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ENVIRONMENTS TO IMPROVE STUDENT LEARNING

## **Final-Year Biology Courses as Teaching-Learning Environments**

*Velda McCune, Dai Hounsell and Jennifer Nisbet, University of Edinburgh*

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### **Abstract**

This paper reviews emerging findings on key aspects of teaching-learning environments in undergraduate biology, with particular reference to three final-year, Honours-level course options with a combined intake of 75 students. In contrast to the first-year course units which are also being investigated by the project, these typically have a tightly-knit course team and relatively small intakes of self-selected students.

The central concern of the paper is with how high-quality learning in the biosciences is defined, pursued and supported in these three course settings. As a proxy for high-quality constructivist learning outcomes, the concept is introduced of 'ways of thinking and practising in the subject'. This encompasses not only knowledge and understanding but also the skills, strategies and values associated with engaging with, and communicating within, the discipline or subject area at graduate or near-graduate level. The paper also examines the three course settings as teaching-learning environments, viewed from the perspective of constructive alignment. It explores the extent to which the students' evolving grasp of ways of thinking and practising in the biosciences is facilitated by their experiences and perceptions of teaching-learning activities, of assignments and assessments, and of the process of adjusting to the demands of honours-level study.

The data on which the paper draws chiefly comprises semi-structured interviews with students and with staff, analysis of course documentation, and questionnaires, informed by a review of the literature on the teaching and learning of biology in higher education.

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### **Introduction**

The present paper is one of four interrelated symposium contributions arising from the work of the Enhancing Teaching-Learning Environments in Undergraduate Courses (ETL) project (<http://www.ed.ac.uk/etl>). The project is a large-scale, four year investigation being undertaken by researchers at Edinburgh, Durham and Coventry Universities with the financial support of the UK Economic and Social Research Council's Teaching and Learning Research Programme (<http://www.tlrp.org>).

The focus of the paper is the findings emerging from the first phase of an ongoing study of three final-year, honours-level course units in the biosciences with an overall enrolment of 75 students. There are two interrelated sets of findings. The first of these examines the students' experiences of mastering ways of thinking and practising characteristic of the biosciences as a subject area at this level. The second is concerned with aspects of the teaching-learning environments in these course settings, as experienced by the students, which seemed to influence the achievement of these high-quality learning outcomes. Before presenting these findings, the paper reviews the relevant literature and outlines the research design followed. The paper concludes with some reflections on the findings and their implications.

## **Literature Review**

### **a. High-quality learning and ways of thinking and practising**

As discussed by Entwistle, in the introductory paper for this symposium, one central concern of the ETL project is to describe and conceptualise high-quality learning as it is understood by the staff and students in the five subject areas under study in the project. One important starting point for our conceptual frameworks for high-quality learning has been the literature on approaches to learning and studying. The approaches describe qualitatively different ways of learning and studying, encompassing both students' intentions when studying and the learning processes they employ. Our current conceptualisation of the approaches, as exemplified in Table 1, draws on more than twenty-five years of qualitative and quantitative research with students across a range of contexts (Biggs, 1987, 2003; Entwistle, 1997, 1998, 2000; Entwistle and McCune, under review; Entwistle and Ramsden, 1983; Marton and Säljö, 1976, 1997; Tait, Entwistle and McCune, 1998).

The deep approach - in combination with organisation, effort and the metacognitive processes described in the 'monitoring studying' scale – provides a partial proxy for high-quality learning in higher education. Further development of this broad generic description of high-quality learning is one aspect of the work of the ETL project and in doing so we will draw on the increasingly rich literature describing students' learning in higher education (see, for example, Biggs, 2003; Boekaerts, Pintrich and Zeidner, 2000; Marton, Hounsell and Entwistle, 1997; Prosser and Trigwell, 1999; Richardson, 2000). In the present paper, however, we will focus on a related task of the project, that of building up conceptual frameworks to describe high-quality learning as expressed within particular disciplinary contexts. Such frameworks may, of course, include aspects of approaches to learning; for example, a description of what it might involve to take a fully deep approach in a particular subject area.

The literature suggests that different disciplinary contexts will each to some extent possess their own norms, language and practices (Anderson, 1997; Ballard and Clanchy, 1988; Becher, 1994; Hounsell, 1988; Lave and Wenger, 1999; Ramsden, 1997). Research findings describing students' understandings and misunderstandings of academic tasks, and of key concepts, tap into the difficulties that students may experience in coming to terms with the understandings and practices of particular communities (Beaty, 1987; Campbell, Smith and Brooker, 1998; Crawford et al., 1998; Hounsell, 1987, 1988, 1997; Norton, 1990; Prosser and Webb, 1994). Bearing in mind the literature about disciplinary differences, and also our initial analyses of interviews with staff in the earlier stages of the ETL project (see for example, Hounsell and McCune, 2002) the ETL team adopted the phrase 'ways of thinking and practising' in a subject area (WTP) to describe the richness, depth and breadth of what students might learn through engagement with a given

**Table 1**     *Aspects of approaches to learning and studying*  
 (Based partly on Entwistle, 1997 p 19)

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**Deep approach**

The intention to understand ideas for yourself  
 Making links between topics  
 Relating what is learned to the wider world  
 Looking for patterns and underlying principles  
 Checking evidence and relating it to conclusions  
 Examining logic and argument cautiously and critically  
 Becoming actively interested in the course content

**Surface approach**

The intention to cope minimally with course requirements  
 Studying without reflecting on purpose or strategy  
 Treating the course as unrelated bits of knowledge  
 Memorising without understanding  
 Accepting ideas without questioning them

**Monitoring studying**

Keeping your studies well focused  
 Monitoring understanding and addressing any problems  
 Monitoring and developing generic skills  
 Monitoring and enhancing the quality of work produced

**Organisation and effort in studying**

Organising your studies  
 Managing time and effort effectively  
 Maintaining concentration

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subject area in a specific context. This might include, for example, coming to terms with particular understandings, forms of discourse, values or ways of acting which are regarded as central to graduate-level mastery of a discipline or subject area. It can encompass anything that students learn which helps them to develop a sense of what it might mean to be part of a particular disciplinary community, whether or not they intend to join a given community in the future.

To understand and fully describe the WTP in a given subject area is a considerable task and one that is beyond the scope of any single research project. Our aim with the bioscience sites in the ETL project is much narrower. We are utilising the emerging concept of WTP to help us to describe high-quality learning as understood and experienced by staff and students in particular contexts. By building up a richer picture of the kinds of learning sought in each setting, we will be better placed to consider the strengths and weaknesses of each teaching-learning environment.

The literature on learning in the biosciences signals a number of aspects which might be expected to form part of WTP in a given setting. This literature is reviewed in Hounsell and McCune (2002) and we will not consider it in detail here. The benchmarking document for the biosciences in the UK (QAA, 2002) gives a comprehensive overview of what biosciences students might be expected to learn from their studies. This document also illustrates the breadth and diversity of the biosciences, which include many partially overlapping sub-disciplines, rather than being one single, clearly defined, community. We have narrowed the field somewhat within the ETL project by focusing primarily on molecular and cellular biology, but even within that narrower grouping there is a range of sub-disciplines.

The potential aspects of WTP in the biosciences described in the literature include different forms of knowledge and understanding and a range of subject specific skills and practices (QAA, 2002; Bond, Bullen and Elliot, 2000; Ryder and Leach, 1996; Séré *et. al.*, 1998; Stefani *et. al.*, 1997). One central theme is that students are expected to be able to use different research methods effectively. More generally they are required to develop a critical understanding of the collection and use of information and data, and the relationship between findings and theoretical frameworks (Leach *et. al.*, 2000; QAA, 2002; Ryder and Leach, 1999, 2000). The authors of the QAA report note that students should realise 'that much of what they are taught is contested and provisional, particularly in the light of continuing scientific advances.' (QAA 2002, p. 4). Against this background, this paper will discuss our initial analyses of high-quality learning as embodied in WTP as experienced by the students in three final year course units in three different higher education institutions. These findings then provide a backdrop to our analysis of the teaching-learning environments in each setting.

## **b. Teaching-learning environments**

Over the last three decades, there has been growing evidence of the impact on the quality of students' learning of the teaching-learning environment, whether approached from the standpoint of institution-wide student sub-cultures (Becker *et al.*, 1968), the academic department as a 'learning milieu' (Parlett, 1977) or students' perceptions of teaching, assessment and course content and structure in everyday course settings (Ramsden, 1997). Research by Entwistle and Ramsden has proved particularly influential, providing compelling evidence, across a range of subject areas, of relationships between students' approaches to studying and their perceptions of the quality of teaching provision, the amount of choice offered in relation to content and method of study, the size of the formally assigned workload, and the appropriateness of assessment methods and procedures (Ramsden and Entwistle, 1981; Entwistle and Ramsden, 1983; Entwistle, 1992). Ramsden has since shown the continuing salience of these findings through annual surveys of Australian graduates using the Course Experience Questionnaire, an instrument which grew directly out of the original studies (Wilson, Lizzio and Ramsden, 1997; Ramsden, 2003). Over the same period, further evidence has emerged of the pervasive, and often debilitating, impact of assessment and feedback on the quality of students' learning approaches and outcomes (Thomas and Bain, 1984; Hounsell, 1987; Tang, 1994; Laurillard, 1997; Wilson, Lizzio and Ramsden, 1997; Scouller, 1998; Entwistle, 2000; McCune, 2000).

Drawing both on research into student learning and constructivist perspectives on pedagogy, Biggs (1996, 2003) has recently introduced the concept of 'constructive alignment' as a means of accounting for the impact of teaching-learning environments on students' learning. From this vantage-point, teaching-learning environments are viewed as complex interacting systems.

Constructive alignment occurs to the extent that key aspects of the system are in harmony in supporting high-quality learning:

In aligned teaching, there is maximum consistency throughout the system. The curriculum is stated in the form of clear objectives, which state the level of understanding required rather than simply a list of topics to be covered. Teaching methods are chosen that are likely to realise those objectives; you get students to do the things that the objectives nominate. Finally, the assessment tasks address the objectives, so that you can test to see if the students have learned what the objectives state they should be learning. All components in the system address the same agenda and support each other. The students are 'entrapped' in this web of consistency, optimising the likelihood that they will engage the appropriate learning activities, but paradoxically leaving them free to construct their knowledge.

(Biggs, J., 2003, p. 27)

Within the present ETL project, constructive alignment is being used as a guiding concept in the study of undergraduate course settings as teaching-learning environments. In the initial phase of the project, it underpinned the analysis of telephone interviews with teaching staff from a cross-section of biology departments which had been highly rated in national quality assessments of teaching (Hounsell and McCune, 2002). That analysis indicated that constructive alignment might helpfully be widened in various respects: to encompass the alignment of learning support and course organisation and management as well as of teaching-learning and assessment activities; to take greater account of the provision of feedback in considering the alignment of assessment; and to incorporate alignment to the students taking the course concerned. It also suggested the importance of attention not only to the teaching-learning and assessment methods adopted, but also to how these methods were deployed and operationalised within given course and departmental settings, each of which could present particular contextual constraints and opportunities which influenced the freedom of action of the teaching staff concerned.

The work of the ETL project has also attempted to take appropriate account of important advances in the understanding of environmental influences which have sprung from other areas of educational research. One is the study by Becher and Trowler (2001) of academic 'tribes' and their territories, showing the importance of disciplinary cultures in understanding teaching and research practices in universities. A second is the seminal work of Lave and Wenger (1999), in which learners are viewed as 'legitimate peripheral participants' in discipline-specific communities of practice. And a third is to be found in the growing attention being given to the formative functions of assessment in enabling students to attain high academic standards (Black and Wiliam, 1998; Sadler, 1989, 1998). The latter is especially relevant in a UK context, given the reduction in students' assigned coursework and opportunities for face-to-face contact with staff which has followed a declining unit of resource and worsening staff-student ratios (Department for Education and Skills, 2003).

## **Settings, Data-Gathering and Analysis**

### **Settings**

The institutions in which the course units surveyed were located varied considerably. B1 is a post-1992 university with a strong commitment to promoting wider access to higher education from hitherto under-represented groups and vocationally relevant degree programmes. B2 is a very large and diverse 'ancient' university with a high research profile. B3 was founded in the late 1960s with a leaning towards science and engineering that reflected its origins in a college of advanced

Table 2 Summary of final year course unit settings, biosciences

	B1L	B2L	B3L
<i>Unit theme</i>	<b>Genomes</b>	<b>Cancer</b>	<b>Enzymology</b>
<i>Unit level, scheduling &amp; duration, credits</i>	First semester module 2-3 hrs p.w. over 12 wks	Second-semester seminar option 6 hrs p.w. for 5 weeks	First-semester seminar option 2 hrs p.w. over 1+10 wks
<i>Student enrolment</i>	26 on 4th/final year, B.Sc. Hons + 20 on 1-yr M.Sc.	25 taking a range of undergraduate honours degrees in the biosciences.	13 taking 4-yr Master's degrees in the biosciences + 1 Erasmus student
<i>Teaching staff for the unit</i>	Two	One, plus guest lecturers	Two
<i>Teaching-learning activities</i>	Lectures (24 hrs) + tutorials (8 hrs) + private study (~88 hrs)	Guest lecture + problem-focused group discussion of data provided by guest lecturer + private study	Paired student presentations + discussion, from choice of 10 topics + private study
<i>Assessment [incl. weightings]</i>	<ul style="list-style-type: none"> <li>Examination, 3 hrs (60%)</li> <li>Two essays (each 20%)</li> </ul>	Essay examination, 3 hrs (100%)	<ul style="list-style-type: none"> <li>Presentations (50%)</li> <li>Two essays ( each 25%)</li> </ul>
<i>Guidance/learning support</i>	Course handbook; and tutorials, where students are encouraged to raise issues arising, including assessment queries	Extensive guidance in course handbook and web site; individual requests/ enquiries	Pre-presentation class briefing; individual requests/enquiries
<i>Other</i>	Research projects/placements for both B.Sc. and M.Sc. in second semester	Some of the students had completed professional placements in research environments.	Master's students had spent their third year on professional placements in research environments

technology. In all three universities, however, the bioscience departments see themselves as active in research as well as teaching and value their links with the professional bioscience community. These concerns are reflected in their curricula in a variety of ways, as will become apparent later in this paper.

As *Table 2* shows, all of the three units investigated were final-year, one-semester honours-level courses involving a total of 75 students. One (B1L) was concerned with the theme of Genomes, and was taken by 20 students doing one-year Master's courses as well as 26 students in their fourth and final year of undergraduate honours degrees in the biosciences. The second, on Cancer (B2L), was being taken by 25 students following a variety of undergraduate honours degrees in the biosciences and cognate areas. The third (B3L) was on Enzymology, with an enrolment of 14 students, 13 of whom were taking four-year Master's degrees in the biosciences, while the remaining student was a visiting student under the Erasmus programme.

As the table also indicates, the three course units differed considerably in their approaches to teaching and learning and in their patterns of assessment. These differences will be examined more fully in the section below on students' perceptions and experiences of the teaching-learning environment.

## Data-Gathering

Data was gathered in three forms: via two specially constructed questionnaires to students (Entwistle, McCune and Hounsell, 2002), through semi-structured interviews with students and staff, and from course documentation and teaching-learning materials. The Learning and Studying Questionnaire (*LSQ*) was completed by the students towards the end of the opening class in each course unit. The scales in the *LSQ* are designed to explore students' aims, intentions and typical ways of studying in a given subject area. The second instrument used was the *Experiences of Teaching and Learning Questionnaire (ETLQ)*. This questionnaire repeats some of the approaches to learning and studying items from the *LSQ*, but asks students to describe how they approached the particular course unit being surveyed, rather than their studies in the subject area more generally, and their perceptions of that course unit as a teaching-learning environment. The *ETLQ* was completed in the penultimate teaching week, when students were also invited to take part in group interviews lasting up to an hour. Teaching staff were interviewed subsequently, and individually, either face-to-face or by telephone. *Table 3* summarises the take-up rates for questionnaires and the interviews.

*Table 3 Take-up rates for questionnaires and interviews in final-year biology*

Course unit	<b>B1L</b>	<b>B2L</b>	<b>B3L</b>
LSQ collected	28	–	13
ETLQ collected	24	20	14
LSQ & ETLQ collected	19	–	13
No. of staff interviewed	2	1	2
No. of student focus groups	5	4	3
No. of students interviewed	13	12	13

## **Analysis**

All of the student interviews were transcribed and analysed by at least two members of the project team. In the first stage of the content analysis, key themes and issues were identified and discussed, focusing particularly on students' experiences of ways of thinking and practising in the biosciences and their perceptions of their course units as teaching-learning environments. A second and more intensive analysis followed, seeking to systematically substantiate and refine the themes initially pinpointed.

In the analysis of the questionnaires, particular attention was also paid to data relevant to these focal themes.

## **Ways of Thinking and Practising**

In this opening findings section of the paper, we are going to begin by considering two broad themes which seem important to understanding the perspectives on ways of thinking and practising in the biosciences described by the students in these three final year modules. The first theme encompasses the students' accounts of their engagement with the primary research literature and with experimental data. The second theme focuses on the students' descriptions of how they were coming to think in an integrative, or synoptic, manner about the biosciences.

Having discussed these two broad themes, we will go on to discuss the students' sense of whether they were learning to communicate in distinctive ways as they moved through their studies. Finally, we will look at data relating to whether the students considered that there was a distinctive 'way of thinking' in the biosciences and, if so, what that might comprise. It is important to bear in mind that all of the findings reported here represent the early stages of our analysis of a subset of the available data. Further data collection and analysis will be required to substantiate and develop the framework reported and to address other aspects of WTP in the biosciences.

## **Engaging with the primary literature and experimental data**

Throughout the interviews the students kept returning to the theme of the importance of engagement with primary literature and experimental data. This seemed to be a particularly important aspect of study in the later years of degree programmes in all of the three biosciences settings. While this relates to their laboratory classes and project work, these settings are not considered here, as none of the three course units in question included a practical component.

Part of what the students were learning was how to locate appropriate sources of information and to select what was relevant within those sources. This seemed to be something that at least some of the students found quite difficult. The importance of very up-to-date findings was also mentioned, perhaps reflecting the fast pace at which knowledge is currently developing in the biosciences (Wood, 2001):



**B3LP V01 60-61<sup>1</sup>**

- S1: That's the whole idea is to get used to proper science. If you're gonna become a scientist, you need to quote papers, you need to have proper up-to-date references. That's one thing they're really pushing you to do this year, they're trying to turn you into real scientists. So if you write essays you're not gonna get a good mark. Even in exams, if you don't use references, you're gonna struggle to get a 2:1. [...] I don't know whether it's just B3 or whether it's just the system that's like that, but they do try and push you quite hard to use proper scientific literature.

**B1LP D01 58-60**

- S1: [For the coursework] He just gives out a sheet of paper with a starting reference and basically you've got to investigate it yourself and write it up yourself, and through the web. You can't really use textbooks because they tend to be out of date. It's up-to-date research that you're looking at so it's basically magazines like Nature or Science.

**B2LP JN 01 154-155**

- S1: Another difficult thing is finding the right paper. I mean, it's a nightmare finding the papers. I don't know if I'll ever be used to looking for.. searching for papers [...] Or even trying to get hold of papers in this university, it's a nightmare because they're not funded well enough to buy a lot of journals and all the journals I needed they don't have. And so you have to find the papers and you only get a mini review because it's not an electronic journal and you have to apply for them to get it sent in from somewhere else which costs them money and it might not even be relevant. Like, you'll get it and you'll be like, 'Oh no it's not actually relevant'. So it's a nightmare trying to get the papers.

**B3LP J 01 520-538**

- S1: In the second year it was more textbook learning, whereas in the third year it was all kind of going to get references, trawling through loads of information that was completely irrelevant rather than it being spoonfed to you in a chapter of a book, and that to me was like, 'Oh my God, there's so much information' where do you start? That for me was the hardest thing for me to change to.
- S2: I found that more interesting than sitting with a textbook [*unclear*]
- S3: But it's so clear! [*laughter*]
- I: Do you feel you know the biochemistry journals now? Do you know where to look?
- S1: Yeah, pretty much. We have quite a good appreciation of which are the good ones, which are the bad ones, which you pick up on placement as well.

The students were also learning to engage with the literature in areas about which they had not directly been taught:

**B1LP D01 60-64**

- S1: The [essay topics] tie in with what you're doing but they're a bit kind of peripheral as well. So you're getting extra learning. [Name of lecturer]'s is, they've been mapped with these genomes. You pick a genome that's been mapped and write a report on it. So, he isn't lecturing on it or anything but it is related to the course but you've got to do your own research and write about it.

**B1LP JN02 41-44**

- S2: It's also reasonably leaning towards your own investigation [for the essays], and what you can learn, because the course work [...] it's actually go and find papers on a certain topic and answer general questions. So it's not so tightly structured that you can do it from the lectures, it's something you have to do yourself. So to do well you're going to have to pay attention to the lectures and have a bit of background investigation as well, I would think.

<sup>1</sup> The coding given before each interview extract indicates the site (B1LP; B2LP; B3LP) and the interview from which the extract is taken (e.g. V01, D01, J01, JN01). The final set of numbers allows the authors to locate the extract within the full interview transcript

Perhaps the most important issue addressed within this section of the data is the ways in which the students were struggling to get to grips with how knowledge was generated in their subject area(s) and with how they might develop their own views and interpretations. It was clear, firstly, that the students sometimes struggled to understand the accounts in the primary literature of how particular findings had been derived and interpreted:

**B2LP JN01 171-172**

- S1: And it's a completely different style of writing as well [in journal papers], I mean, textbooks make it blatantly obvious. Good diagrams and just.. you know really plug away until you understand it. But scientific writing, you have to think about it and understand it instead of just rote learning.

**B2LP JN 01 150-151**

- S1: [...] and it's journal papers as well which are so difficult to read to start with. And then, once you get used to reading the abstract and the conclusion and skipping over the rest [*laughing*] it's all fine! [...] But, I mean, it's so difficult 'cos it's such scientific reading from such a level way above our heads, 'cos it's people who've been doing this for years and years and they forget that students read these as well!

**B2LP V02 278-279**

- S1: [...] if we read the original papers, and you have to understand exactly what they did, you know, what experiments did they do and exactly, you know, what they get. So, it's a bit hard like that I think.

Further, not all of the students agreed that it was necessary to fully understand the primary literature:

**B1LP D01 78-79**

- S1: Mhm, I think we ought to have exams because, in all fairness, doing assignments, you can just look up the relevant papers and basically take out the relevant parts that, you aren't actually having to digest it and fully understand it the way you would in an exam question [...]

Some of the students did, however, seem to see the importance of engaging with the literature in depth. This may have been supported by their understanding that interpretations could be contested and that it was therefore legitimate and even expected that they would put forward their own interpretations:

**B2LP V02 402-404**

- S1: Kind of, all our references, or most of them, are articles, scientific articles. So, when we are reading them we don't have to say, 'Oh yeah, okay, these are the conclusions, yeah cool.' But we have to say, 'Why did they do these experiments, why not others? Okay, why is this working this way, why these conclusions?' So we always have to ask why things are happening and I think that if we are able then to answer this is our, you know, understanding, we have to prove that we are understanding the concepts [...] and then we will memorise them of course because we understood.

**B1LP D01 79 -87**

- I: What's actually necessary to do well on a course like this? Are there certain things that get you relatively high marks?
- S1: I think being able to give your own opinion and find evidence and base your opinions on evidence and give reasons for your opinions, that seems to be the main thing this year is giving your own opinions, correctly evaluating the stuff you're getting as opposed to just, this is good because it says so.
- I: Is that hard to do?
- S1: I find it hard – [*unclear*] at the end of the year I just want to go and get a job. I don't want to go

and change the world and find some new cure for anything, just want to go out and get a job. It's part of the course so you have to do it.

- I: [...] [S2], do you share [S1's] view about doing well, what's necessary to do well on the course?
- S2: Yeah, you have to find various papers and understand them by reading them and then you have to summarise what they're saying, obviously whether you agreed with that or not. And studying [this area] there's a lot of disagreement, you know they're not all saying the same thing or coming from the same line of thought. So they have different opinions. [S1: yeah]
- I: There is a bit of scope. It's not as if there is a right answer that you're supposed to find it's one of these things where it's a matter of judgement.
- S1: So long as you've got evidence to back up your ideas with. As I say, it's not what it is just because it is, you've got to give evidence.

#### **B2LP V01 262-285**

- I: What would happen for example if you disagreed about the interpretation or disagreed about how a process or something was working? How does that get?
- S1: Ehmm, no idea!
- S2: Well, I guess.. Is this for a paper that you would put into a journal or just like..?
- I: Well, either for a paper or just maybe more generally how that might be handled in biology, 'cos I guess it's probably quite different.
- S1: I think the best way would be for, like maybe a discussion between a group of scientists, those that believe and those that don't believe! [...]
- S2: If someone finds a problem with it in the group of people that you've asked, then there's bound to be others who are gonna think the same things. So you have to kind of deal with that before you can basically write it in a report and say "This is true, this is what I found".
- I: So I guess this is not straightforward then that you got this bit of data therefore [unclear]
- S: Oh no!
- S1: No, nothing is ever clear-cut. So I think that's one of the main things we've learned as well, that nothing really proves anything. Well, not one experiment it's gonna.. you have to back everything up with several experiments.
- S2: I guess we've learned a bit about that in this topic as well in this course. [...]
- S2: Yeah, you've got to find out everything about the topic before you can make an assumption about it from your results, otherwise.
- I: How about theories, how do theories come into interpreting the?
- S2: You can never really rely on.. I mean, theories are good because if there is no other answer for anything then a theory is like the most possible answer that you could have for something, but you can't take them.. So many theories have been disproved, I mean, without evidence you can't say that this is right. You can say "Oh this is probably what will be right", but...
- S1: It's true, yeah. We need to do this to maybe prove it or.. yeah.

Despite this apparent willingness to engage with the interpretation of findings, other aspects of the students' talk seemed to reflect a view that they might not necessarily be in a position to develop their own views or to be critical of established sources:

#### **B1LP V01 155 - 163**

- S1: It's difficult to question things that you read in journals sometimes I think because, I mean, we're just undergraduates [...] I mean, this will only be a three-week piece of a module, you know, and these people have composed these journal articles. They've spent months, years maybe, doing ... I often find it difficult to try and question some of these things.
- S2: It takes time to understand them for one thing, but once you're actually.. once it clicks then you're able to do ...
- S3: Yeah, you do have a kind of assumption that everything you read in a journal is true!
- [Laughing]

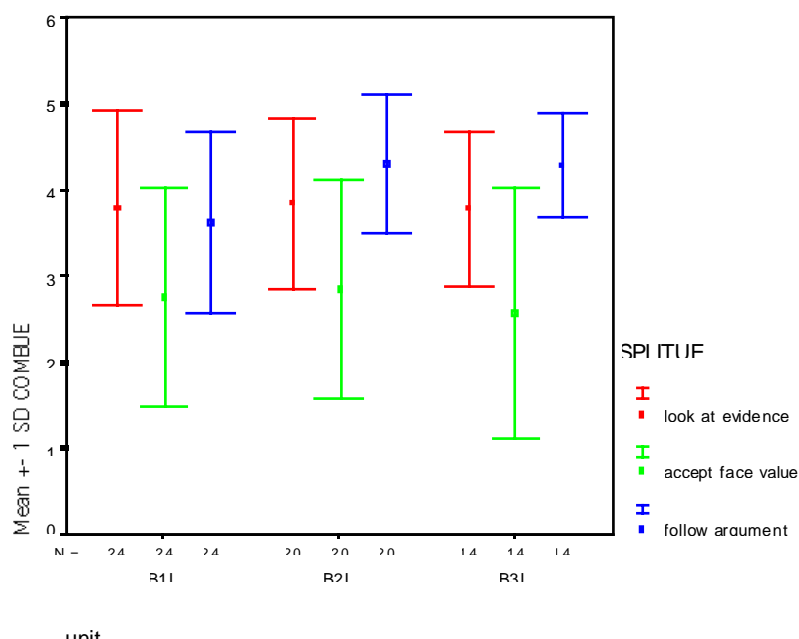
- I: And how about yourself. Have you found that you've been able to be critical?
- S4: Well it's difficult because they've spent their whole life studying it and it's hard to actually understand it and be able to question it in the length of essay and the time you've got to do it in. I mean, this semester, we've had twelve courseworks and we're only here for twelve weeks. And the first two weeks, I mean, you might not get them given out so I feel, this year, you haven't been able to hand in your best because everything's just one big rush.
- I: Everybody's nodding.
- All: Yeah, definitely.

### B3LP D01 309-313

- S: If you find a reference that's applicable to what you're trying to do, it's a modern reference then, you know, you don't really need to be critical. You can just assume it's right 'cos otherwise it wouldn't have been published. They generally are right and they make sense.
- S: Everything's peer review anyway so.. [S: Yeah]. If they really didn't catch the fact that it's complete rubbish then all the undergraduates aren't gonna..
- I: So what's being critical mean, then? Would that be getting two papers that come to slightly different conclusions about the same process or something?
- S: The thing is they're usually so specific in that case so "in this particular type of cell with this particular type of protein, this happens". And they're sort of saying well if you've got this particular type of cell and the same protein then something else happens, then they've usually proven it to beyond a reasonable doubt I'd say.

Figure 1 sets out the students' scores on three items from the ETLQ which are particularly relevant in relation to their engagement with evidence. Across all of the three settings the students' scores were markedly higher on the items 'I've looked at evidence carefully to reach my own conclusions about what I'm studying' and 'It has been important for me to follow the argument, or to see the reason behind things' than on the item 'I've tended to take what we've been taught at face value without questioning it much.' This supports the findings from the interviews that the students are making an effort to engage actively with evidence in their subject areas. Nonetheless it is clear that not all of the students agreed fully with the former two items, nor did all of them entirely disagree with the latter. This perhaps echoes the students' concerns about making their own interpretations of evidence, as discussed above.

Figure 1 Students' scores on items about evidence



The students were not learning about the interpretation of data solely from their engagement with the primary literature. In some cases – particularly in B2L – they discussed the interpretation of data in their classes. Their practical classes, projects and work placements may well also have been important in this regard. While it is not possible to consider these influences in depth here, some of the students' comments did indicate that as they learned how they themselves might conduct appropriate experiments to answer a given research question this might support their ability to interpret other studies:

#### **B2LP JN02 108-110**

- I: And what about techniques and procedures - to what extent do you feel you've learned the techniques and procedures of a biologist?
- S1: [The lecturers are] putting up their experiments [in the class]. Before they can actually give you the results and say "What does this mean?", beforehand they'll go through "This is the sort of the experiment you would do to find out this sort of result, this is how you would do it, this is what the results would mean for different sorts of situations". So they actually go through a series of experiments and tell you how they did it, what sort of things are involved, and then they'll give you the results and you'll have to work out the same sort of things that they did.

#### **B2LP V01 176-201**

- S1: I think it was the work placement [...] - it has made me more interested in it, and it has made [me] more knowledgeable about it and.. I don't know.. I think I'm more cleverer for doing it! It's like, I know I carry out experiments and think for myself. It makes you think for yourself, it makes you know where to go and look for information if you need to find something out. 'Cos basically you're studying something that hardly anyone knows as much about it as you do, so.. It gave me more confidence in science more than anything else, which made me more committed. [...]
- S2: [...] That's what I found as well [about the placement]. I found myself a bit more cynical of things as well. Like, when you hear reports and tabloids and everything, these miracle cures and everything. My mom always comes by to say "Oh, did you hear about this and that..?", but now I take it with a pinch of salt kind of thing. It has definitely taught me to think more like a scientist and it has also given me a lot more confidence working in the labs on experiments and the interpretation of results and everything like that.
- S1: [Placement] is the best thing I could have done for my degree. If had stayed on and rushed on just on fourth year, I wouldn't have known anything really about the whole background of science. I'd be like, "Oh, here are the facts that we've been given", but I wouldn't have a clue about how people went around doing it [...]
- S2: Yeah, is all the experience as well that helps enormously, especially for, like, data interpretation and everything.. hemm.. I find myself, even just from my knowledge from the work placement, just sort of interpreting some of my results in the lab that I found, sort of, maybe non-specific binding or whatever, like that. It has been quite handy. [...]
- S1: You've gone up a level [because of the placement], you're not a student anymore.
- S2: You've been given a problem, so you'll think more about the problem and, sort of, all the aspects of it. Like if you want to do an experiment or whatever, you'll think more of what you'll need to put in, what needs to be in there. It's almost more logical.
- S1: Yeah.. Like last year, when writing up a lab report in third year, you would write what you'd found out and stuff, but from last year now I can write, "Well this is how I went about trying to research what I was wanting to find out, this is how I researched into what the experiments I would do. These are the experiments and this is what I'd do if I had more time in the future". So you're not just writing, "Oh, this is what I've done and the results are this!". It's like you're explaining everything and you can bring in lots of different things into the whole. It's hard to explain, I mean, but I just feel much more confident. [...]
- S2: 'Cos, I mean one bit of advice that was given to me right at the beginning of my work placement was that.. I said to this guy, "You know, I feel as if I should know these things", but he said, "Well, don't approach it like that, approach it like you don't [know?] anything and

you're here to learn". That's exactly what I did and it came out absolutely brilliant, well I felt that has.

- I: So they gave you problems to work on and it's helped you understand what you think about the problems?
- S2: Even when you're doing the experiments, like the significance of what, of how you're setting the experiment up, sort of, equal loading and everything like that. I think that's.. I mean, part and parcel of what it is to be a scientist.

Some of the students also commented on the ways in which their placements had helped them to appreciate how science is done in the 'real world' and the ways in which that seemed to differ from their experiences within their taught courses:

#### **B3LP D01 346 - 354**

- S: Yeah. It's much more real [on placement]. It's a different world completely, yeah.
- S: Much more interesting I'd say.
- S: Yeah, much more interesting.
- I: Why.. how's it different? Why's it more interesting?
- S: Real science isn't really about learning it's about, it's about finding, it's about trial and error, discovery sort of thing. Whereas being at university is about learning, it's not really about trial and error.
- S: Yeah, it's back to this whole instead of just learning stuff for the sake of learning it and just memorising it, you've got to think of how it works, you've got to understand how it works. And then you've got to start thinking about how you can change that or play with it or develop it.
- S: It could be any other number of things so then you've got to try and identify which one it is. I dunno, it's something you haven't thought of and you learn that from someone who's being doing it all their life. [...]

#### **B3LP D01 293-305**

- S: Yeah, the placements are excellent. The most I've learnt, I think, is from the placements.
- S: Definitely. I'd agree.
- S: The practicals we have [at university], practical lab classes and stuff like that is just you go and follow a kind of a procedure, it's all in the book, and just try and finish it as quickly as possible so you don't really learn much do you?
- S: I don't think you understand it as you're going through it [...]
- S: Well that's the thing about biology experiments - they don't work first time round -S: No - so the best thing about a placement is when it doesn't work you've got, you know, 6 months to do it in.
- S: You can plan it yourself as well when you're on placement as well which is a big part of science.
- S: Yeah.
- S: [Unclear] lectures, find out how the stuff's done, then on placement you learn - [it] never works!
- S: Yeah.
- S: It takes years to do [unclear] make this one little statement. It's a sentence to make - ah they've discovered this. You realise that took them 20 years to make that statement. Reality and theory.

### **Thinking integratively or synoptically**

The students' comments on the ways in which they were coming to see the interconnections between different topics in the biosciences as their studies progressed seemed to shed light on a potentially important aspect of ways of thinking and practising in the biosciences. At present we

have somewhat less data on this sub-theme than on the students engagement with data and the primary literature, but the findings are at least indicative that integrative understanding may become an important theme as the data collection and analysis progresses. The students' comments seemed to indicate that they were coming to see interconnections within and between topics more often as they progressed into the later years of their studies:

**B1LP V01 224- 227**

- S1: I think with this year though, most of the modules are more integrated within each other, like, a certain logic about oh right, that was covered [...].
- S2: Yeah, there's a lot of interlinking.
- S1: [...] In previous years it was you had this module and then you had another module and they just were totally unconnected. And, like I said, that was bringing people up to speed and now they're kinda trying to weave it in and it is more of a course than just five separate modules.

**B2LP V 01 19-20**

- S1: Yeah we tend to concentrate a lot on specific pathways, cos there's a lot of sort of integration between all the different talks [on this module] and everything we've had [...]

**B2LP JN 02 92-104**

- S1: I think probably the most important thing that I've probably learned over the past years is the ability not just to remember stuff, but to actually think about it. It's not enough to memorise a big bunch of lecture notes, you've actually got to think about what the point of learning this is and ..
- S2: How it relates to other things.
- S1: .. yeah, and how it relates to other things.
- I: And you find that that's required of you, generally?
- S2: Yeah.
- S1: And the problem sessions that we have in this module emphasise that. It's not enough just for someone to sit and tell you, "We did these experiments because", "This is what we decided the experiments meant because." It's what do you actually think that these experiments might mean, rather than just telling you what they do mean. Because you actually have to think about it, it might make you remember it and maybe relate what you've learned to other things.
- S2: Yeah 'cause like when we had the one where we did the papers last week and someone.. one of the papers we had to do was on homologous recombination and we haven't done that since third year..
- S1: Oh yeah!
- S2: .. and it's quite good 'cause you see that you have to kind of go back and think about things that you may have not looked at for a while.
- S1: You can relate what you've learned before to what you're doing now.
- I: And the lecturers make those links too?
- S1: Yeah.

There is also a link back to the previous sub-theme, in that thinking integratively or synoptically seemed to be part of the process when students were interpreting findings or thinking about how to conduct their own experiments:

**B2LP V02 633-649**

- S1: Not only learning the method of technique, but also knowing where is, where to apply it and why to apply and what will, what it will tell us and all that. So, combining things [...]
- S1: But also, how I can combine three techniques for this purpose, and what you said earlier, but also that. How you can combine many things that can lead you to this specific goal. For

example, I'm doing cell cultures. What do I need to do so I can see that, I can see how cells react [unclear], for example.

I: So is it more along the lines of separate bits in the earlier years.

All: Yeah.

I: And then you got asked to learn how to synthesise when you got to third year?

S: Yeah.

S2: First and second year you just need to memorise little points to get the multiple choice answers right. You don't need to learn how it all links together to write an essay on it. Different way of learning within the first two years compared to the next two.

Several of the students also spoke of the importance of seeing what they were studying within a wider context:

#### **B2LP JN02 81-86**

S1: He put what we would be learning into context. The pathologist came in and said "This is what it looks like if someone has this sort of thing". And he puts what you're actually learning into the context of people actually [...] die from this sort of thing [...] So we're not just learning mechanisms and pathways, it actually has a point.

S2: Yeah, I think that's the problem as well, you kind of go through it and you don't really get why you're doing this and why you're studying this and what's gonna be the outcome of it [...] and it helps you to realise that this is actually a real life thing, that you are gonna go out and, as she said, people do die from it.

I: So you can see the relevance of what you're doing. Would you say that's more so because you've done the placement year, or?

S1: I think when you're on - well, I worked for a pharmaceutical company, so all the work that they're doing, they're trying to make money out of it. Like you're in a disease, so they put everything into a disease context, straight away, whereas at uni they don't, they'll teach you the stuff but they may not necessarily put it in a disease context.

S2: In my placement I worked in a research Institute. We were researching into diabetes, but I never really saw the direct correlation with what the actual work that I was doing. Because as you say, like pharmaceutical companies they are looking to make money out of it, so they are going for the disease straight away, whereas in a research institute they are kind of just looking at stuff that is interesting and that is not maybe directly.. So I didn't see that so much because of my placement, it wasn't so direct.

#### **B2LP JN01 183-186**

S: [...] I think just relating things to real life, you know, and when talking about in biology generally I think that if I'm thinking about [a disease], thinking about the lectures, I always relate it back to therapy for [that disease] rather than just the actual, you know, the molecular side of it.

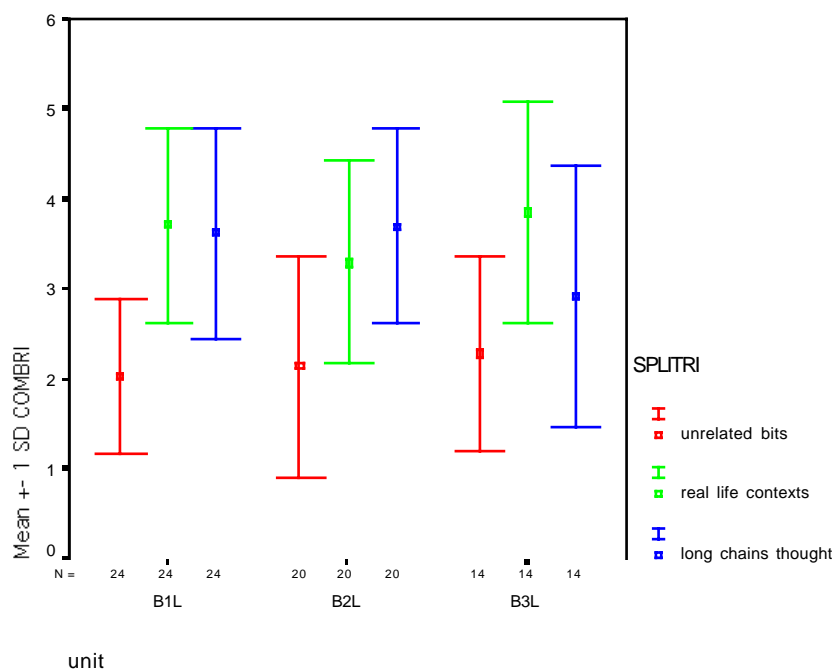
S: [...] I always find it easier to think of biology in a context. I always find it so difficult to think of it in a molecular context but when I thought about it in context related to, like, people or animals or something like that then I always find it so much easier and more interesting as well.

S: Holistic approach rather than just right down to the bare bones.

As might be expected from the above comments in the interviews, the students tended to agree with the ETLQ item 'In making sense of new ideas, I have often related them to practical or real life contexts, as illustrated in *Figure 2* below. They also tended to agree with the item 'Ideas I've come across in my academic reading often set me off on long chains of thought.' This item may seem less obviously representative of interconnective or synoptic understanding, but it does often correlate with other such items in analyses of inventory data. Finally, the students tended to disagree with the item 'Much of what I've learned seems no more than unrelated bits and pieces in my mind', again supporting the interview findings.



**Figure 2** Students' scores on items about integrative or synoptic thinking  
(mean and 1 standard deviation; 5 = agree, 1 = disagree)



### The students' perspectives on 'ways of communicating' in the biosciences

The students' perspectives on 'ways of communicating' in the biosciences can be broadly divided into their perspectives on written and on oral communication. The students had rather more to say about written communication, as only one of the course units in focus in this part of the ETL project included oral presentations. Many of the students had, however, given presentations in other course units or on work placement. In relation to their placement experiences, some of the students also made intriguing comments about learning to communicate in workplace settings.

#### Written communication

In relation to written communication, it was clear that the students felt that their skills had developed considerably over their time at university. Not surprisingly, however, the students did seem to differ in their confidence in their skill in this area and some indicated that they still had a lot to learn:

##### B2LP V02 497-520

- I: Would you feel now if somebody said next year you're going to write a scientific paper or give a presentation at a conference, have you started to feel you could communicate as a biologist?
- S1: No.
- S2: Not yet.
- S3: Don't know the technical language. [...]
- S2: I suppose in my project I was supposed to write something scientifically and I just wrote an essay, 'cause that's how I do it, and when I seen my supervisor's version of the same thing I wrote it was like, 'Wow, can't do that yet, at all.'[...] Well in comparison to his. I only used some

of the work. He [...] referred back to other articles that he's written and other people's work whereas I only did it to my work. [His] was more scientifically written, presented, written in a certain way. Whereas mine was just like the introduction, the method, the results as normally. And his was much better obviously, 'cause he's had more experience in it. [...]

S4: We're trying.

S1: It's just practice I think.

S4: I mean it's only the first time that we're doing something like that, so in the beginning it's always difficult. Further on, we're more experienced. I think we'll do fine, hopefully.

#### **B2LP JN01 214-226**

I: To what extent do you feel that the course and the module are helping you to learn to speak and write like a [bioscientist] [...]

S1: This is all that I've had on learning to do that, so obviously it's been coming on leaps and bounds. But because I'm doing a dissertation, I've got an essay to write, I think it's every fortnight for a tutorial, and obviously when I'm doing past papers then I have to write essays and stuff and read papers that are written in a scientific manner, so I'm learning from that as well so it's a big step. [...]

S2: We've had four years of [written work] so I mean it's been gradual for us you know.

S3: I don't know, but I think most of the learning was really this year mainly in writing and..

S2: Yeah. A lot of the earlier years are learning how to be a student and learning how to study and, to be honest, you would be lucky if you remembered anything from first or second year. I mean it's so basic that you do remember it but, at the same time you'd be lucky if you remembered the details or anything like that!

S3: I think this is the very first year that we actually have the chance to think or to write and speak as a scientist.

While most of the students seemed to agree that they were learning to write in a scientific manner, this was not something that was easy for them to fully explain. Some of the students seemed to be indicating that they had had to come to terms with several different genres of scientific writing over the course of their studies. The puzzlement of the students at site B3 when asked to write in a somewhat different genre (without explicit discussion of the change) gives an interesting insight into their sense of what it might mean to write like scientist or bioscientist:

#### **B3LP V01 116-125**

S1: I've no idea, well the essays are ridiculous questions. [...]

S2: I don't know what to write.

S1: What sort of question's that? It's ridiculous! [...]

I: So you're not very clear how to deal with it?

S1: Yeah, it's not at all I don't know [...] I wouldn't call it a normal style scientific question of problem solving. It's more justification. I'm not too convinced of the actual necessity of that. I mean, it's something different. Maybe it will be good to stretch us to think in a different way but on the other hand [*draws a big breath*] I'm very dubious. I'm not too sure of the purpose or, I mean, you know, what it's supposed to be testing 'cos it's not testing our scientific knowledge, it's just more your ability to rationalise I think.

#### **B3LP J01 168-198**

S: There is write-ups of practicals, which are a very different way of writing.

S: You get more scientific in your writing, you don't get very good at, you know, writing lots of flowing things ...

S: Opinions and stuff.

S: But then we're not told if this essay, if they want opiniony type stuff, or if they want ...

- S: It's all personal interpretation.
- S: I don't know, though. [...]
- S: But I think that could be quite factual, that could be very factual. The one we did last year, mine was really fact-based and I don't know. [...]
- S: I asked, for my other one I asked 'cos it's only a one thousand five hundred essay and it's on a very very big topic, and it's all about biochemical ethics and so it's generally a discussion about your opinions, but also I didn't know whether I was supposed to bring in like background as to how it actually works or anything like that. When I emailed her she said no, you make it opinionated and a very small factual, so I did.

**Table 4** Summary of the students' descriptions of 'writing like a bioscientist'

Own view based on evidence	A scientific style of writing	Other aspects
Provide and interpret evidence	Use terminology correctly	Structure appropriately
Expose conflicting evidence	Be concise and to the point	Analyse at an appropriate level
Relate theory to data		Think about your audience
Use primary sources		
Acknowledge your sources		
Be objective		
Be precise		

The broad elements mentioned by the students in relation to writing like a bioscientist are set out in *Table 4*. As with the findings reported earlier, we will require further data collection and analyses to explore and substantiate some of the points made here. The students typically indicated that writing in the biosciences involved putting forward their own views based on evidence. Although, as should be apparent from the findings presented earlier in this section, this was not always a straightforward matter.

Some of the students went on to explain that they were learning a particular 'scientific' style of writing for their written work which involved, for example, using terminology correctly and being concise and to the point. The student quoted below was the only interviewee who indicated rejection of this style:

**B3LP V01 66-67**

- S1: It's so boring [...] You're trying to do it in a certain scientific style. You've got this ridiculous stuffy ancient scientific style that you have to do to be accepted in the scientific community and we're expected to produce pieces of work in the same style, you know, using time-old traditions in science [...]

In relation to their use of scientific terminology it seemed that at least some of the students were required to engage with two rather different forms of language in their studies, one being 'lab

slang' and the other the formal use of terminology required in their written work:

**B2LP V02 561-569**

- S1: And for me, okay, the hardest part is going to be we cannot use any lab slang. So, we cannot say, "Well, we put to the proteins to centrifuge", we have to say, like "we pelleted the protein", but I mean for everything. Like we cannot say, "We did the PCR", we have to say, "And then we ran the, whatever, reaction." So, it's really technical, and it's really a good command of the language.
- I: [...] So I suppose you are gradually learning lab slang as you go along, but not the other.
- S2: Not the other.
- S3: We won't really use it until it's actually in the article, when you write it, that's it.

The importance of concise writing was mentioned in a number of different interviews:

**B1LP JN03 127-128**

- S1: Well that's generally what we have to do, is write as concisely as possible and to the point.

**B2LP V01 259-260**

- S1: Like concise writing. This would be the key point for it, straight to the point, don't muck around too much. I think it's the best.

**B2LP V02 211-212**

'Cause last year in the exams we could just write basically anything, and now they want something totally specific and if it's not specific then it's not really important, shouldn't be included [...]

We have not yet completed a full analysis of the students comments about learning to structure their written work in more meaningful ways, but an indicative extract is given below:

**B1LP JN01 77-81**

- I: And, in terms of communicating, to what extent have you learnt to speak and write like a [bioscientist]?
- S1: [...] All the way through the years, I've found that I've tended to kind of list. I've found a lot more flow. This year I seem to be able to have more of a story and be able to relate my experimental evidence a lot more to the theory. I feel I'm a lot better at it now.
- I: Can you pinpoint what's made you better?
- S1: What's made me better? [I: Yes]. The amount of essays I've done! Yeah there's so many, and plus that I find that I am really enthusiastic about what I do. So I try, I'm always trying to find ways of bettering what I've done before.

There were only brief comments in these interviews about audience, and about level of analysis in written work:

**B1LP JN03 127-128**

- S1: You expect the people reading it are going to have that basic understanding so you don't need to explain the basics, you just need to get to the point of what you're talking about. Em, I suppose not to be too afraid of being overly scientific about it, because, if it's going to be read by peers and they'll be able to critically assess it that way and understand it easier too.
- S2: Yes.

**B2LP V02 274-279**

- S1: How do you explain it, at a molecular level rather than more general, that's important as well, that's what they wanted us to do.

## *Oral communication*

In many ways, the students' comments about oral communication echoed their discussion of their written work. The students tended to indicate that they had developed some skill in oral communication, but that they still felt that they had a lot to learn. Several of the students indicated concern with the appropriate use of language and with the needs of their audiences. The students also emphasised the importance of the evidence underpinning their presentations. These aspects are not considered in detail here, as the data on oral communication from these particular interviews is somewhat limited.

As in earlier research into oral presentations carried out by two of the authors (Hounsell and McCune, 2001) one distinctive feature of these oral presentations seemed to be the opportunities they afforded for questions following the formal presentation. Like the students in our earlier research, these final year students were sometimes more daunted by the idea that they could be questioned, than by presenting per se:

### **B2LP JN02 124-125**

Because it might necessarily not be the standing up and the talking that terrifies you, it might be the having to answer the questions if you're put on the spot after your presentation.

### **B2LP V01 247-249**

- S1: Obviously you can't prepare something the night before and then expect - obviously, if you really know your subject too right you'd probably could - but for ourselves it's obviously more beneficial to prepare something a week or so in advance and then obviously go over the notes and everything. So you can go on and if someone asks you a question you're not gonna lose your place or whatever.
- S2: Yeah, that's I found as well. That the lecturers, because they do know everything about the topic, you know that you can't go in to give a presentation completely blind, you need to basically have researched everything, 'cos if someone asks you a question and you can't answer you gonna look really unprofessional.
- S1: Oh God, yeah!

One important point to make in relation to this particular data set is that some of the students seemed to be learning about forms of oral communication other than formal presentations. In the following extracts, the students discuss communication in placement settings:

### **B2LP JN02 127-136**

- I: That was interesting what you were saying about using different language for different audiences. Can you tease that one out a bit more?
- S2: Yeah, to people you see in the office every day, you consider them to be sort of like friends, people you work with, who you see on a regular daily basis, whereas the whole department you would maybe only see them, walk past them in the corridor, and you don't necessarily work with them all the time [...] they have their own subject area that they work in [...] so you would have to give them a lot more background information than necessarily you would with people who work on the same thing as you. And also in our department, each group worked on a different area [...] So if you went to the department meeting someone would maybe say, "Oh that's an interesting technique, I would consider choosing that" or, "Oh you've had a result that might relate to what I'm doing in the lab". So you would sit down and discuss how maybe we could correlate, get together and correlate our results and sort of work something out from there.
- I: Can you actually give an example of, say, the different kinds of communication, the different forms that you would use for different audiences?

- S2: Well, for the group meetings we would just be sitting around the table having a chat, it wouldn't be a formal presentation or 'polished' results. You would just say, "This is the preliminary result I got from such and such an experiment, what do you think of this, is there something I could improve in my experiment?". Just a general chat. Whereas if you move up to sort of department meetings it would be 'polished' data that you're presenting in a formal manner, so you would have to sort of be able to say, "These are the experiments that were done and these are my results. I had a chat with people in my group, they suggested that I should do this, so that's what I did and here are my 'polished' results".
- S1: More like a kind of seminar type thing rather than just a group.
- S2: Yeah, just a general chat.

#### **B2LP V01 271-272**

- S1: I think as well, you're not gonna put any results into a bit of scientific writing that you've not already discussed with somebody. You're not gonna be just putting it in blind and just going on, "Oh, this is what I think". You're gonna have talked to at least three or four other scientists and if they had disagreed with you then you're gonna try and find out, 'Well, someone doesn't think this so I'm not gonna put it into my report already, I'm gonna find out whether they are right or wrong'.

#### **B2LP V01 178-179**

- S1: [Placement] is the best thing I could have done for my degree. If had stayed on and rushed on just on fourth year, I wouldn't have known anything really about the whole background of science. I'd be like, 'Oh, here are the facts that we've been given', but I wouldn't have a clue about how people went around doing it, or I wouldn't know about how companies worked. You know, you're being taught the science but you don't know the bigger picture, and when you do your work placement you get to find out everything about it, and how it all works and how everyone can just phone up other scientists that they know are on the same field and just ask them for help and stuff. [...] The knowledge is in the people's heads rather than in books, so you know to go and ask someone about something.

#### **B2LP V01 201-218**

- S1: Yeah.. I think the major thing is that [the placement] has made more confident in talking in front of other people and integrating myself into like groups of scientists, you know, with students I couldn't. In third year I had one friend on my course and that was it. I just went to uni and just left it behind me. But now [...] you're talking to lots of different scientists and it's more beneficial if you get involved and it has just given me much more confidence than I had.

### **The students' perspectives on 'ways of thinking' in the biosciences**

The first point to be made here is that not all of the students agreed that there was a distinctive 'way of thinking' to be learned in studying within the biosciences. At one extreme, the student quoted below suggested that there was no clear distinction between the biosciences and other non-science subjects that he had studied in terms of ways of thinking:

#### **B1LP D01 88-100**

- I: To what extent do you feel now you've learnt to think like a biologist or a bioscientist?
- S1: No, I don't think so at all. I've been a student for some time. I've studied law and accountancy and it's very similar, you do exactly the same for law. Find the evidence, write what you think and present a summary of what you believe. Exactly the same, no change at all.
- I: Exactly the same as a biologist?
- S1: Same with accountancy, often what you're looking at is variance analysis. Very similar. [...]
- I: Presumably there are some techniques and procedures particular to bioscience, collecting evidence, some of the lab work I guess is specialised?

- S1: Yes but you're just looking for proof, I mean, if you're putting forward a theory or a hypothesis and you're proving it by doing experiments, so it's just exercises in logic isn't it?
- I: And law is the same?
- S1: Sure.

Some of the students did talk about the ways in which the biosciences were distinct from other subjects, as in the second quote below, but did not necessarily consider that the ways of thinking with which they were engaging were entirely different from some non-science subjects:

**B1LP JN02 49-52**

- I: That leads on quite nicely to the next question and that is, to what extent do you feel you've learned to think like a [bioscientist]?
- S1: I think biology's not so scientific, like maths or physics, because maths and physics it goes very logical thinking. But biology is not such a thing, especially some aspects of it like evolution or something. It's more like philosophy to some extent. I've talked to students from computer science and maths and physics and their thinking is different. Quite logical I think. Straight, not looking at things from different aspects as in philosophy I think. So I think biology is to some extent like literature subjects, that's what I think.

**B2LP JN 01 186-188**

- I: We're interested in how people learn to think like a biologist. To what extent do you feel that you have learned to think like a biologist?
- S1: Ways of thinking, pictures - pictures, pictures, pictures. Biology's all pictures and diagrams. That's the best way. [...] one of my friends was writing, in politics, was writing an essay and I looked at it - no it wasn't, it was the lecture notes - I was looking at the lecture notes and I was just, like, I'd actually never seen a lecture note that was just writing. The whole page was just writing, the whole entire thing. [...] it was really bizarre. [...]

Finally, some of the students focused on distinctions within the biosciences:

**B2LP V02 187-203**

- I: You were saying a little bit earlier about the people thinking in different ways. Can you maybe say a bit more about that?
- S1: Because we have different backgrounds and we are naturally interested in different things, people see the same lecture as a completely different thing. And for instance it was, okay funny, because first lectures in biochemistry I felt really like, 'I'm so stupid, I don't understand anything of this.' It was all chemistry and mathematics, but then they start from the molecular biology part and I see that everybody else was thinking exactly how I was feeling in the beginning because they are all biochemists. And I was feeling, 'This is dead easy. This is just you know really, really easy.' And so we start discussing this and see how people really do feel the things completely in different ways. And they see the things much more in chemistry terms, and I see the things much more in pathways, and what's happening and stuff. And so everything that has to do with this I understand very easily. And they understand very easily when people say, "Well and then there is this ligations. And the molecules interact in this way." And it's just completely different views of the same thing actually. [...]
- I: So [molecular biologists'] thinking that's more about things like pathways, seeing how things connect to one another, and the chemistry's like some small parts of that?
- S1: Yeah.
- I: How about the others? Do you see things in one of those particular ways?
- S2: Obviously we see some things different because chemists for example, know some more specific things, for example in Krebs cycle, that I don't know all the enzymes that are involved. And I see some other things, like for example, PCR, how it is done. [...] we understand some things better, and biochemists understand other things better. But I don't think there's a different way

of thinking in general, as concerns biological issues. It's just that they know some things more, and we know some things more. But I think that the general idea is the same. I don't know. That's my impression. Because we all started from the same background and then we evolved in other things. [...]

S1: I don't think we see things all in the same way. I really don't think.

#### **B3LP J 01 377- 385**

I: So do you think of yourselves as biologists?

S1: Biochemists. [*others agree*]

I: Sorry!

S2: There is such a big difference over biochemistry [...] Biochemistry is a unique subject and people don't realise that. They see biochemistry and think that you're half a biologist and half a chemist and that's SO not what it is, it's a real big misconception.

Whilst not necessarily seeing the ways of thinking that they were learning as being different from those they might learn in other areas, the students were nonetheless able to talk at some length about the ways of thinking that they were developing in engaging with the modules under consideration in the ETL project, and with their studies in the biosciences more generally. *Table 5* sets out the main aspects of the students' accounts of these ways of thinking. It is important to note that the data we have supporting the inclusion of all these various aspects varies in its extent and that they represent only these students' perspectives on what might be included within 'ways of thinking', rather than everything that might be encompassed within this theme.

*Table 5 Summary of the students' descriptions of 'ways of thinking'*

<b>Engaging with evidence</b>	<b>Integrative or synoptic thinking</b>	<b>Other 'ways of thinking'</b>
Understand how evidence is generated	Make interconnections within topics	Use visualisation
Be able to design your own studies	See the links between topics	Think systematically
Know that interpretations are contested	Consider the wider context	
Know how science is done in the 'real world'		
Form opinions based on evidence		
Think critically about evidence/interpretation		

The first two sub-themes in Table 5 have been considered earlier in this paper. When the students were asked whether there was a distinctive way of thinking that they were learning, and about what that might involve, several of them referred to engaging with evidence, or to integrative or synoptic thinking. Within the sub-theme "other 'ways of thinking'" the idea that thinking like a bioscientist involves visualisation is strongly expressed by the students quoted below:

#### **B2LP JN01 186-201**

I: We're interested in how people learn to think like a biologist. To what extent do you feel that you have learned to think like a biologist?



- S1: Em ways of thinking, pictures - pictures, pictures, pictures. Biology's all pictures and diagrams. [...] I never write sentences in lecture notes, it's always molecules and pictures! [...]
- I: So the visual side works for you?
- S2: Yeah. I think a lot of biologists are very visual because you have to, because you're not seeing anything, you know what I mean, you have to visualise it in your head.
- S3: [...] yeah, 'cos it's so hard to see things, mainly with molecular biology 'cos things are so small, you do really have to draw them in a bigger scale so that you can really understand what do they mean and how can they possibly work. So I think, I'm agreeing with what [S2] said, to be able to visualise things and draw them there. [...]
- S2: But yeah, it's difficult to learn biology in words.

While this aspect was not discussed extensively by the other students, some sense of the importance of visualisation can be seen in the following extract where students are talking about the value of PowerPoint for communication in the biosciences:

**B2LP V01 233 -237**

- S1: [...] I think the way that scientists communicate now, by using PowerPoint, is so much easier than just standing up there and talking, if you can see something and the way the animation acts has helped.. Sorry, is that what you were asking?
- I: Yes, that's correct.
- S1: Yeah, I think the way you see, they can make one protein go and interact with another one on the screen with PowerPoint.
- S2: You can see it rather than trying to picture it in your head and maybe getting things wrong in your head, and then that just messes up everything.

The extent to which thinking systematically is seen by students as important aspects of thinking in the biosciences will only become clear with further data collection. The extract below simply provides an initial indication that this might be relevant:

**B2LP JN01 191-192**

- S2: And systematically. It's such a systematic course. [...] I only just sat down last year to learn amino acids [...] so I sat down one day and just systematically organised how, like, in size of all the amino acids and then just, now I can draw them all.. draw all the amino acids and I remember all the things [...]

## **Students' Perceptions and Experiences of the Teaching-Learning Environment**

### **Introduction**

This section of the analysis is concerned with features of the teaching-learning environment in the three course units, as perceived by the students, that seemed to work for or against the pursuit of high-quality learning — and of ways of thinking and practising in particular. From the vantage-point of constructive alignment, it looks at the alignment with high-quality learning of teaching-learning activities on the one hand, and on the other, assessment and feedback. It also identifies a hitherto unexplored, yet potentially important aspect of teaching-learning environments: students' experiences of adjustment to teaching-learning and assessment requirements at honours level.

## TLAs and Alignment

There was a considerable degree of commonality between all three course unit settings in their teaching-learning environments as experienced by students. All three modules were perceived by the students as offering a well-organised, supportive learning and teaching climate in which teaching staff were enthusiastic and approachable, and in which interaction between students was encouraged. This is evident in the mean sub-scale scores summarised in *Table 6* and *Figure 3*, notably those for 'organisation, structure and content', 'alignment', 'integration of teaching and learning materials', 'encouraging high quality learning'; 'staff enthusiasm and support', and 'interest, enjoyment and relevance', all of which are above the mid-point on the scale. It is also apparent in many of the interview comments which follow below.

*Table 6 Means and Standard Deviations for ETLQ environment sub-scales in the three course units*

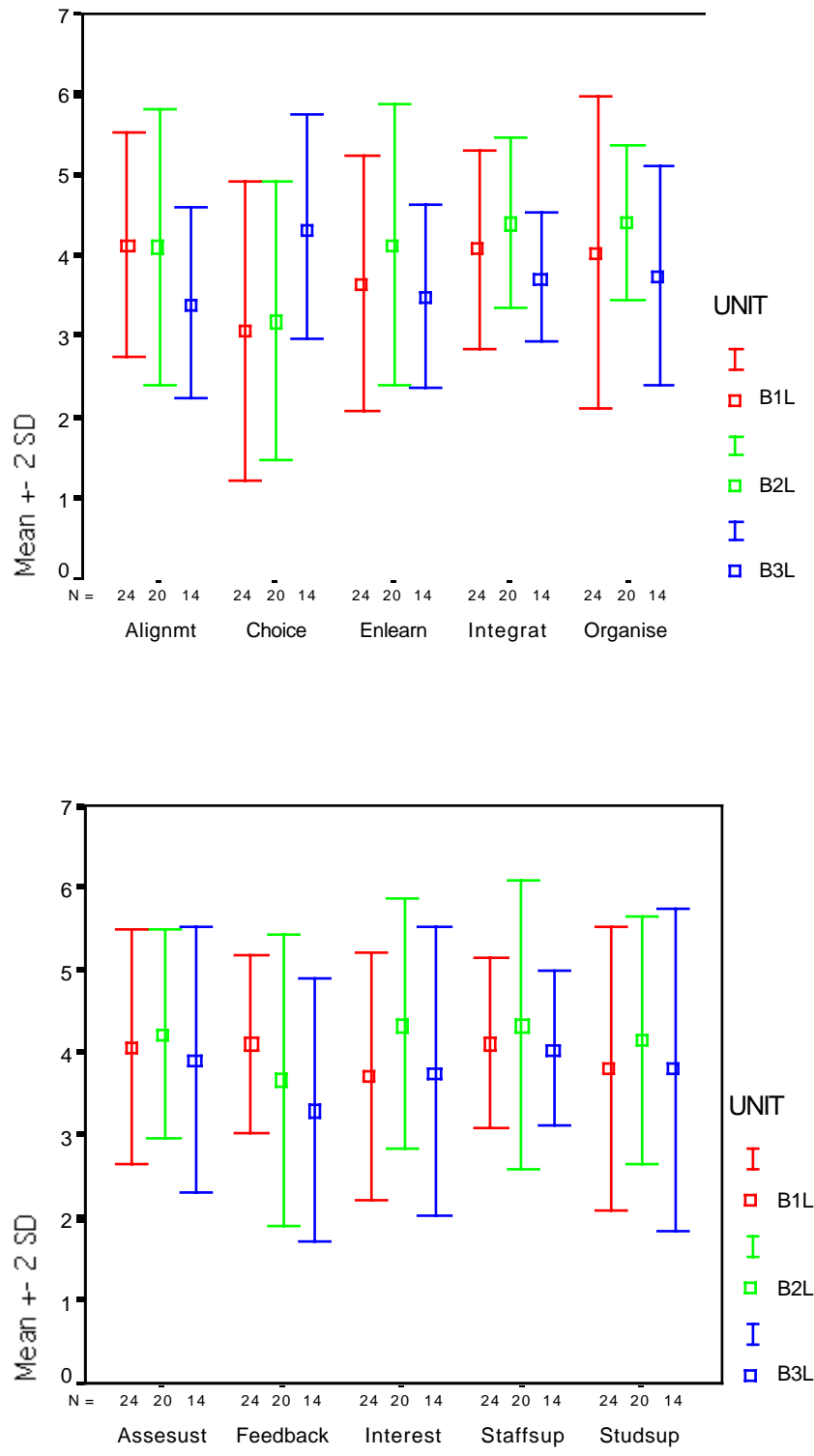
COURSE UNIT SUB-SCALE	B1L (n=24)		B2L (n=20)		B3L (n=14)	
	<i>mean</i>	<i>SD</i>	<i>mean</i>	<i>SD</i>	<i>mean</i>	<i>SD</i>
organisation, structure & content	4.06	.97	4.43	.47	3.76	.68
alignment	4.14	.69	4.12	.85	3.43	.59
integration of teaching & learning materials	4.10	.62	4.42	.53	3.74	.40
choice	3.08	.93	3.20	.86	4.36	.69
encouraging high quality learning	3.67	.78	4.14	.88	3.51	.57
clarity & feedback about assessment	4.12	.54	3.68	.88	3.31	.80
assessment for understanding	4.08	.71	4.24	.63	3.93	.79
staff enthusiasm & support	4.14	.52	4.35	.88	4.07	.47
support from other students	3.83	.86	4.17	.75	3.81	.98
interest, enjoyment & relevance	3.73	.75	4.35	.76	3.79	.89

However, while all three course units were viewed positively by their students in these various respects, each differed markedly in the teaching-learning strategies adopted to pursue high-quality learning outcomes, as *Table 2* above had indicated. In B1L, a traditional approach was followed which combined twice-weekly lectures with regular tutorials in which students had an opportunity to raise questions and issues which were concerning them:

### **B1LP JN03 131-133**

- S1: It is a really good module [...]. It all interlinks.
- S2: Yeah, with the lectures you're able to see it coming together...because of the relevance regarding how the science is applied, and how the basis of the science can be used to understand new concepts, so that helps bring that sort of process together.
- S3: Same here.

Figure 3 Means  $\pm$  two Standard Deviations for ETLQ environment sub-scales in the three course units



### **B1LP JN02 10**

- S1: We were given a very clear subject guide, lecture guide, and before we started [the lecturer] told us exactly where we were going to be, what sort of topics we were going to be investigating [..] And [the lecturer]'s tried to link it closely to some of the main textbooks, so that they're set out in a similar fashion, so that if we have trouble we can go to the textbooks.

In B2L, the first part of each three-hour session consisted of a talk by an external speaker from a biosciences research institute lecture. For the second part of the session, students were given data generated from the guest lecturer's work and assigned problems or questions arising from the data which they worked on in small groups prior to plenary discussion:

### **B2LP V01 25-26, 31**

- S1: What I enjoyed most about it is that we've had a lecturer for each different topic. It's been a different lecturer, so it's been someone whose really keen on the topic and who really knows everything about it and is working on it [...]
- S2: [...] The way that it's been taught as well, that's been really good, especially where it has been split into two. This is the first module I've had that's been sort of split into both lecturing and a problem solving session at the end.[...]
- S1: Because we get the half-hour break or twenty-minutes break between each section, we always find ourselves just sitting and talking over the problems [...] because we get them beforehand. [...] So we are just looking at them and just kind of talking through the stuff that we've learned in the first half, so that you learn it a lot better if you discuss it with other people.

### **B2LP V02 52**

- S: And so it's really good to have people who [...] are actually specialised in the lecture that we are you know being given. [...] And then the way that you know they divide off, [a] section lecturing and then the other off doing something really [...] different like discussions and problems. This makes us really think about things and not just be like passive, you know, attending a lecture.

### **B2LP JN01 19-23**

- S1: Em, the problem solving sessions we have at the end of this module are [...] one of the most helpful parts of this option.[...]
- S2: I would agree with that.
- S3: Yeah I entirely agree with you as well, that the problem-based sessions are quite important.
- S1: Also what's good about [the problem solving sessions] is that, when you go through the lecture and you're learning it all and you're maybe not taking it in as much if, you know what I mean, it's just a lecture. But then once you read through the problems and then you have to actually think through the lecture, or flick back through your notes and think about everything you've been taught, so it kinda consolidates it all just at the end of the lecture. Em, make sure that all the points that people don't understand are brought up and things, it's quite good.

And in B3L, the weekly seminars took the form of presentations by two of the students, addressing one of ten topics drawn up by the two members of staff. Each 45-minute presentation was expected to include overhead slides and a short handout and was followed by questions and discussion:

### **B3LP J01 5**

- S ...We haven't actually had anything taught to us by the lecturers, it's all been taught by the students. It's all been around research which we've never had before like until the final year.

### **B3LP D01 29-36**

- S: It's the first time we've done seminar courses. [...]
- S: Normally it's sort of exams and then practicals (unclear) the practicals but then I prefer it because you don't have to do the exam basically.

- S: Definitely yeah!
- S: It's a nicer way of learning. It's less forced, it's more.. you know, you research the topics that you like sort of thing. Sit back and enjoy!
- S: You actually get Christmas.
- All: Yeah.
- S: Which can only be a good thing! Than spending it revising Boxing Day, Christmas Day - it's a pain.

#### **B3LP V01 34-35**

- S: I think it's actually quite useful too, that you're given a topic which you don't know anything about usually and you have to actually concern yourself with it and research it [...] And also when other people present it, em it's quite nice because it's different to lectures and you learn that, especially in this module, about the usefulness of certain applications or yeah certain techniques.

### **Alignment of Assessment and Feedback**

As with teaching-learning strategies, so too were assessment regimes strikingly different from one another, both in the assessment methods used and in the balance struck between end-of-module examinations and formally assessed coursework. In B1L, there was a mixed economy: assessment was based on a three-hour examination which contributed 60% of the final grade together with two coursework assignments, each of which counted for 20% overall. In B2L, by contrast, assessment was based solely on a three-hour examination paper, while in B3L, it was wholly geared to coursework, combining marks for the students' seminar presentations (including contributions to the ensuing discussion) and grades for two 1500-word essays on questions set by the tutors.

Given these variations in methods of assessment, there were also, not surprisingly, related differences in the potential for students to get feedback on how well they were doing. On the face of it, the students in B1L and B3L had appeared to be much better-placed, since the two coursework assignments which students in both groups were required to submit, (and the seminar presentations given by B3L students) seemed to hold out the prospect of *extrinsic* feedback (Laurillard, 2002), while the B2L students had had no such opportunity. However, on closer scrutiny, the B2L students' experiences turned out to be much more positive.

For these latter students, it seemed, there were good opportunities for *intrinsic* feedback — in Laurillard's distinction, the kind of feedback which is not provided in response to a formally assigned task which has to be completed in the students' own time, but which is, rather, embedded in day-to-day teaching-learning activities and arises spontaneously and integrally in student-tutor exchanges. Such intrinsic feedback was available in the problem-solving sessions, which enabled the students to gain repeated practice in tackling problems grounded in authentic data, and to check out answers with one another and with the lecturers and module coordinator. Thus, as the extracts below indicate, they felt they were well-prepared for the kinds of questions which would be set in the exam; they had 'the basis for you to succeed' and would 'know what the module coordinator was looking for in answers'. A further source of guidance as well as reassurance was the ample website for the course unit, which included model answers and past exam questions.

#### **B2LP JN01 19**

- S: The problem solving sessions we have at the end of this module , [...] they're something you don't get in all the modules and it's [...] really helpful especially for one of the papers in the exam, the problem solving bit.

## **B2LP JN 02 64-69**

- S1: I've looked at one [exam paper] and it is quite good. [The module coordinator] asks all the people who've lectured to write an exam question specific to what they think you should have gained from their lecture, and then she decides which [...] would be the most appropriate, to sort of give you a wide range of questions in the exam. And I think it's quite good the way that the sessions are run, so you've got one subject then another. Some of them overlap so, even if say you didn't turn up for one of them, or you didn't really understand one, there might have been another session somewhat related to what you've learned that could help you maybe to answer the question about that. So even though [...] one person teaches this, one person teaches that, they do all sort of interlink. And I think that will be good when it comes to the exam.
- S2: Yeah, 'cause you can kind of bring points in from different lectures, although a question might be kind of related to one particular session, you can also bring in points. And I think that's what they are looking for as well, is that you can bring in different points from different sessions and not just kind of look at one session and answer everything that you've learned in that.
- S1: Yeah, it's not just memorising something, and you've got tunnel vision and you just regurgitate stuff. You're actually thinking "Oh this could be related to this, this could be related to this".
- I: So you feel you're getting enough guidance there, in terms of what the exam will be covering?
- S1: Yeah, we do. There's stuff on the internet, like (unclear) websites and stuff that says 'this is how you should go about this sort of thing'.

## **B2LP V02 379-387**

- S1: You've got your [unit handbook] that tells you all your references and learning objectives for each lecture.
- S2: And the lecture actually itself, and then afterwards it's like discussions been done and then you've got the reference and I think there is objectives as well in this.
- S3: And even answers to the problems that we've done. And the discussions afterwards. If you miss anything during the lesson you have it.
- I: So everything you know is there and you know exactly what you have?
- S4: I think it's really demanding because you have to think and you have to do a lot of work for it, but in the end, it's, they also give you like the basis for you to succeed I think. If you do work of course. So it's good.

## **B2LP V01 113-117**

- S1: We've not been given anything, really, in the Cancer module to do with the exams. But I know that [name of module coordinator] has got something on the website on how to answer the questions and giving example answers.
- S2: Yeah, it's all the past exam questions from something like 98 onwards. I mean, I was quite surprised when I got the e-mail, like, just before Christmas and everything, and I went to the website and just seen this whole, like structure of stuff [the module coordinator]'s got all set up and everything for the module, which I thought was really good.
- S1: Yeah, lots of links to other cancer-related websites.
- S2: And even to the, sort of, recommended reading. [The module coordinator]'s got links to the journals and stuff, they're all up on the website, which I thought was really good.
- S2: So when it comes to studying I don't think we'll have a problem accessing any information at all, I think it will be there and we'll have examples on how to answer the exam questions, and we'll know what [the module coordinator]'s looking for in answers, so . . . Even though we've had no assessments, I think this is probably gonna be one of the easiest exams to study for . . .  
(laughter)
- S3: . . . This year anyway

In fact, both the B1L and the B3L students also had some opportunities for intrinsic feedback — the former in their tutorials, where they were encouraged to raise questions of their own; the latter, to a more limited degree, in the post-presentation discussions. But the potential for extrinsic feedback in both these course settings proved problematic. For the B1L students, any feedback on their two assignments – in the form of a grade and comments – would not be forthcoming until after the end-of-module exam (a practice which seems fairly commonplace in some UK universities and seems to reflect concerns about communicating provisional marks to students prior to formal examination board meetings). The levels of concerns about deferred feedback were especially apparent amongst the MSc students who, unlike their BSc counterparts, had no past experience of feedback in the department to draw upon and were understandably anxious to know whether they were operating on the right lines. (In the following extracts, MSc students are asterisked.)

**B1LP V01 195-204**

- I: And are you expecting quite good feedback on the assessment?
- S1: I'm not sure how that works this year because all the courseworks are due just before we go off for Christmas break and we've got exams when we come back. Like, previous years, we have had courseworks back so we have a grade and we can have an idea in our head what kinda grade we're sitting on, but I'm not actually sure if we're gonna get any feedback before the exams.
- S2: That's another problem as in some of the courseworks we've done in the past we haven't actually got a grade so you don't have a clue what you've to do for the exam.
- I: And the feedback you've had in previous years have you learnt a bit from that, has that been..?
- S1: Yeah. I would say so. I would say more last year. I think last year, because there was such a big jump from second year to third year.
- S3: Yeah, there was a lot we hadn't been told about what exactly you had to put in your coursework.
- S1: Styles and things.
- S3: So this year, well we know now what exactly they're looking for.

**B1LP JN 03 60-66**

- I: What kinds of guidance or feedback are you expecting on your assignments when you do get them back?
- S1: Well, usually, if you're handing things in this late, we don't usually get them back, really. By the time they've taken them away over the Christmas break and they get back, sometimes some lecturers are really bad for marking and it takes them weeks, so sometimes you don't even get feedback and it's just waiting for your overall grade for the module...to see how well you've done, which is quite bad, actually.
- S2\*: Yeah, it is, because you need some sort of gauge, before you go into your exams, of how well you're doing, you know, because if you know you're doing really badly, then you've still got time to get help.
- S1: Yeah.
- S2\*: And, if you're doing well, then you know what you're doing's right, you know you're on the right track.

**B1L PJN 02 37-39**

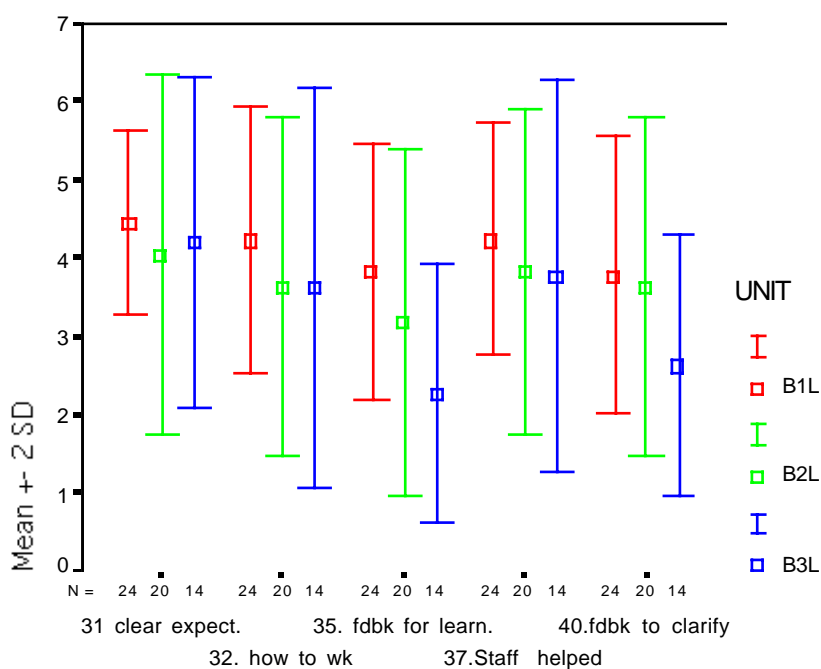
- S2\*: I've never done any coursework in English, so I hope if I can get any feedback, it's what part is insufficient, or structure, or language, that it will tell me how to improve. Not just grades, but to know where I can improve it and how. That's what I want to get.
- I: (to S1). Yourself?
- S1\*: I probably want something similar, really, telling you exactly where you've gone wrong. Actually, instead of telling you where you've gone wrong, how you could actually improve.

For the B3L students, feedback was rather more problematic. As *Table 6* above showed, their overall mean score on the 'feedback' sub-scale of the ETLQ was lower than those for B1L and B2L students. A comparison of the scores on individual questionnaire items is also illuminating, as *Table 7* and *Figure 4* indicate. None of the students agreed or strongly agreed with the statement 'The feedback on my work helped me to improve my ways of learning and studying' (Q.35, mean = 2.3, standard deviation = .83), while only one student agreed with the statement 'The feedback given on my set work helped to clarify things I hadn't fully understood' (Q. 40, mean = 2.6, standard deviation = .84). To some extent, it should be noted, these scores may reflect the fact that the students had not submitted their essays for the module at the time when they were

*Table 7* Item Means and Standard Deviations for the ETLQ 'Feedback' sub-scale in the three course units

COURSE UNIT	B1L (n=24)		B2L (n=20)		B3L (n=14)	
	<i>mean</i>	<i>SD</i>	<i>mean</i>	<i>SD</i>	<i>mean</i>	<i>SD</i>
31. clear expectations	4.46	.59	4.05	1.15	4.21	1.05
32. how best to work	4.25	.85	3.65	1.09	3.64	1.28
35. feedback for learning	3.83	.82	3.20	1.11	2.29	.83
37. staff support	4.25	.74	3.85	1.04	3.79	1.25
40. feedback to clarify	3.79	.88	3.65	1.09	2.64	.84

*Figure 4* Item Means  $\pm$  two Standard Deviations for the ETLQ 'Feedback' sub-scale in the





interviewed, and thus would not yet have had opportunities for feedback on that part of their assessment. Feedback did, however, seem to be a concern that these students had about their studies more generally, rather than something that was specific to the Enzymology module, as the interview data indicated.

The interview data also suggest that the students' concerns extended beyond simply a desire for improved feedback, but instead spanned a cluster of interwoven issues relating to guidance about tutors' expectations for assignments, an understanding of assessment criteria and their application, and ground rules for advice-seeking, as well as to the communication of marks and comments. Before considering the interview data on these issues, however, the other and much more positive item scores in *Table 7* and *Figure 4* should be borne in mind: clarity about what was expected in the assessed work (Q.31, mean = 4.2, standard deviation = 1.05); encouragement to think about how best to tackle the set work (Q.32, mean = 3.6, standard deviation = 1.28); and provision by staff of support needed to help in completing the set work (Q.37, mean = 3.8, standard deviation = 1.25).

### *Guidance on Assignments*

As far as their oral presentations were concerned, the B3L students appeared to be both satisfied with the guidance they had been given and with their grasp of what was expected of them.

#### **B3LP J01 203-213; 281-282**

- I: Were you given general guidelines about how to do [the presentations]?
- S1: We were at the beginning, weren't we?
- I: So you had some idea what was expected of you, then?
- S2: Um, and they gave us just starting materials, like lead references and where we could go.
- I: For each individual seminar?
- S1: Yeah. [...]
- I: And you produce a handout as well? Is that something you're supposed to do?
- S3: Yeah, we were told, and they've all been quite different, like we had to do the first one and ours was very different to what's been, like the last few have been quite similar in their style of what they've included whereas we were told at the beginning that we just, you know, it just had to be a list of references. I'm sure they said that at the beginning.

However, in two of the three interviews there were indications of uncertainty about what was expected in the two essays which the students were due to complete by the end of the semester. A lack of past experience of (and present practice in) writing essays, together with a perceived paucity of feedback on those essays which had been submitted for other modules, also contributed to their uncertainty.

#### **B3LP V01 116-127**

- I: What would it take to do a really good essay for this course? What would be important?
- S1: I've no idea, well, the essays are ridiculous questions. I mean it's one of the questions is em why is —
- S2: — An enzyme a protein?
- S1: Yeah, why is an enzyme a protein?
- S2: I don't know what to write.
- S1: What sort of question's that? It's ridiculous! [...]
- I: So you're not very clear how to deal with it?
- S1: Yeah, [...] I don't know, [...] I wouldn't call it a normal style scientific question of problem

solving. It's more, justification. I'm not too convinced of the actual necessity of that. I mean, it's something different. Maybe it will be good to stretch us to think in a different way but on the other hand [draws a big breath] I'm very dubious. I'm not too sure of the purpose or, I mean, you know, what it's supposed to be testing 'cos it's not testing our scientific knowledge, it's more your ability to rationalise, I think.

- I: And have you been given any guidance for the essays – about how you might go about [them]?  
S2: I think you can ask, maybe I will go and ask him what he would expect because I don't know what to write at all.

#### **B3LP J01 153-161**

- S: We don't have much kind of guidance on how to do essays.  
S: – Like none!  
S: But we don't get any kind of like, you know, sit down and explain, or like, 'cos I mean the last time I wrote anything was GCSE when I was sixteen. 'A' levels are so specialised that you kind of forget how to write essays, and yet they are important and yet you don't get feedback and you're not told, I don't know ... I think that's one flaw.  
S: Or perhaps if we had some more of them.  
S: Yeah, start them early so we'd had practice by now.

### *Understanding Assessment Criteria and Their Application*

There were also indications on the part of at least some of the students that (despite the guidance given in the opening session by the module coordinator) they did not have a clear grasp of the range of criteria which would be used in assessing their presentations and how these criteria would be applied.

#### **B3LP V01 111**

- S: I'm not sure how much is covered by content or how much is actually covered by how flamboyant and charismatic you are or how well your presentation goes. Or if you've got problems with your computer then, does that affect your mark, and stuff like that? It's, I mean, it's all pretty dubious like I said. I'm not sure how much is actually down to how [...] well structured it is or just how well he likes you or how well he likes your presentation or how interesting he's found it.

#### **B3LP D01 149-156**

- I: And you get assessed on the presentations?  
S1: Yeah.  
I: How is that done?  
S1: I don't know. I've noticed that they keep writing notes down as we're talking so I guess it's got something to do with that! We don't know.  
S2: I'm not sure either.  
I: So do you get a grade at the end of the semester or do you get some...?  
S2: – Probably get it back with the exam results.  
All: Yeah.

### *Ground Rules for Advice-Seeking*

A further source of uncertainty was what the 'ground-rules' were for buttonholing a lecturer to raise a question or obtain further guidance on what was expected. While some of the students had had experience of seeking advice in this way, others seemed unsure as to whether it was possible or acceptable. In the first extract below, the exchange of comments leads to a resolve to seek

clarification at the following class; in the second extract, the discussion leads to reflections on the equity of approaches to staff by individual students, and a suggested way forward.

**B3LP J01 189-201**

- I: So for the essays you've got to write for this module, do you get a chance to ask anyone about them?
- S1: No.
- S2: You could do if you wanted to.
- S3: If you wanted to go and see them and ask them, I'm sure they'd be fine.
- S2: I asked, for my other one I asked 'cos it's only a one thousand five hundred essay and it's on a very very big topic, and it's all about biochemical ethics and so it's generally a discussion about your opinions, but also I didn't know whether I was supposed to bring in like background as to how it actually works or anything like that. When I emailed her she said no, you make it opinionated and a very small factual, so I did.
- S1: I might ask then.
- S2: Yeah, I think we should maybe raise that next week 'cos, you know, it must vary within the professors that are marking it.

**B3LP V01 126-135**

- I: And have you been given any guidance for the essays – about how you might go about [them]?
- S1: I think you can ask, maybe I will go and ask him what he would expect because I don't know what to write at all.
- S2: Yeah, I'm sure most of these lecturers are quite approachable if you actually do go and get in contact with them but then there's a fine line — I don't really like doing that because there's a fine line between sort of pestering, annoying them or how much information you can actually get or whether because you got information from them they'll sort of down-mark you. I mean..
- S1: Yes?
- S2: No, I don't think that happens but, I mean –
- S1: Okay! *[laughs]*.
- S2: It's a point though. I mean, you know I mean, everyone should have the same amount of help to make it fair otherwise what's the point?
- S1: Yes, that's true.
- S2: And if you've got people they do have people that they, you know, prefer more and will give more help to or if you go and ask them they'll be like really keen. So I, I'm not keen on asking the lecturers for help 'cos I don't really see that it's something that's particularly fair.
- S1: Yes, but maybe you were to ask something [?]. Maybe we can ask then and everybody can get the information.

***Communicating Marks and Comments***

As has already been noted, the students were not expecting to find out what mark they would be awarded for their presentations until after their exams, and thus did not know how well they had done. But it also appeared to be the case that, although their presentations would be positively received and commended, there was little or no accompanying feedback offering fine-grained comments on the quality of their presentation.

**B3LP J01 199-109**

- I: Do you get much feedback on [the presentations] from the lecturers? [..]
- S1: They were encouraging. We were the first up and they did say, Well done, that was a good start.
- S2: They don't hold you back after, though, do they, and tell you where you went wrong? 'Cos like

in my biochemical ethics everyone leaves and the people that did the presentation they stay behind with the two lecturers and they tell you how they think you performed. So you get a very clear instant reaction whereas this one you don't at all. So you've no idea how well –

S3: – Yes, but because you're not doing two, you don't, there's no ... I suppose it would be good for them to say that just so you improve presentations generally.

S: And also so you have an idea of like where you are.

But as other interview comments seemed to suggest, a lack of feedback comments was seen less as a specific characteristic of the seminar presentations, or of assignments in this particular module, than of assessment practices more generally within in the department concerned.

#### **B3LP J01 95-109**

S1: We don't know how to gauge it 'cos we were given a little sentence last year on [an essay], our mark with a sentence, like, 'Improve your grammar', or something like that, but generally, you know, whether we go for the facts or for opinions is never really expressed.

S2: I was told, yeah you've got the facts but there's no ideas.

S1: Oh!

#### **B3LP V01 153-160**

I: And are you expecting much feedback at all on assessments? Do you normally get some feedback?

S: We get a mark.

I: But I mean, like, comments on why you did well or..?

S: No, you get a mark. That's it!

I: Have you –□ you might not have had any back yet so you don't know?

S: We never get any feedback ever from anyone.

I: Really? Mhmm. That seems a shame.

I: So, yeah.

#### **B3LP D01 157-186**

S: Yeah, one thing it seems to be like apparently in all the modules we do, the feedback on the things we do doesn't sound very good, I don't think. If we had in the practical . . .

S: Or there isn't any! [*laughter*].

S: Especially in the exams we'll just get a percentage (S: Yeah). There will be no feedback to how people answer the exam, there'll be no . . . [*all talk together*]

S: It's really annoying!

S: And the same with practical reports, the same with essays as well, and probably the same with the seminars as well - we'll just get mark and that'll be it.

I: The same with essays?

S: Well, we get the essays back and they're corrected but there's not really ...

S: Well they used to give you a mark sheet and it's got, like, structure, bibliography and references (unclear).

S: It's a tick sheet.

S: Yeah.

S: Yeah, they tick you from A to E.. F?

S: Something like that, yeah.

S: Yeah, it's like five tick boxes.

I: That's it? What about the comments?

- S: Few and far between. Definitely.
- S: It definitely depends on the em, who's marking it though. Some will just put 'very good' 'liked it' or some will put reams and reams of text depending on how..
- S: 'Very good'.
- S: I never —
- S: — I never got those.

## Adjustment

Lastly, in seeking to understand the relationships between the students in these three course units and the teaching-learning environments in which they were pursuing their studies, it needs to be borne in mind that these environments were neither stable nor unvarying, but had themselves been in metamorphosis. Thus mastering the challenges of undergraduate study was not simply a matter of managing the transition in first year from school or college to university. There were further processes of adjustment to be encountered in succeeding years, and particularly in coping with the demands of honours-level courses, where patterns of teaching and assessment could undergo a step-change.

For the B2L and B3L students in the present study, becoming accustomed to a hitherto unfamiliar approach to teaching and learning (in the one case blending guest lectures with problem-solving group work, in the other, focused around student seminar presentations) was a significant dimension of their experiences:

### B2LP V01 39-44

- I: And are people quite happy to speak out [in the problem-solving discussions] ?
- S1: I think at first ...
- S2: Yeah, there's still a bit of reluctance.
- S1: Yeah, I found I started talking a lot towards the end, but not because I think I'm more right with my answers, but just because I feel more comfortable in the class.
- I: So what's led to that? It sounds like the atmosphere has maybe got easier as you've gone on. Is that usually what happens?
- S2: Ehmm, I think is just a matter of maybe getting used to this sort of style of teaching and everything, because.. I mean, all through almost pretty much of first, second and third year it has always been a set of.. the lecturer comes up, either writes notes on the board or maybe gives you one or two handouts, but he is still like constantly talking a not a chance to like answer questions, but you also - in like first, second and third year - you were in really big classes as well which doesn't help much.

### B3LP J01 5

- S: We haven't actually had anything taught to us by the lecturers, it's all been taught by the students. It's all been around research which we've never had before, until the final year.

### B3LP D01 106-121

- I: Is doing a presentation an unfamiliar thing, or have you done lots before?
- S: Em, no I've done one. One when I was on placement in the second year but that was it. I haven't done any before that or since.
- I: A bit nerve-wracking?
- S: Mm, not as half as bad as I was expecting actually. I thought it was gonna be terrible but it wasn't really at all. So it was fine. [..]
- S: I thought it was pretty nerve-wracking! (*laughing*)

- S: Me too!
- I: Beforehand or when you were doing it or..?
- S: Em more when I was doing it and I didn't think it would be beforehand! (*laughing*)
- S: [...] For the first half of it! But you get into it.
- S: Yeah, you get into it. [...]
- S: It seems that the more seminars people have been to, the more relaxed everyone seems to be. So I guess people are getting used to doing it.

More generally, studying in their final year had put a greater onus on students across the three course settings to manage their study priorities and juggle with competing deadlines for assigned coursework. In the perception of some, there had also been a very substantial workload to manage.

#### **B3LP J01 241-245**

- S1: It's just kind of like lots of different deadlines at the same time. I prefer concentrating basically on one thing. I don't like chopping and changing all the time. I can't deal with like having to write an essay and do a presentation at the same time. I prefer just to have two days when I can concentrate on one thing, but at the moment I'm having to like chop and change.
- S2: – It's a pain –
- S1: – It gets me a bit kind of flustered sometimes and I think just sit down, [name of student], and do one thing.

#### **B3L PV01 line 142**

- S: I've ended up with [...] about three seminars and eight 2000-word essays, and it's really difficult to sort of structure that all the way through the year, and they're all due in for the last week. I mean, where do you start?

#### **B3LP J01 489-503**

- S1: You have to be very independent and you kind of have to have quite a lot of confidence in yourself.
- S2: You have to be quite dedicated as well.
- S3: You really have to be dedicated, yeah.
- S2: You have to have motivation.
- S3: You have to have some kind of driving force, don't you, to keep going.
- S1: [...] Especially 'cos ours is a Masters, more is expected of us than the BSc. Compared to my housemates I do like double the amount of work they do [...] I don't know if people appreciate that really, that it is quite a lot different to other degrees.

#### **B1LP JN03 94**

- S: I think there's a lot more work than what we're used to. I thought perhaps the lectures would get a lot harder in what we were doing but it's not that - they're ok to understand - it is just the sheer volume of what we've got to do, it's a lot higher than what we've previously been used to. But, saying that, we don't have labs this year, so we don't have lab reports, so they're obviously compensating it ....Plus the exams. There are a couple of three hour exams and we've never ever had a three hour exam before. I think the most we've ever had at once was a two hour, it's always been an hour and a half, so that's going to be a shock to the system.

#### **B1LP D01 165-168**

- S1: The workload is huge. [...]. . . They've got high standards and they want them met. [...] The social side of the university just passes you by 'cos you've got too much work on. There can't be many students that have their Christmas wrecked by all the studying.
- I: You mean you're taking work home every night?
- S1&2: Yes
- S1: It's work all the time.

Across the three modules, however, there was a pervasive perception that the most exacting transition had fallen between the first and second and the third and final years. The shift which was called for was at its most intense in the assessments, whether in a move away from a reliance on multiple-choice exams or in the requirement, in coursework, to track down and distil relevant sources.

**B2LP V02 648**

- S: [In] first and second year, you just need to memorise little points to get the multiple choice answers right. You don't need to learn how it all links together to write an essay on it. [It's a] different way of learning within the first two years compared to the next two.

**B3LP J01 517-521**

- S1: You don't get any [essays] in first or second year, they just appear in third or fourth year.  
I: So what kind of assessments did you get in first and second year?  
S1: They're all lecture courses and exams.  
S2: There is write-ups of practicals, which are a very different way of writing. [...]  
S1: I thought the biggest jump was second to third [year].  
I: What's the big jump between second and third?  
S3: Well it's a different style, like in the second year it was more textbook learning, whereas in the third year it was all kind of going to get references, trawling through loads of information [...]

**B2LP V01 125-132**

- I: Have you ever done exams like this before where you're doing essays?  
S1: Third year.  
S2: Yeah, only third year. I don't think that was a good idea either because I wasn't prepared for examinations in that format. Second year and first year's all multiple choice . . .  
S1: . . . which is just horrendous. I mean, it's like a one-hour multiple choice exam for each module or something. It's good at the time because it's a multiple choice, but when it comes to preparing you for your third and fourth year, it's just —  
S2: — I don't think you remember anything unless you can link them all together in a way that —  
S1: — very difficult —  
S2: — that makes sense to the whole picture like you would in an essay. If you're just doing, like, ticking a box and knowing facts you're never gonna remember them. So I didn't feel very prepared for third year at all. It's the only thing that I haven't thought was good about this whole course.  
S1: Yeah.

**B1LP V01 201-206**

- I: And the feedback you've had in previous years: have you learnt a bit from that ?  
S1: Yeah. I would say so. I would say more last year. I think last year, because there was such a big jump from second year to third year.  
S2: Yeah there was a lot we hadn't been told about what exactly you had to put in your coursework.  
S1: Styles and things.  
S2: So this year, well we know now what exactly they're looking for.

## Concluding Comments

In this paper we have presented two interrelated sets of findings, drawing on quantitative as well as qualitative data, from an ongoing study of students following final-year course units in three bioscience departments. The first set of findings was concerned with the students' evolving grasp of ways of thinking and practising in the biosciences, and identified four salient themes. One focused on the students' engagement with the primary research literature and with experimental data. It included the challenges of locating and selecting from appropriate and up-to-date sources of information, getting to grips with how knowledge was generated in the subject area, and developing their own views and interpretations on topics where knowledge could be contested and uncertain. Another theme encompassed the students' increasing experiences, as they progressed into the later years of their studies, of thinking about the subject integratively, or synoptically, discerning interconnections within and between topics and seeing what they were studying within the wider context of professional practices in the biosciences or everyday life. The third theme was students' growing mastery of the requirements and conventions of written and oral scientific discourse, including the deployment of evidence to underpin their interpretations and coming to terms with different genres of scientific writing. Lastly, there were students' perspectives on the extent to which the biosciences called for a particular way of thinking, and what this might consist of.

The second set of findings presented were concerned with the extent to which the teaching-learning environments in these three course settings were perceived by the students to facilitate or constrain the achievement of high-quality learning, in the guise of ways of thinking and practising in the subject. Teaching-learning activities in all three settings seemed to be relatively well-aligned to the latter, despite the fact that they took sharply contrasting forms. The assessment strategies followed in each course unit were equally diverse, not only with respect to the assessment methods employed but also in relation to opportunities for extrinsic and intrinsic feedback, where there were indications that at least one of the three modules was less well aligned. The students' concerns about feedback in this course unit, however, did not simply take the form of a desire for fuller comments on their assessed work, but were closely interwoven with concerns about guidance on tutors' expectations, uncertainty about both assessment criteria and the ground-rules for buttonholing tutors to seek further advice, and questioning of wider departmental procedures for communicating marks and comments. This section of the findings also brought to light an important, but hitherto largely overlooked, dimension of students' experiences of teaching-learning environments. For these students at least, patterns of teaching and assessment had undergone a step-change in the later years of undergraduate study, bringing with it a concomitant need to adjust to unfamiliar study demands.

In the light of these findings, it seems reasonable to consider the emerging outcomes of this component of the ETL project as potentially promising. Conceptually, both ways of thinking, on the one hand, and constructive alignment on the other (albeit in a modified and extended form) seem thus far to offer worthwhile avenues to the pursuit of a fuller understanding of how high-quality learning might be defined and supported. And methodologically, a blend of quantitative and qualitative approaches to data-gathering appears to have already shown its merits. At this juncture, however, it would be premature to attempt any definitive observations or conclusions, not least because the present paper is a report of work-in-progress rather than a completed investigation. There will be further data-gathering in at least two of the three course settings, surveying the next cohort of students with particular attention to the impact of initiatives, devised in collaboration with departmental partners, to enhance the quality of student learning. There are



complementary analyses to be completed, both of interviews with teaching staff and of parallel data from first-year course units in the same three university departments. And last but by no means least, these embryonic findings need to be examined alongside, and in interrelation with, the findings which are simultaneously emerging from the other subject areas being surveyed within the wider ETL project.

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## Contact details:

ETL Project  
Higher and Community Education  
School of Education  
University of Edinburgh  
Paterson’s Land  
Holyrood Road  
Edinburgh EH8 8AQ  
United Kingdom  
[etl@ed.ac.uk](mailto:etl@ed.ac.uk)

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