for students studying the Animal Diversity module. For example, the guide to the taxonomy of the animal kingdom, called the 'Taxonomy Explorer', is a supportive hypermedia resource that supports learning throughout the module, while the guide to the Cole Museum and the searchable catalogue of the Cole Zoological Collection are resources that support the students when preparing their exhibit design and when studying for the examination. The formative learning quizzes in the 'Quiz Centre' section are engaging and provide students with immediate and detailed feedback to enhance their learning and retention of taxonomic principles. To provide further learning support the Taxonomy Explorer section includes a glossary of over 150 key words that appear in the text.

Taxonomy Explorer

Arguably the most educationally rich resource on the CD-ROM is the hypertext guide to the taxonomy of the animal kingdom, which is called the 'Taxonomy Explorer'. This has been designed in close accordance with the latest navigational and presentation principles and includes design features to enhance student engagement with the material, while preventing cognitive overload and providing enough instructional support to ensure all learners can use the resource effectively (Meyer, 2005). The structural design of the Taxonomy Explorer section is based on a tree metaphor, which is highly applicable to both multimedia design and the general principles of taxonomy. This approach to design ensures that students are always aware of their position within the section and are able to visualise their position within the taxonomic tree of the animal kingdom. This design feature should greatly enhance the students' understanding of taxonomic principles and conceptualisation of animal taxonomy.

Evaluation and Development

The first edition of the Animal Diversity CD-ROM is now in its first year of use and its evaluation is ongoing. The evaluation strategy adopted was based on the framework outlined by Jackson (1990) and has included the capturing of students' experience of using the CD-ROM, independent evaluation of whether it has met its pedagogic objectives and assessment of student performance in the module.

Students' experiences of using the CD-ROM were captured using a questionnaire. This was designed to determine their level engagement with it and to examine their perception of it as a learning resource. Their answers indicate that they found the CD-ROM beneficial and that they felt it had improved their understanding of zoology and especially taxonomy. They also found the CD-ROM engaging, attractive and interesting. In addition, initial feedback from academic staff has suggested that the CD-ROM does meet its pedagogic objectives, and, perhaps more importantly, preliminary data from levels of attainment in the module's practical exam indicate that using the CD-ROM has helped the students to develop further both their zoological knowledge and taxonomic skills.

Full evaluation of the CD-ROM's pedagogical outcomes and the collation of end-user feedback are currently ongoing and a second edition is in development. This second edition will include modifications to the structure of the CD-ROM to improve its performance and will also include new content written by the students themselves.

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[P31] PDAs in fieldwork: a pilot study on green energy from the Lake District

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Keywords: PDAs, fieldwork, geography, IT, problem-solving

Introduction

Fieldwork is an essential component of the learning process in all undergraduate Awards in geographical sciences. Whilst some fieldwork activities rely only on observations and basic fieldwork skills (e.g. measurements, sketching, maintaining a field notebook), other activities lend themselves to the use of IT in the field. This pilot study introduces an on-going research project on the use of PDAs in the field to enhance geographical fieldwork skills (Savill-Smith and Kent, 2003).

Background

This study took place during a Level 2 compulsory field week to the Lake District for students on Geography, Environmental Science and Environmental Management Awards. One of the field trip topics involved an environmental impact assessment of green energy in the Workington area. There were 3 main objectives:

1. To assess whether green energies could replace nuclear and/or coal generated electricity in the local area.

2. To evaluate the environmental impact of green technologies on the local environment, if they did replace conventionally generated energy.

3. To estimate the potential reductions in CO2 emissions for the Workington area by converting to green energies.

Fieldwork activities

The exercise was carried out on 2 separate days with relatively small groups of 12-14 students. PDAs were used to assist in data collection in 2 main ways. Firstly by allowing calculations to be made in field so that field observations might be enhanced or reviewed and secondly to provide easy access to a number of maps and other images.

During a visit to the Visitors' Centre at Sellafield nuclear power station, students were assigned with finding out the relative proportions of electricity-generating technologies in the UK and to assess their environmental impact. The Centre has excellent displays where a wealth of information can be gathered. Students then visited a wind farm, a village hall powered by solar energy and a hydroelectric energy facility near Ullswater. At each location students were given a few simple calculations to perform on PDAs that were pre-programmed using Excel. Students were expected to input basic data based on field observations and the PDAs calculated various pre-set parameters.

As an example, the Excel file for Oldside Wind Farm produced the following outputs:

i) The energy output for an individual turbine, taking into account variables such as total wind speed and daily variations.

ii) The maximum and realistically probable energy output for the wind farm on an annual basis.

iii) Estimates for the annual local energy demand, based on a set population and estimating the number of houses. N.B. for this exercise the local industrial energy demand was ignored, but this could also be incorporated in future years.

iv) The actual footprint size of a wind farm required to satisfy the local energy demand.

v) The amount of potential reduction in CO2 emissions should this hypothetical wind farm be built.

These calculations were then used to debate in the field issues associated with the environmental impact of the new hypothetical wind farm.

Advantages of using the PDAs

Although it is possible to provide students with facts and figures in handout form to initiate debate in the field, there is a clear advantage in students 'discovering' their own information. Ownership of data is a key issue in educational achievement and it seems that students engaged more meaningfully with the exercise by working out parameters for themselves, rather than simply reading relevant data from a handout. Otherwise, the advantages were:

i) Data input onto the PDAs was quick and calculations were easily achieved on an Excel spreadsheet.

ii) The PDA screen was easily visible in bright sunshine.

iii) All students 'coped' well with the technology, despite a few concerns from some students prior attending to the field day.

iv) The zoom tool on the PDA makes maps much more accessible.

v) A real understanding of environmental footprint issues was achieved to a much higher level than on previous trips.

Feedback from students included comments such as '. . .helped me understand environmental impact', 'Better than a simple handout. . . .', 'Not at all intimidating', 'Good to work out the reduction in carbon emissions for wind and solar energy. . . .'

Conclusions and future work

This pilot study has suggested that there is scope for using PDAs in a fieldwork context. As students seemed to adapt to the technology without any obvious difficulties, the research will extend into other field applications using Visual Basic programming instead of Excel. This will enhance the accessibility of the files on the PDAs whilst still allowing calculations to be made. Other potential applications will include profile plotting (e.g. surveying, levelling), video clips, maps, GPS surveys and a number of mapwork applications. It is also planned to have follow-up exercises in class using data collected on PDAs.

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[P32] Threshold concepts, troublesome knowledge and knowledge gaps

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Background

Within the science subjects, there are challenges that undergraduate students face. Science is often seen as difficult, but what are the reasons for this? Are there some concepts that most students find difficult because they are abstract and conceptually difficult or are their problems caused by a lack of prior knowledge (knowledge gaps)? Are there some key concepts which are fundamental to the understanding of the subject?

Meyer and Land call these key concepts, *Threshold concepts*, which they define as 'core concepts that once understood, transform perception of a given subject'. Once understood, these concepts are rarely forgotten and often have boundaries with other concepts leading to a greater overall understanding.

Meyer and Land also describe another problem, that of *Troublesome knowledge*. These are concepts that appear alien or counter-intuitive. Students are often able to perform mechanical tasks and techniques but fail to understand the underlying concepts and therefore the bigger picture. They are unable to apply their knowledge to new situations. Threshold concepts are often troublesome knowledge and cause major barriers to learning if not understood.

An additional factor is a lack of prior knowledge: Students enter degree programmes with a variety of backgrounds and qualifications, meaning that some students may have knowledge gaps. This can be due to either differences in syllabus content between qualifications e.g. Access and A-Level (A2) courses, or differences in how A2 courses are delivered in colleges. Further complications arise with Interdisciplinary courses (e.g. Sports and Forensic Science) which have students with mixed qualification profiles of AS Level and A2 Level in key subjects and therefore have knowledge gaps in key areas for their chosen course of study.

Research methodology

CELS is conducting research with undergraduate students and academic staff at NTU across both pure and interdisciplinary science degree courses. Data is being captured through focus groups and questionnaires with the aim of identifying troublesome knowledge, threshold concepts and knowledge gaps.

Focus groups are being held with students from each year of a given course to capture in depth data about concepts within their course that they find difficult. The findings of this area of the research are then used to create a questionnaire to be completed by all members of that course. This enables us to ascertain if the troublesome knowledge identified by the focus group participants is seen as troublesome by their peers. The questionnaire also captures data about the student's backgrounds to identify potential knowledge gaps. This allows us to distinguish between knowledge that is indeed troublesome, from that which students find difficult because of a lack of background knowledge.

Research outcomes

The first focus group was run with Level 1 Forensic Science students who identified a number of chemistry concepts that they saw as being difficult. These were then compared with findings from a study carried out in 2006, which compared the chemistry content of science access courses with A2 Level Chemistry. The following concepts, identified as being covered briefly or not at all in the Science Access course, were also identified as causing difficulties for the 2005/2006 Level 1 Forensic Science students with Access entry level qualifications:

- Spectroscopy
- Chromatography
- Mole calculations
- Bond types
- Functional Groups

> *'we have people who have done "A" levels here and I think they understood a lot more than we did'*
>
> 2005/2006 Level 1 Forensic Science student with Access to Forensic Science entry qualification.

A follow up questionnaire to be completed by all Level 1 Forensic Science students will seek to distinguish between knowledge that is difficult because it is troublesome knowledge from that which is difficult because of knowledge gaps.

New learning materials are being developed to address problems faced by students due to knowledge gaps and troublesome knowledge. E-learning materials for Mole calculations and Molecular geometry (which includes bond types) are currently under development.

For more information see **www.ntu.ac.uk/cels**
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[P33] Observed structured clinical exams (OSCEs): uptake and usage in schools of pharmacy

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Keywords: pharmacy, observed structured clinical exams

Introduction

Current government policy on the role pharmacists' play in delivering health care is driving educational direction and delivery for under and postgraduate pharmacy courses. Traditionally, pharmacy was predominantly science-based but in latter years, to meet government and patient expectation, the course has evolved into a hybrid syllabus between science and elements of social science (known as pharmacy practice). This discipline covers areas such as evidence-based practice, diagnostic skills, dispensing and consultation skills. These skills are akin to medical education and require each student to competently perform them. In medical education, observed structured clinical examinations (OSCEs) are widely adopted to measure clinical competence, yet other professions allied to medicine have been slower to embrace this method of assessment. (Grand-Maison *et al*., 1992; Prislin *et al*., 1998) Anectdotal evidence suggests that pharmacy educators have begun to embrace assessment methods that tackle a student's ability to demonstrate competence. This exploratory study aimed to determine to what extent schools of pharmacy were using OSCEs to assess competence.

Method

A self-administered survey was sent to all English-speaking schools of pharmacy (n=142) in 2005. This list was derived from the world list of schools of pharmacy (**http://www.pharmacy.org/schools.html**), although further internet Google searches were performed to ensure the list was as complete as possible.

The survey consisted of three sections. Section A sought basic information on the school of pharmacy and if they used OSCEs; section B focused on when they used OSCEs and for what purpose and, section C asked for the rationale behind using OSCEs. Questions on the survey instrument consisted mainly of multiple response and closed questions, although a small number of open-ended questions were used to allow respondents to express additional views. Analysis of this data was investigated for themes and reorganised with similar responses grouped together.

Quantitative data were analysed using SNAP version 6 (Mercator) questionnaire analysis package.

Results

Seventy-four schools replied after two mailings (52% response rate). Most schools of pharmacy ran a 4-year programme but two schools offered a 5-yr course. Average student numbers in the current programme cohorts were increasing year-on-year (Year 1, 117; year 2, 110, year 3, 108; year 4; 101). Thirty-five schools (47%) used OSCEs as part of their assessment programme. All schools used them on a formative basis and 60% for both formative and summative assessment. Schools used a mixture of scoring criteria from pass/fail (n=10) to % marks (n=19) whilst a number used a combination of methods. More schools had begun to adopt OSCEs in recent years (18 post 2000 compared to 14 pre 2000) and tended to use them in the latter stages of the programme (65%, n=45/70 in years 3, 4 and 5). Canadian schools had the greatest uptake of OSCEs (100%) and the USA the lowest (35%). OSCEs were predominantly used in pharmacy practice (n=33) but not exclusively as chemistry (n=1), pharmacology (n=2) and other pharmacy disciplines, for example pharmaceutics (n=3) also employed them. The most common skills tested were patient counselling, calculations, diagnosis and ethical dilemmas. Respondents justified the use of OSCEs stating they mimicked real life practice and gave better global assessments of the students' ability to perform certain tasks.

Discussion

OSCEs are being increasingly used in schools of pharmacy to determine student competence, and the range of skills being tested focuses on those most closely related to actual practice. This is in line with medical education and to be expected; the ability to perform a clinical task to a competent level is a pre-requisite for patient safety. OSCEs are very labour intensive and with increasing numbers of students being enrolled onto pharmacy courses it remains to be seen whether OSCEs are viable in the future.

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[P34] Integration of multimedia technology into the curriculum of forensic science courses using crime scene investigations

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Introduction

Virtual reality technology is a powerful tool for the development of experimental learning in practical situations. Creation of software packages with some element of virtual learning allows educators to broaden the available experience of students beyond the scope that a standard curriculum provides. This teaching methodology is widely used in the delivery of medical education with many surgical techniques being practised via virtual reality technologies (see Engum *et al*., 2003).

Use has been made of this technology for a wide range of teaching applications such as virtual field trials for an environmental science course (Ramasundaram *et al*., 2005), and community nursing visiting education scenarios (Nelson *et al*., 2005) for example. Nelson *et al*. (2005) imaged three-dimensional representations of patient living accommodation incorporating views of patient medication in order to deliver care modules via a problem-based learning approach.

The use of virtual reality in the teaching of crime scene science was pioneered by the National Institute of Forensic Science in Australia as part of their Science Proficiency Advisory Committee testing programme. A number of scenarios were created using CD-ROM interfacing, allowing as near as possible normal procedures to be adopted. This package included proficiency testing integrated into the package and serves as a paradigm for the creation of virtual reality crime scene scenarios (Horswell, 2000). The package is commercially available on CD-ROM as part of the series ‘After the Fact’ (**http://www.nfis.com.au**).

The CD-ROM package is geared to proficiency training of serving scenes of crime officers and thus contains details that may not be needed in the education of other parties with a need for forensic awareness. These include undergraduate students studying towards forensic science degree programmes in the UK as well as serving Police Officers. These groups may need virtual reality crime scene material geared to their specific knowledge requirements. In addition, Prof J Fraser, President of the Forensic Science Society and a former police Scientific Support Manager, speaking to the United Kingdom, House of Commons Science and Technology Select Committee in its report ‘Forensic Science on Trial’ (2005) states:

> ‘The documented evidence in relation to police knowledge of forensic science, in terms of making the best use of forensic science, is consistently clear, that their knowledge needs to improve and therefore their training needs to improve’.

This clearly identifies a need for further training of serving police officers in forensic science.

It was with this in mind that staff at the University collaborated with the West Midlands Police Service. The aim was to create a virtual reality CD-ROM that could serve as part of the continuing professional development of serving police officers in the area of scene management. Adaptation of the CD-ROM could allow some introductory materials to help undergraduate students of forensic science.

Methodologies

Crime scene investigation learning objectives were developed to be appropriate for our target audience. These included:

- Issues of health and safety at crime scenes
- Securing the crime scene
- Common approach paths in crime scene examination
- Protecting labile evidence
- Dealing with witnesses
- Continuity and integrity in evidence handling
- Evidential value of trace and contact evidence.

The delivery vehicle chosen for the police clientele was via CD-ROM avoiding many of the problems associated with web-based delivery in restricted access sites. The student audience would view the final product using a web-based interface, which meant that the lengths of individual video clips were kept as small as possible.

Production of the CD commenced by looking at various ways of storyboarding a crime scene scenario. An appropriate storyboard and script was conceived, for production at the West Midlands Police (WMP) Crime Scene Training Facility. The Training Facility allowed the collection of video and images. Part of the scenario developed involved members of the WMP who were able to ‘act’ as Police Officers and victims. The use of serving Police Officers gave credibility to the scenario when viewed both by other serving officers and undergraduate students.

Video clips were used to introduce the viewer to the crime scene and guide them around the area. The images were used to provide close up views of all the possible evidence as well as displaying the main crime scene area as a partial panorama. Again size and number of images were key considerations due to their effect on the final file size.

The team members’ individual expertise was combined to produce a series of questions with formative feedback responses that would test the viewers’ knowledge in Crime Scene Investigations. The questions were scored so that the viewers obtained an overall score and ‘feedforward information’ (Gibbs and Simpson, 2005) at the end of the resource allowing them to assess and improve their knowledge where necessary.

The media, text and questions were combined seamlessly using Macromedia Flash™. The program allowed the team to stream the relevant content only, giving the viewer quicker access to the resource. The program also allowed the team to control the viewers' movements in order to guide them through the resource (Hammerton, 2005).

Accessibility features were included in the resource such as the ability to change the background colour and to use the resource without a mouse.

Results and Discussion

Undergraduate students

The software was trialled with undergraduate students as a web accessible package linked to a second level module introducing students to crime scene investigation. The package was accessed during formal teaching time as part of the formative assessment for the module and allowed the students to consider issues relating to material that would be later tested by means of a formal examination.

Integration of the software into a web-based format allowed the estimation of time taken to complete the tutorial as well as the overall score gained by the students. The null hypothesis tested here was that: H_0 there is no relationship between time taken to complete the tutorial and the score gained by the students.

This was tested using product-moment correlation coefficient where a score can vary between ± 1.0 to indicate positive or negative correlation. A score near to zero indicates no correlation between the two variables. The results of this test gave a value of -0.53 for the product-moment correlation coefficient indicating that there was some negative correlation with time taken to complete the test and the score gained. This result is surprising and may indicate that students who had prepared for the tutorial and knew the expected response were able to progress much more quickly to successful completion of the tutorial. The average time taken to complete the tutorial was 12 minutes with an average score of 70%. This may indicate that the questions were not searching enough for this client-base.

The students were asked to reflect on the learning experience by means of a guided questionnaire designed as a five point Lickert test with a section for students to allow free response comments. The evaluation questions are shown below:

1. The instructions given on the first page were clear and easy to follow
2. The quality of the images is sufficient for accurate deduction
3. The information was logically presented
4. The quality of the graphics made the exercise interesting
5. The interaction that was required made the exercise interesting
6. The exercise was difficult to follow
7. This type of exercise should be used more often to support mock crime scene investigations
8. This type of exercise should be used to replace mock crime scene investigations

9. Working through the exercise really made me think

10. I learnt more from doing this type of exercise than studying course material

11. The exercise was not very challenging

12. The feedback in the exercise helped me understand things better

13. The feedback in the exercise showed me how to do better next time

14. I don't understand some of the feedback in the exercise

15. I would recommend this exercise to other students.

The results showed that there was strong agreement with questions 1-5, 7, 9, 13, and 15, agreement with question 12, not sure about questions 10 -11 and disagreement with questions 6, 8, and 14. The conclusions that could be drawn from these responses were that the software package was well constructed and easy to follow, that the students would like to see more of these as support of crime scene investigations but would not see them as an alternative to crime scene investigation practicals. The students also felt that they were made to think. Free comments supported these observations with their overall assessments described as:

- 'Well thought out, exciting, logical and interesting!'

- 'Good program, interesting, compliments the lectures well, informative, would be good for other forensic modules to include programs like this.'

- 'A very entertaining exercise. Would be better if more challenging and interactive.'

Further development of this software may need to include extension exercises for the more able student.

The Police Force

Preliminary trials of the CD-ROM were circulated to one operational command unit for serving officers to evaluate. The responses were not formally assessed via questionnaire but informal feedback was given. The response from this was favourable and the software was demonstrated to a group of interested parties from Centrex (The Centre of Excellence for Police Training) and the Forensic Science Service with a view to expanding this arm of the project's remit. The response from this was favourable and compared well with previous products designed by the Forensic Science Service for police forces with evidence preservation in mind. However, the way in which police continuing professional development was being managed changed, with all training materials needing to be subjected to a validation audit by training authorities within the force. This process is still underway at present and the outcome of this will determine the future use of the package within the Police Services of England and Wales.

Overall Summary and Future Developments

The creation of high quality software materials using Macromedia Flash has been successfully carried out at the University. The software has been well received by both client bases and is being used to deliver teaching at the University. Demonstration of the software at a learning and teaching conference (Sutton, 2004) has led to an invitation of staff from within the West Midlands Police Service and the University being asked to co-author a text around crime scene investigation utilising some of the techniques successfully piloted in this project.

The software will be developed using the methodologies as a vehicle for final year undergraduate student projects. This will increase the range and scope of simulations that are offered to students at the University.

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[P35] *Fungi Online*: web-based introductory mycology for undergraduates

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Keywords: *Fungi Online*, flexible delivery, mycology, fungi, e-learning, self-assessment

In 2001 the '*Fungi*' website was launched. Its primary aim was to support formal classes on fungal biology being delivered to first-year bioscience undergraduates as part of an introductory microbiology module at Queen's University Belfast. However, the website proved popular with many UK and overseas colleagues responsible for teaching introductory mycology, who found it a valuable learning resource and who adopted many of its materials in support of their own teaching and their students' learning. Students' reactions to the website included: '. . . *absolutely fabulous. Great idea and a great help in my understanding of fungi'; 'Excellent web site'; 'Fungi web site was very good, especially the sample questions and quiz*'. Mycologists expressed their regret when the website had to be suspended, following its author's move to a new institution, and were eager to see the website re-established as a resource that could support their courses and enhance their students' learning experience. A successful application to the British Mycological Society's Small Grants fund ensured that a newly designed website could be hosted and supported for an initial two-year period.

The aim was to redesign and re-establish the '*Fungi*' website, under a new title, '*Fungi Online*', and new independent domain, fungionline.org.uk.

Specific objectives included:

1. redesigning and implementing the website '*Fungi Online*';
2. extending the mycological content of the website;
3. redesigning and extending the 'Quiz' (a formative self-assessment test) to provide an interactive learning experience for students;
4. ensuring that the website satisfied guidelines regarding web accessibility and usability;
5. evaluating the e-learning materials designed via feedback from tutors and their students;
6. disseminating and publicising the web site and outcomes of the project.

'*Fungi Online*' was launched in August 2006 and is hosted by Netcetera (**www.netcetera.co.uk**), with all materials delivered via the website freely available via the Internet. The website was designed and implemented using *Macromedia™ Dreamweaver™ MX 2004*. To help ensure that *Fungi Online* complied with appropriate web accessibility and usability guidelines (such as those produced by the W3C, TechDis and

Main sections:		
- Introduction to fungi	- Growth kinetics	- Recommended resources
- Fungal spores	- Asexual sporulation	- Quizzes
- Structure of hyphae	- Sexual sporulation	- Links to societies & groups
- Hyphal growth	- Glossary of terms	- Links to related web sites

Table 1: Overview of *Fungi Online* content

Figure 1: *Fungi Online* home page at www.fungionline.org.uk

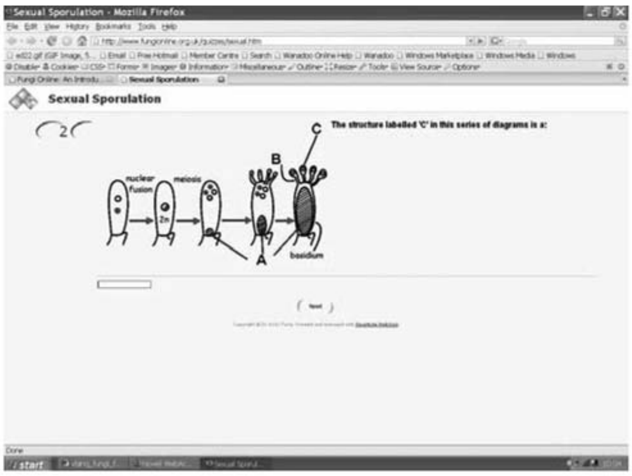

Figure 2: Sample question screen from one of the quizzes

UsableNet), the website was implemented using Cascading Style Sheets (CSS) (**Figure 1**). Although the main sections of the original website, '*Fungi*', were retained (**Table 1**), the mycological content of each section was extended.

The self-assessment quiz, a feature of the original *Fungi* website that learners and their tutors found particularly valuable, was redesigned and extended using *SmartLite*'s affordable software *WebQuiz XP* software (www.smartlite.it/). Seven quizzes, delivering a total of 100 questions, provide formative self-assessment tools, made up of objective questions, to deliver a more engaging and interactive learning experience for students

(**Figure 2**). The quizzes provide students with an opportunity to self-assess their knowledge and understanding of fungal biology in a non-threatening environment and to receive prompt feedback on their performance.

In addition, an online form provides users with the opportunity to provide feedback on the website and/or to ask a specific question, e.g. '*Your website is excellent and recommended to my 120 students. You have done a wonderful job*' (UK-based tutor).

Monthly statistics on website traffic, provided by Netcetera, indicate that during the first six months following its launch in August 2006, website traffic increased rapidly, peaking through January 2007, when almost 23,000 hits and 1200 unique visitors were recorded.

'*Fungi Online*' is sponsored by the British Mycological Society through its Small Grants Scheme.

[P36] *Biomathtutor*: students' and tutors' verdicts

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Keywords: *Biomathtutor*, e-learning, mathematics, life sciences, evaluation, contextual learning

Introduction

Biomathtutor represents video-led, multimedia and interactive e-learning materials which aim to support post-16 mathematics learning in the life sciences. The pilot *biomathtutor* DVD-ROM was designed and produced in collaboration with the Educational Broadcasting Services Trust (EBST) and was funded by a NTFS 2003 award. Its development represents a timely initiative in response to growing evidence of a mathematics skills deficit among increasing numbers of bioscience undergraduates (Tariq, 2002).

Biomathtutor adopts a contextual, scenario-based problem-solving learning model which aims to motivate students to <u>*want*</u> (rather than merely <u>*need*</u>) to learn the mathematics they will encounter in their chosen discipline. The case study scenario presented, which covers aspects of haematology and microbiology, is introduced to the students through a stimulating high quality narrated video. Computer-assisted formative self-assessment is provided via thirty-three scenario-linked questions and twenty-four additional extension practice exercises; these cover a range of basic mathematical concepts presented in biological contexts. In addition, a series of brief face-to-face video tutorials, similar to those incorporated in *mathtutor*, deliver and support the teaching and learning of some of these mathematical concepts.

In 2006, the Higher Education Academy, through one of its e-learning research grants, funded a twelve-month project to assess the impact of blending *biomathtutor* with more traditional teaching methods to support mathematics learning within the life sciences. One of the aims of this project was to evaluate students' and their tutors' reactions to the pilot *biomathtutor* learning resources.

Methodology

Colleagues in eleven UK institutions, representing both pre- and post-1992 universities, who had volunteered to participate, were each forwarded a copy of the *biomathtutor* DVD-ROM. Most arranged for the contents of the DVD to be transferred to one of their institution's servers so that their students could access *biomathtutor* via their university's intranet, often via a link from their virtual or managed learning environment (e.g. WebCT, Blackboard). In some instances, where relatively few students would be involved, copies of the DVD-ROM were produced and distributed to those participating.

Two types of data collection instruments were used in the evaluation of students' and tutors' reactions to *biomathtutor*. Firstly, separate questionnaires were designed for students and their tutors. While the majority of questions were multiple-choice in format, using a Likert scale, open-ended questions were included to gain further insight into respondents' particular likes and dislikes with regard to *biomathtutor*. Secondly, students and tutors participated in focus groups and semi-structured interviews respectively, with a view to gaining further insight into their use of *biomathtutor* and their views regarding the embedding of e-learning resources such as *biomathtutor* into current learning and teaching practices to develop a more blended learning experience.

Results and discussion

Overall, both students' and their tutors' reactions to *biomathtutor* were positive. Tutors reported that the resource is useful when teaching maths to bioscience undergraduates, the content of *biomathtutor* is relevant to undergraduate curricula and that *biomathtutor* has the potential to enhance student's competency in elements of biomaths.

Regarding the design and structure of *biomathtutor*, both students and tutors thought it was well designed, easy to navigate through, and provided a logical sequence of materials through which students could work. The potential of *biomathtutor* to support learning was recognised, with responses indicating that presenting maths in the biological context helped students to better understand the logic of the mathematical calculations and manipulations. The following comment supported the view that the mathematical and biological content were linked appropriately:

> *'Problems well related to Biology. Clean explanations and worked examples'* (a physiology tutor)

Both students and tutors agreed that the case study film was informative and enjoyable to watch and that it provided a valuable learning experience, particularly in conjunction with the related questions. The feedback provided on users' answers to all questions was also helpful and enhanced the learning experience.

> *'It's helped me build the bridge between maths and biology because although there was a lot of maths in 'A' level chemistry, it wasn't biologically related . . . but this one* [biomathtutor] *helps on a bigger scale with other things, the case study questions, all the maths helps us see the link, show us the link and then teach us how to work things out, transfer one number into another and work out differences and things like that'* (2nd-year physiology student)

When evaluating the maths tutorials, participants raised the interesting point that it wasn't always clear what the tutorial was about from the title alone; however, the tutorial itself provided an adequate explanation of the topic it covered. Another issue that was raised concerned the time it took for some tutorials to get to the main point of the topic. Some suggestions for future development included changing the order in which the tutorials appear, re-naming the tutorial titles and in the tutorials themselves, showing the workings out more clearly on the board:

> *'I felt the use of the tutorials on the board was possibly a little confined space-wise, maybe if it was written on a white board on a wall I think that would be more useful, because you can space things out a bit more because once or twice the board looked a little cluttered'* (2nd-year physiology student)

Finally, it was felt that whilst there existed the potential to integrate *biomathtutor* into the curriculum, the course and module content would have to be taken into account when assessing the relevance of this resource to students' learning needs. The suggestion was also made that *biomathtutor* would need to be developed further to include a variety of case study scenarios, reflecting a diversity of bioscience fields. One student's observations were that:

> *'The use of only one case study was disappointing. I'd have preferred more case studies encompassing different clinical conditions with other clinical and pathological tests performed and additional data to analyse'.*

In conclusion, this project has explored students' and their tutors' reactions to the pilot *biomathtutor* resources and their views regarding the potential for blending *biomathtutor* with more traditional teaching methods to support mathematics learning within the life sciences. Overall, the findings indicate that there is support for integrating *biomathtutor* into the curriculum and the perception that such integration would support the teaching and learning of mathematics in bioscience courses and ultimately help improve the mathematical skills of life science undergraduates.

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[P37] 'Kit in a Kase': versatile science activities for all

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Keywords: outreach, resources, practical, science, schools

The Centre for Effective Learning in Science (CELS) at Nottingham Trent University (NTU) is a HEFCE funded Centre for Excellence in Teaching Learning (CETL) aiming to create a new image for science as relevant, accessible and achievable. This will be achieved by improving science teaching and promoting science with young people through working with NTU academics and teams from the wider community, schools and colleges.

The Outreach strand of CELS, coordinated by Dr Georgina Westbrook, has run events and activities for over 6000 school children of all ages in the last 18 months. We have done this through a variety of events such as science festivals, lectures, workshops and demonstrations hosted in our new facility at our Clifton campus (**Figure 1**) as well as through our 'Kit in a Kase' activities in schools.

Figure 1: The new CELS building at the Clifton Campus of NTU showing our school laboratory, lecture theatre with demonstration bench and our IT suite

The 'Kit in a Kase' concept, originally developed in collaboration with The University of Nottingham's Public Awareness Scientist, Dr Sam Tang, allows scientific topics to be delivered in the classroom with the emphasis firmly on practical experimentation. The topics explored are based on the familiar and therefore make the science relevant to the students. 'Real' scientists deliver the activities not only giving the children an alternative learning experience but exposing them to science role models to help dispel the myths surrounding the subject.

The Kits themselves have developed in two stages. Initially designed with primary schools in mind, the Kits contain equipment that can be bought 'off the shelf' in high street stores and supermarkets therefore reducing the costs and the hazards involved. These activities have proved extremely popular with schools in the East Midlands region and have supported the pupils' studies by encouraging their interest in science, backing up the curriculum and extending their practical skills base (**Figure 2**). At present, the topics covered by these Kits include:

Figure 2: The 'Oil Spill Kit in a Kase' in action

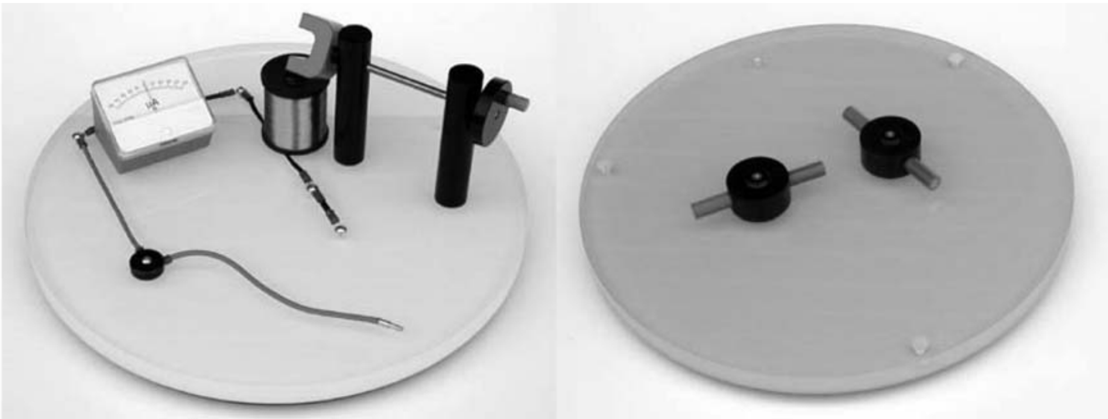

Figure 3: Two examples of the exhibit style resources used in the new ‘Magnetism Kit in a Kase’

- Colour Chemistry
- DNA
- Environmental effects of an Oil Spill
- Materials
- The Body

The second stage has seen the development of a set of resources designed for all age ranges with changeable supporting materials. New hands on experiment Kits are used in schools and can be fixed for use in an exhibit style format so allowing the science topics exposure to the general public (**Figure 3**). The topics covered by these new Kits will include:

- Magnetism
- Drugs
- Materials
- Sports Performance

Through the ‘Kit in a Kase programme, CELS is promoting science and inspiring people of all ages into thinking about what goes on around them. These ‘Kits have been used in schools already as well as more public events such as the Newark and Nottinghamshire County Show and the Nottingham Science City celebrations and East Midlands ‘i-Festival’.

[P38] Development of entry-level formative assessment packages for MSc students

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Keywords: formative assessment, MSc level

Due to the nature of science education we (within the University of Wolverhampton, and at other institutions, Gibbs and Simpson, 2004) carry out a considerable number of formative assessments, especially in the form of practical write ups. However, these are very often summative at the same time with grades being assigned to the work. This is especially the case at Masters Level. Assignments that are purely formative in nature are extremely rare within the Forensics and Molecular Biology group (SAS) at postgraduate level. The reasons for this at Masters level may be due to the assumption that the students are well developed before they arrived, and the one year nature of the course leading to strict time constraints. Our recent experience of these students suggests that their previous subject knowledge is variable and patchy. Hence there is an urgent need for early formative assessments that highlight the students' most appropriate learning strategies.

Formative assessment can be defined as a task which is intended to inform students about how to do better (Knight, 2001). Considering the importance of formative assessment it is perhaps surprising that in universities in general we are seeing a decline in this activity. Resource constraints are the main factor leading to a reduction in the quantity, quality and timeliness of feedback (Gibbs and Simpson, 2004). Within the Forensic Science and Molecular Biology group these constraints are also being experienced. This has recently been exacerbated at MSc level by growth of the number of students on MSc Microbiology and Biotechnology and MSc Bioinformatics and Molecular Genetics. Cohorts combined on these degrees have normally been between 10-20 students. At present the combined cohort size is 35. Traditionally these courses have attracted students which are UK based. In the last few years we have seen a large increase in the number of overseas students, such that the vast majority of MSc students are international in origin (**Table 1**). The first degree studied was also very varied. We have found that this has raised a number of concerns for us beyond the obvious worries over levels of English ability, most notable of which is the level of subject specific knowledge. The diversity of students means that far more guidance is likely to be required (Gibbs and Simpson, 2004).

We have undertaken the development of a formative assessment system that both allows the student to assess their current level of knowledge and provides guidance on the material that needs to be covered to improve. Questions were structured according to level (equivalent to undergraduate years one, two and three) and academic topic (e.g. Menedelian genetics, transcription, genetic manipulation). This has been developed on the University's own virtual learning environment (WOLF). The assessment was designed to give immediate feedback on performance and guidance to where to find out more about the topic, as the feedback should be as prompt as possible to engage the student (Black and Wiliam, 1998). An example of the questions and feedback provided is shown in **Figure 1**.

Country of origin	2005/6	2006/7
UK	3	2
India	16	12
Nigeria	2	2
Ghana	1	2
Cameroon	0	1

Table 1: Countries of origin of students registered on a typical MSc module

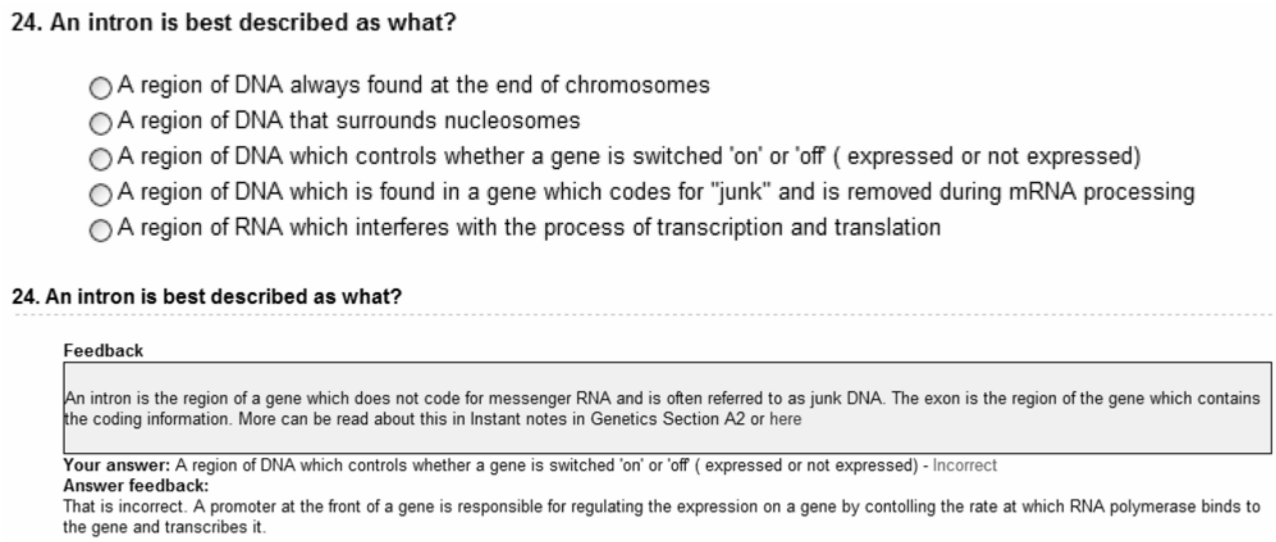

Figure 1: Example of formative assessment and feedback. The link provided (shown as 'here') in the feedback opens in a new window to **http://en.wikipedia.org/wiki/Intron**.

Initial feedback from the students has been very favourable. They have praised its ease of use and commented on how it both provides a useful learning resource and an incentive to study. An evaluation of this formative assessment will be presented.

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[P39] As seen on TV: using video clips in science teaching

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Keywords: television, multimedia, copyright, TRILT

In the autumn of 2006, a UK publishing house sent an e-mail to academics pointing out that you can 'enrich your students' learning experience through the use of quality broadcast documentaries, dramas and current affairs programming'. The memo went on to advise that, for £195 per episode (falling to £125 per episode if 4 or more were ordered), they could provide copies of classic BBC programmes for lectures, tutorials and workshops.

As an enthusiastic user of TV footage in my teaching particularly, but not exclusively, in the field of bioethics, I thoroughly endorse the sentiment of the circulated message. Experience shows that broadcast material can, indeed, be a way to enliven lectures, to convey concepts and ideas that even the most animated of PowerPoint slides cannot achieve, and can serve as excellent discussion starters. Thanks, however, to the Educational Recording Agency (**ERA**) and the British Universities Film and Video Council (**BUFVC**) there is no need to pay such substantial fees for the right to use programmes. This short article is intended to offer practical advice on the more cost effective ways to obtain television programmes, both at the time of transmission and archived copies of previous broadcasts, and guidance on the legal use of available material.

Legal use of copyrighted material

The ERA licensing scheme permits use of TV and radio broadcasts for non-commercial, educational purposes. The Licence specifically covers programmes on the five terrestrial television services and their digital sister channels, including BBC3, BBC4, ITV2 and ITV3 and E4, plus the Welsh-language station S4C and BBC radio (ERA, 2005). Other satellite and digital TV stations are not presently included under any licensing scheme and Open University programmes are specifically *excluded* as they operate under separate arrangements.

The terms under which recorded material can be used are clearly defined. For example, any videotape, CD or DVD of programmes recorded via the ERA scheme must include: the date when the recording was made; the name of the broadcaster; the title of the programme; and the exact words 'This recording is to be used only for educational and non-commercial purposes under the terms of the ERA License'. The same four items must be included on the packaging case in which the recording is stored. It is permitted to change the format of the recording (e.g. to convert a clip from a DVD into a Windows Media file for embedding in a PowerPoint presentation) provided that the same acknowledgments are included and the programme is not materially altered, e.g. by replacing the original soundtrack with new dialogue (for full terms see ERA, 2005).

What's on and when?

With the legal position clarified, how can we know what has been/will be broadcast and how do we obtain copies of interesting programmes? It is here that the BUFVC (**www.bufvc.ac.uk**) really comes into its own and deserves to be better known by academics. Let's start with knowing what is available. At the risk of introducing yet another acronym, the pivotal service here is **TRILT**, the Television and Radio Index for Learning and Teaching (**www.trilt.ac.uk**). TRILT is provided to member organisations by BUFVC and works in two ways. Firstly, you can use TRILT to set up *weekly e-mail alerts* warning you of forthcoming programmes matching key words of your choice. Armed with this information you can ask your local audio-visual team to make a recording for you at the time of transmission or, indeed, to request a recording directly via the TRILT site. Secondly, you can search the TRILT database of transmission history covering millions of TV and radio programmes broadcast since 1995. All the search terms you would expect are there, so there should be no excuse for failing to track down the documentary or drama you seek.

Of course, this latter feature would be of little benefit without another aspect of BUFVC, namely *the off-air recording back-up service*. Failure to personally record a programme no longer leaves you sending forlorn e-mails to colleagues to see if they happened to have got it taped. Since June 1998, the BUFVC has routinely stored all programmes broadcast on BBC1, BBC2, ITV, C4, five and, since their launch, BBC3 and BBC4. Staff at member institutions (see **www.bufvc.ac.uk/aboutus/memberlist.html**) can request copies in a variety of formats and these are distributed via the authorised representative for the institution. Various numbers of free copies are included as part of the different categories of BUFVC membership, and it is therefore likely that you can obtain a copy of a broadcast you want for the price of materials plus any administrative fee levied by your university or college.

The combination of these various services now makes it a realistic proposition to set up databases recommending tried and tested programmes and/or clips to colleagues in other institutions. So, for example, we have exploited the growing ease of Web 2.0 technologies to establish **bioethicsbytes.wordpress.com** where multimedia resources on issues relating to ethical aspects of modern biology can be discussed. In principle it is even permissible, under the terms of the ERA Licence, to m ake available copies to other academics for the price of materials plus postage (provided that their place of work also has a Licence and the recipient adheres to the legislation concerning the labelling and permitted use of the recording. This is not, however, a route that we have chosen to travel at present).

One area in which TRILT cannot help is news footage since, *de facto*, reportage is not known in advance. Even here, however, the potential to use clips for teaching is increasing rapidly. The BBC are beginning to stream significant news stories on their website and, unlike streamed editions of other programmes, it is the current intention to sustain the availability of the news footage in perpetuity (use the 'search' feature on **bbc.co.uk**; the multimedia clips are listed on the right-hand side of the screen). In another development, Independent Television News have a searchable database **itnsource.com** where you can seek out not only ITV and Channel 4 news items, but also the complete Channel 4 and Granada TV catalogues. Having identified a clip in which you are interested you can either order it direct from itnsource or, of course, if it was broadcast after June 1998, from BUFVC. Finally, ITN, Reuters and the BUFVC have joined forces in the Newsfilm Online project which will make copies of significant news footage available on the web to any interested parties, free of charge. The date for the nomination of potential clips for the conversion process has now passed, but there may be the opportunity for other material to be included at a later date if this initial project is considered a success (see **newsfilm.bufvc.ac.uk** for details).

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