
THE DEVELOPMENT OF STUDENTS' WAYS OF THINKING AND PRACTISING IN THREE FINAL-YEAR BIOLOGY COURSES

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Abstract

Findings are presented from an ongoing study of three final-year, honours-level course units in the biosciences with a combined intake of eighty-five students. The data on which the analysis draws comprise semi-structured interviews with students together with findings from an Experiences of Teaching and Learning Questionnaire. The investigation forms part of a wider project concerned with the enhancement of teaching-learning environments in undergraduate courses in contrasting subject areas.

The paper focuses on two interrelated aspects of the students' experiences within the teaching-learning environments represented by the three course settings. First, it explores the students' evolving grasp of ways of thinking and practising in the biosciences, as experienced through engagement with the research literature and with experimental data, and in efforts to master the requirements and conventions of the subject for written and oral discourse. Second, it examines the extent to which the teaching-learning environments represented by the three course settings were congruent with the development of ways of thinking and practising in the subject, looking particularly at the role of intrinsic and extrinsic feedback and adjustment to the demands of honours-level study.

Background and introduction

The broad concern of this paper is with the facilitation of high-quality learning in undergraduate biology. Drawing on findings emerging from an ongoing empirical study of three final-year biosciences course units, the paper focuses on two interrelated aspects of the students' experiences of these courses as teaching-learning environments. First, it explores the students' evolving grasp of distinctive ways of thinking and practising in the subject, as represented in their engagement with experimental data and the research literature, and in their growing mastery of the conventions of written and oral scientific discourse. Second, it examines the extent to which the students' perceptions and experiences of teaching-learning and assessment activities seem to support or constrain their engagement with these distinctive ways of thinking and practising in the biosciences.

The paper stems from the Enhancing Teaching-Learning Environments in Undergraduate Courses (ETL) Project, funded under the Teaching and Learning Research Programme by the UK Economics and Social Research Council. The chief goal of the project is to explore ways of strengthening undergraduate teaching-learning environments so as to improve student engagement and high quality learning. The project is being pursued collaboratively with departmental partners in five contrasting subject areas, and is being undertaken in three main phases. The present paper stems from work in part of the second phase of the project, where the focus has been chiefly on first and final year course units in a cross-section of university departments.

Literature review

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

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. Our current perspectives on high-quality learning draw on more than twenty-five years of qualitative and quantitative research with students across a range of contexts (for example, Biggs, 2003; Entwistle, 2000; Marton, Hounsell and Entwistle, 1997; Prosser and Trigwell, 1999). One important starting point for us within this literature has been the research relating to students' 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. The deep approach – which involves an intention to understand combined with related learning processes, such as looking for patterns and underlying principles – can be seen as a partial proxy for high-quality learning in higher education.

Our current conceptualisation of high-quality learning also includes systematic, well-organised, self-regulated, studying and as such it draws on both the strategic approach to studying (Entwistle and Ramsden, 1983) and the wider literature on self-regulation and metacognition (Boekaerts, Pintrich and Zeidner, 2000). Further development of these generic frameworks describing high-quality learning is one aspect of the work of the ETL project (Entwistle, McCune and Hounsell, 2003; Entwistle and McCune, under review). 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 to 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; Lave and Wenger, 1999). 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 coined 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 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. Research findings describing students' understandings and misunderstandings of academic tasks, and of key concepts, tap into the difficulties that they may experience in coming to terms with the WTP of particular academic communities (Campbell, Smith and Brooker, 1998; Hounsell, 1997; Prosser and Webb, 1994). WTP can potentially 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, for example, by pursuing a particular profession.

To understand and fully describe the WTP in a given subject area is a considerable task and one that would be beyond the scope of a single research project. Our intention in the ETL project is not to develop a taxonomy of all of the different aspects of WTP for a particular context but rather to use WTP as a means of including, within our perspectives on high-quality learning, important themes which might otherwise be overlooked. Thus we are using the notion of WTP to enhance our understanding of 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.

b. Teaching-learning environments and constructive alignment

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; Scouller, 1998; Entwistle, 2000; McCune, 2000).

Drawing both on research into student learning and constructivist perspectives on pedagogy, Biggs (1996, 2003) has 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.

(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 opening phase of the project, it underpinned the analysis of telephone interviews with teaching staff from a cross-section of departments in biology (Hounsell and McCune, 2002) and the other four subject areas which had been highly rated in national quality assessments of teaching. 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.

These considerations in turn necessitated greater alertness to potential limitations of alignment, at least as it is sometimes construed. First, the geometric connotations of alignment as a metaphor can be taken to imply a single 'line of sight' between a given learning outcome and a particular teaching-learning strategy and method of assessment. Yet as our telephone interviews suggested, there may well be various configurations of teaching and assessment that would be apt for a given learning outcome. Second, since contextual constraints on teaching and assessment seemed ubiquitous rather than exceptional, and thus a fact of educational life, alignment might more properly be regarded as an ideal that is well worth striving but one that is seldom likely to be attained in any full or complete sense. With these considerations in mind, 'congruence' rather than 'alignment' appeared to be a more appropriate way of capturing the nexes between high-quality learning outcomes and the strategies deployed to pursue these outcomes.

The opening phase of the ETL project also sought to take 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 and feedback in enabling students to attain high academic standards (Black and Wiliam, 1998; Sadler, 1989, 1998; Ecclestone, 2002). 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 have 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 three final-year bioscience 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 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.

As Table 1 shows, all of the three units investigated were final-year, one-semester honours-level courses involving a total of 85 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, all but one of whom were taking four-year Master's degrees in the biosciences.

Table 1. Summary of final year course unit settings, biosciences

	B1L	B2L	B3L
<i>Unit theme</i>	Genomes	Cancer	Enzymology
<i>Student enrolment</i>	First semester module 2-3 hrs p.w. over 12 wks	Second semester seminar option 6 hrs p.w. for 5 wks	First semester seminar option 2 hrs p.w. over 1+10 wks
<i>Scheduling, contact hours and duration</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>Core teaching provision</i>	Lectures + tutorials	Guest lectures followed by problem-focused group discussion of data provided by the guest lecturers	Paired student presentations + discussion, from choice of 10 topics
<i>Assessment [incl. weightings]</i>	<ul style="list-style-type: none"> 3-hr exam (60%) Two essays (each 20%) 	3-hr essay exam (100%)	<ul style="list-style-type: none"> Presentations (50%) Two essays (each 25%)
<i>Guidance/learning support</i>	<ul style="list-style-type: none"> Course handbook Tutorials, in which students are encouraged to raise issues arising 	<ul style="list-style-type: none"> Extensive guidance in course handbook and web site Individual requests/enquiries 	<ul style="list-style-type: none"> 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

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 student questionnaires which had been devised and piloted in the first phase of the project (Entwistle, McCune and Hounsell, 2003), 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 at or close to the beginning of the 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* also asks students about the demands made upon them by the course unit, and what they feel they have learned from it. It was completed in the penultimate or final 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 2 summarises the take-up rates for questionnaires and the interviews. Since B2L was an intensive course which ran over only five weeks, its students completed only the *ETLQ*.

Table 2. Take-up rates for questionnaires and interviews in final-year biology

Course unit	B1L	B2L	B3L
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 in full prior to analysis by at least two members of the project team. In the first stage of the 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 themes initially pinpointed.

The analysis of the questionnaires included a review of the results for individual items as well as sub-scales, and a factor analysis which has been reported elsewhere (McCune, 2003). Particular attention was also paid to data relevant to the focal themes identified in the interviews.

Findings on ways of thinking and practising

This opening findings section of the paper considers 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 centres

on the students' sense of whether they were learning to communicate in distinctive ways as they moved through their studies.

Engaging with the primary literature and experimental data

Throughout the interviews a recurring theme in the students' comments was the importance of engagement with primary literature and experimental data. This seemed to be a particularly fundamental characteristic of the later years of undergraduate study in all three biosciences settings. Although many of the students' experiences of engaging with experimental data had taken place in laboratory classes, 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. At least some of the students seemed to find this quite difficult. The need to make use 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 60-61¹

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. [...].

B1LP D01 58-60

S1: [For the coursework the lecturer] 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.

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'?

Perhaps the key issue addressed within this section of the data is the ways in which the students were struggling to understand how knowledge was generated in their subject area(s) and how they might develop their own views and interpretations. This may have been supported by their understanding that interpretations could be challenged and that it was therefore legitimate, and even expected, that they would put forward their own perspectives:

B2LP V02 402-404

S1: So, when we are reading [scientific articles] 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?' [...] we have to prove that we are understanding the concepts.

B1LP D01 79 -87

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 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] [...]

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 processes or something was working? [...]

- 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". [...]
- 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. [...]
- 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...

Despite this apparent readiness 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 [...] spent months, years maybe, doing [...]
- S4: [...] it's hard to actually understand it and be able to question it [...] I mean, this semester, we've had twelve courseworks and we're only here for twelve weeks. [...] 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.

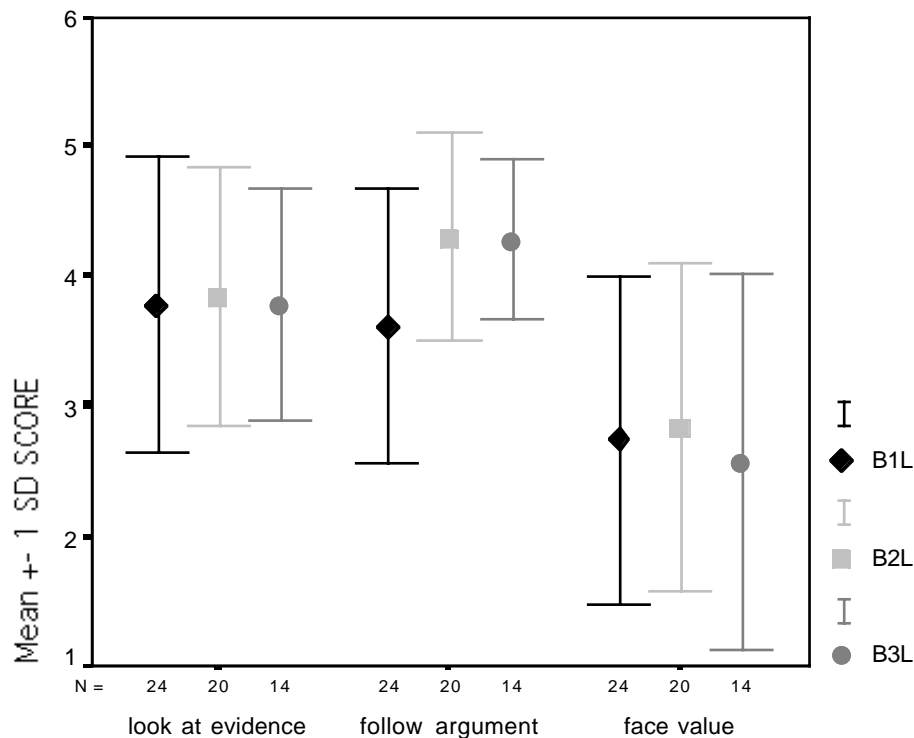
B3LP D01 309-313

- S: If you find [...] a 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..

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 were 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.

The students were not learning about the interpretation of data solely through working with the primary literature. In some cases – particularly in B2L – they discussed the interpretation of data within the timetabled classes for the course units in focus in this study. More generally, the practical classes, projects and work placements, which formed part of the students' wider degree programmes, also played a part in supporting their active and critical engagement with research findings. While it is not possible to consider these influences in depth here, some of the students' comments did indicate that these experiences supported their ability to interpret research evidence:

Figure 1. Students' ETLQ scores on 'Evidence' sub-scale (Means \pm 1 SD; 5=strongly agree, 1=strongly disagree)



B2LP JN02 108-110

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?" [...] 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 makes you think for yourself [...]. 'Cos basically you're studying something that hardly anyone knows as much about it as you do, so.. [...]

S2: [...]. 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 [...].

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'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 [...] You've gone up a level [because of the placement], you're not a student anymore.

B3LP D01 346 - 354

S: Yeah. It's much more real [on placement]. It's a different world completely, yeah. [...]

I: Why.. how's it different? [...]

S: Real science isn't really about learning 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.

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

In describing what they had learned about 'ways of communicating' in the biosciences the students talked, not surprisingly, about many of the familiar requirements of scientific communication such as precision, conciseness and proper acknowledgement of sources. In this paper, however, we will focus on what the students had to say about the more elusive aspects of mastering the conventions of written and oral discourse in the biosciences. 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.

It was clear that the students felt that their skill in communicating within the biosciences had developed considerably over their time at university. Not surprisingly, however, the students did seem to differ in their levels of confidence and some indicated that they still had a lot to learn. Part of the challenge for them seemed to involve coming to terms with the variety of forms of language, and different communicative genres, required for different aspects of their studies:

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.

B3LP V01 116-125

- S1: I've no idea, well the essays are ridiculous questions. [...] I wouldn't call it a normal style scientific question of problem solving. It's more justification. [...] 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.

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.[...] 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.

The students also seemed to be developing an understanding of the communicative expertise required to meet the needs of a range of audiences, each of which placed different demands on the students:

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 [...] 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.

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: 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're gonna look really unprofessional.
- S2: Oh God, yeah!

This attention to the needs and expectations of different audiences can also be seen in the extract below, where the student is speaking about her work placement experiences.

B2LP JN02 127-136

- S2: 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 [...] 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. [...]
- 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".

This and other comments made by the students indicated that formal polished presentations only represent one aspect of the oral communication skills required to be a practising scientist. The students pointed up the importance of the ability and readiness to refine ongoing work, and to learn from other scientists, through informal discussion:

B2LP V01 178-179

- S1: 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.

B2L PJN 01 236-238

- S1: You see so much of the, like, not even mis-communication but you just.. I mean on my placement, like, all I wanted to do is just get all of the groups that were researching this topic together to have a wee chat, you know what I mean, 'cos they would have just solved so many things. 'Cos there are so many experiments being done that are just so pointless, because someone's done it several times over but nobody knows because they never published it because.. I hate that bit of science, they don't publish things when they don't work. I mean, they should have a journal for experiments that never worked because people will just do it again and again because people don't wanna say "Oh this never worked" because then it'll make them look like a fool but then someone else is gonna do it and waste more thousands of dollars and pounds and time and..
- S2: I agree with you!

Of the three course settings considered here, the students' discussion of practising scientists' data in the B2L seminars perhaps provides the closest parallel to these more informal discussions of emerging findings:

B2L PJN02 29 -32

- S1: I think that's what's good about the group discussion, because you're actually sitting and discussing

stuff with people rather than sitting and trying to work it out yourself. And it might give you a perspective that you wouldn't necessarily have had yourself.

- S2: It's always easier to give your answers when about you expect 4 or 5 of you have discussed it and all come to the same conclusions. You feel more confident about speaking out in class than you would do if it was just something you came up with yourself.

B2L PJN 01 17 - 23

- I: Looking at the whole teaching and learning experience, which aspects would you say you've found most helpful in getting to grips with the subject? [...]
- S1: The problem solving sessions we have at the end of this module [...] [are] good for, coming from a placement perspective, being on placement you have to, like, when you're actually working in the area you have to know how to interpret all your experimental results. And objectively as well as, like, be able to interpret them in the first place and this really helps with it. I think that was 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: [...] So it kinda consolidates it all just at the end of the lecture. Makes sure that all the points that people don't understand are brought up and things, it's quite good.

Findings on the course settings as teaching-learning environments

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. Looking first at the broad sweep of the teaching-learning environment on a range of dimensions, the section then goes on to consider three key facets: congruence of teaching-learning activities, congruence of assessment and feedback, and the hitherto little-explored yet potentially important theme of students' experiences of adjustment to teaching-learning and assessment requirements at honours level.

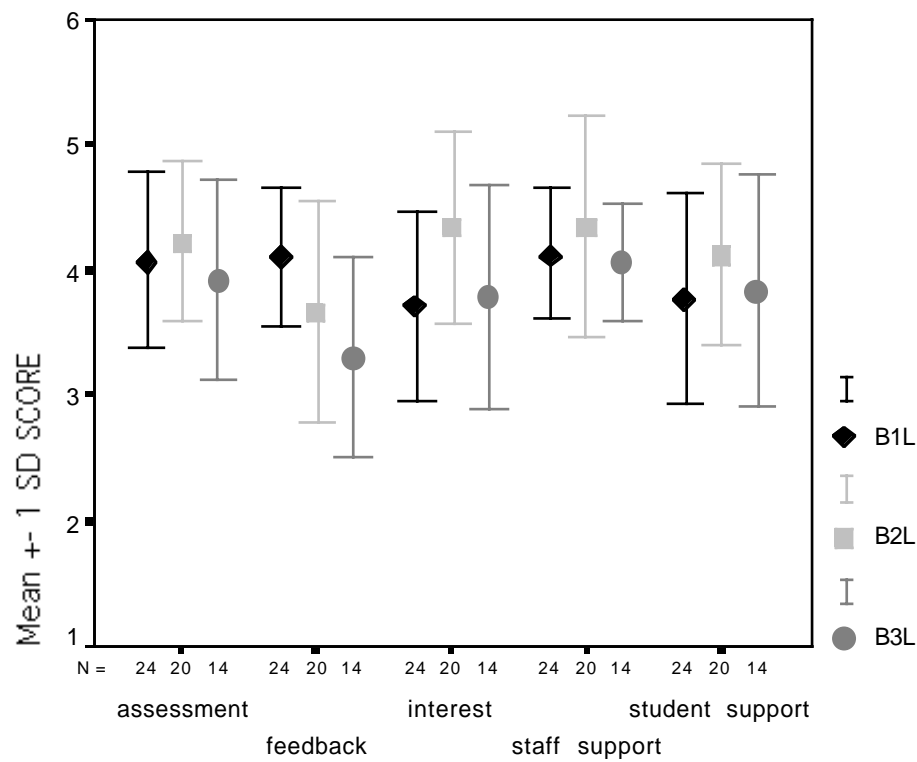
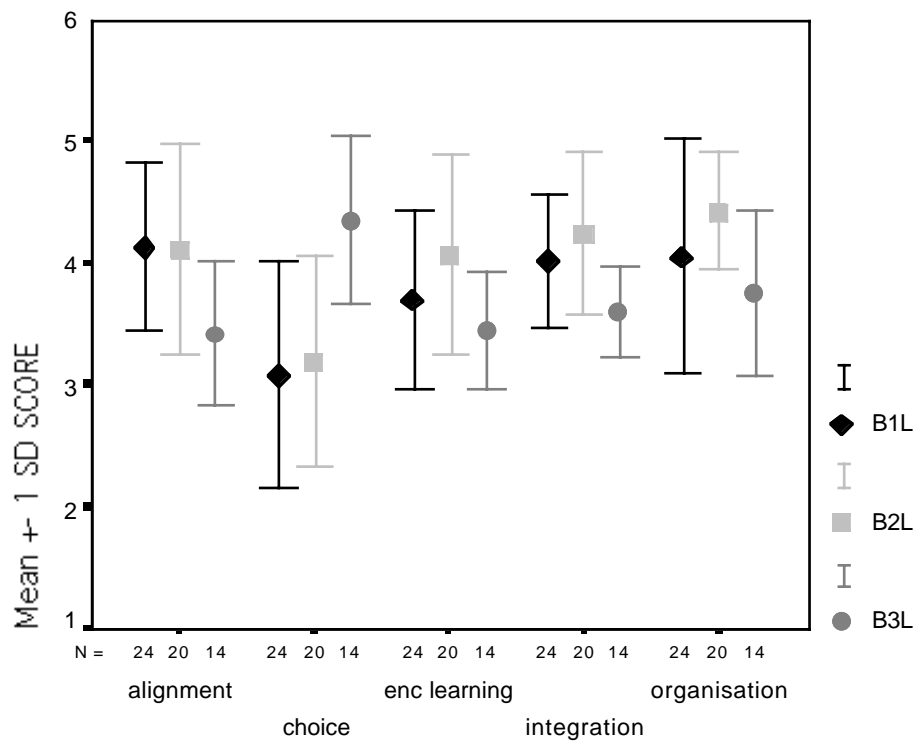
Students' overall perceptions and experiences of the teaching-learning environments

A considerable degree of commonality was evident, across the three final-year course settings, in the students' experiences of these settings as teaching-learning environments. All three modules were perceived by the students taking them 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 can be seen not only in the students' many positive interview comments — above and in what follows — but also in their responses to the Experiences of Teaching and Learning Questionnaire. Figure 2 summarises the mean scores for the questionnaire sub-scales most directly concerned with students' experiences and perceptions of the modules as teaching-learning environments. All of these mean scores are above the mid-point on the scale, and encompass a range of features which include congruence or goodness-of-fit of the teaching and assessment approaches adopted (*alignment*); the encouragement given to high quality learning (*enc learning*); the degree of integration of teaching and learning materials (*integration*); the extent to which curriculum aims were clear and the unit well-organised (*organisation*); the degree to which assessment was geared to understanding (*assessment*); the effectiveness of feedback (*feedback*); the extent to which the course unit was perceived to be interesting, enjoyable and relevant (*interest*); and the supportiveness shown by staff and student peers (*staff support, student support*). The most marked difference is in the scores on the *choice* sub-scale, reflecting the scope given to the B3L students to choose their seminar topics, in contrast to the set curriculum followed by the B1L and B2L students.

Teaching-learning strategies

Like their overall experiences of the teaching-learning environments in the three course units, the students' perceptions of the teaching-learning strategies adopted were also positive. This is particularly important to note since, as was indicated earlier in Table 1, each of the three course units differed markedly in the teaching-learning strategies which had been deployed to pursue high-quality learning

Figure 2. Students' ETLQ scores on 'Environment' sub-scales (Means +/- 1 SD; 5=strongly agree, 1=strongly disagree)



goals. The students' experiences of these different strategies, and their favourable reactions to them, come across most clearly in the interviews. In module 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 of concern to 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.

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, by contrast, the first part of each three-hour session consisted of a talk by an external speaker from a biosciences research institute. 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 [...] 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.[...]
- 1: 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 JN01 [19-23 ??]

- S1: 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, makes sure that all the points that people don't understand are brought up.

And in module 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 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 [...] research it. And also when other people present it, it's quite nice because it's different to lectures and you learn [...] about the usefulness of certain applications or yeah certain techniques.

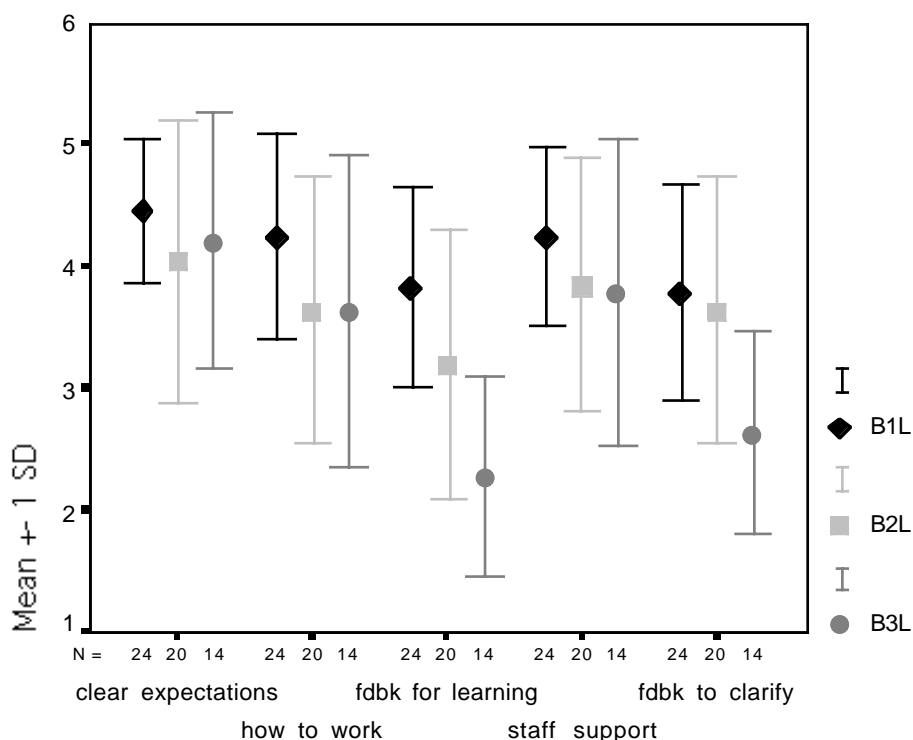
Assessment and feedback

As with teaching-learning strategies, so too were assessment regimes in the three course units 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.

Despite these differences, the questionnaire findings, as we saw earlier in figure 2, appeared to suggest that assessments and set work were reasonably congruent with the promotion of the reflective understanding and critical thinking associated with ways of thinking and practising in biology. But more searching scrutiny of the item scores on the 'guidance and feedback on assessment' sub-scale reveals a more complex picture than the broadly positive impression conveyed by the sub-scale mean alone, as figure 3 indicates. Across all three course units, there are consistently positive scores for clarity about what was expected in the assessed work (*clear expectations*), encouragement to think about how best to tackle the set work (*how to work*), and provision by staff of support needed to help in completing the set work (*staff support*). However, the figures for two items are much lower in the case of B3L, falling below the mid-point on the scale. None of the B3L students agreed or strongly agreed with the statement 'The feedback on my work helped me to improve my ways of learning and studying' (*fdbk for learning*, mean = 2.3), while only one student agreed with the statement 'The feedback given on my set work helped to clarify things I hadn't fully understood' (*fdbk to clarify*, mean = 2.6).

Further illumination is provided by the interview data, which can helpfully be considered in terms of guidance about expectations, on the one hand, and on the other, the adequacy of feedback from staff.

Figure 3. Students' ETLQ scores on 'Feedback' sub-scale (Means \pm 1 SD; 5=strongly agree, 1=strongly disagree)



Guidance about expectations

Across all three course units, the interviews provided frequent confirmation of the positive impression given in the questionnaire data, as in the following examples:

B1L PV 01 (B.Sc.) 135-137

- S4: I think [the two lecturers] really help because when we got the [assignment] question I was like, 'What's that!'
- S2: So was I.
- S4: And then [name of lecturer] said, 'We'll have a tutorial'. And he took us through step by step what exactly should be in it, and how we get the information [...] All we had to do was read the journal papers and write the essay. So he gave us all the help we needed for it.

B2LP V01 113-117

- S1: [The 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. [...]
- S1: Yeah, lots of links to other cancer-related websites. [...]
- 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.

B3LP J01 203-209

- 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.

However, while the B3L students seemed broadly satisfied with the guidance they had been given on what was expected in their presentations, they felt much less confident and more anxious about what was required in the two essays which the students were due to complete by the end of the semester. Various factors seemed to have fuelled their uncertainty: a lack of past experience of (and present practice in) writing essays; unfamiliarity with the kind of essay assigned in this module, which had been designed to foster sustained critical reflection that drew on what they already knew and understood rather than called for new reading around the topic; and a perceived paucity of feedback on those essays which had been submitted for other modules:

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.

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!

There were also indications of uncertainty amongst the B3L students about what the ground-rules were for buttonholing a lecturer to raise a question or obtain further guidance on what was expected. While some had had experience of seeking advice in this way, others seemed unsure as to whether it was possible or acceptable, or raised questions about the equity of approaches to staff by individual students:

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 [module] I asked 'cos it's only a 1,500 [word] 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 126-128

- 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 [...] 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.

Adequacy of feedback

As far as the provision of feedback is concerned, it needs to be borne in mind that only the B1L and B3L students were required to undertake assigned coursework of the kind that would offer opportunities for feedback of the conventional kind. In the case of the B1L students, there was a marked difference of view between the BSc and MSc students. While both groups expressed concern that the timing of assessments meant that there would be little opportunity to digest or respond to any feedback comments on their assignments before they took the end-of-module exam, the BSc students were nonetheless reasonably confident – given their extensive past experience of lecturers' comments on their written work – in their grasp of what would be expected in their assignments. The MSc students, by contrast, were relative newcomers to the department and thus much more anxious about feedback:

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.
- 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.

B1LP JN 03 60-66

- S2: You need some sort of gauge, before you go into your exams, of how well you're doing, 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 right, you know you're on the right track.

In the B3L course unit, the students' presentations represented one potential opportunity for feedback, but it appeared that, although positively received and commended, little or no fine-grained comments had been offered on the quality of each presentation.

B3LP J01 199-109

- 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 [module] the people that did the presentation 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,... 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.

At the time when the interviews took place, the students would not have had their essays returned. However, wider concerns were expressed about the provision of feedback more generally within the department:

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!

B3LP D01 157-186

- S: [For essays] they used to give you a mark sheet and it's got, like, structure, bibliography and references [...]
- S: Yeah, it's like five tick boxes.
- I: What about the comments?
- S: Few and far between. Definitely.
- S: It definitely depends on 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.

Intrinsic feedback

Finally, it should be noted that while the B2L students had no set coursework – and therefore no opportunities for such extrinsic feedback – they seemed generally confident about what was expected of them in their assessed work (and certainly more so than their B3L counterparts). This was apparent not only in the questionnaire data but also in the interviews, which suggest an explanation in a combination of the rich guidance already noted above together with the opportunities the students had to get *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 (Laurillard, 2002, pp. 55ff.) 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 guest lecturers and the module coordinator. Thus, as the extracts below indicate, the students 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'.

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 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, they also give you the basis for you to succeed, I think.

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.

Adjustment

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. Indeed, for these students honours-level study represented a step-change in patterns of teaching, learning and assessment.

For the B2L and B3L students, 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 42-44

S1: I found I started talking a lot towards the end [of the course unit], 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?

S2: Um, I think it's 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 [the case that] 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, [it's] not a chance to answer questions, but in 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.

More generally, studying in their final year had put a greater onus on students across the three course settings to manage their study priorities as well as cope with an escalating workload:

B3L PV01 line 142

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

B1LP JN03 line 94

- S: 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.

B3LP J01 493-503

- 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.

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.

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.

B3LP J01 517-521

- 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.

Concluding observations

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 at undergraduate level. As already noted in the opening sections of the paper, our aim has not been to dissect WTP in the biosciences in its entirety, but instead to make use of

it to pinpoint salient themes in high-quality learning in the subject at undergraduate level that could otherwise go unnoticed. In the present paper, two such clusters of themes have been picked out: engagement with the primary research literature and with experimental data; and the students' growing mastery of the requirements and conventions of written and oral scientific discourse.

The surfacing of these two clusters of themes seems to bear out the potential benefits of WTP as a lens through which to view learning at this level. Thus we saw how, extending beyond but rooted within the secure understanding of a deep approach, lay formidable epistemological challenges for these students – most notably, getting to grips with how knowledge was promulgated and generated in the biosciences, while at the same time developing their own views on topics within the subject area where knowledge could be uncertain and open to differing interpretations. There are echoes here of the much more questioning attitude to knowledge and authority characteristic of the 'contextual relativistic reasoning' which lies at the core of Perry's scheme of undergraduate intellectual development (Perry, 1970), but in the present instance it has a very particular subject anchorage rather than the more loosely demarcated boundaries around a student's "intelligible universe of the moment" (Perry, 1988, p. 148).

No less crucially, these indications of a sea-change in the biosciences students' ways of *thinking* about what was known and understood within the field appeared to be tightly interwoven with their *practising* of the subject. In part, the shift in ways of thinking seemed to arise from and through the students' experiences of engaging directly with experimental data and with the research literature through which advances in the subject area were communicated and debated in the biosciences community. But no less importantly, they also seemed to have been nurtured in the students' efforts to communicate their burgeoning grasp of topics in ways that accorded with the established requirements and conventions of the biosciences as a subject area. Fulfilling these conventions entailed the appropriate deployment of evidence to underpin their interpretations and coming to terms with different genres of oral as well as written scientific discourse.

But what then can be gleaned from these findings about how WTP was facilitated within the three teaching-learning environments? Three principal observations suggest themselves, albeit tentatively. First, the teaching-learning and assessment strategies adopted by the teaching staff in the three course settings appeared to be broadly congruent with the promotion of WTP, despite the fact that, outwardly at least, these strategies had taken very different forms. However, it also needs to be borne in mind that, in all three settings, WTP was most clearly evident in situations in which students were pursuing active rather than passive learning tasks (for example, in undertaking experimental work on placements, participating in problem-solving discussions, and presenting orally and in writing). It may therefore be more appropriate to consider these environments in terms of Biggs' Level-3 thinking about teaching, where the focus is on 'what the student does' (Biggs, 2003, p. 24). From this perspective, there were probably greater similarities than differences between these three course settings in how they sought to 'engage students in appropriate learning activities' (Biggs, 2003, p. 26).

A second observation has to do with the pivotal role of feedback in teaching-learning environments. The students' concerns about the effective provision of extrinsic feedback in one of the course units did not simply take the form of a desire for fuller comments on their assessed work (as feedback is commonly conceptualised) but were closely linked to unease 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. And in another of the course units, an ostensible dearth of opportunities for extrinsic feedback seemed amply counter-balanced by evidence of rich intrinsic feedback in timetabled classes. This finding underscores the significance of Laurillard's little-noticed distinction between extrinsic and intrinsic feedback, and the desirability of considering the relationship between the two as complementary. Taken together, these two findings mirror contemporary perspectives on formative assessment (Black et al., 2003) in suggesting closer attention is needed to the congruence of feedback practices with the promotion of high-quality learning outcomes.

Third, our analysis of the interview data indicated that the students' progress through their degree programmes had not been an altogether smooth one. Patterns of teaching and assessment had undergone a step-change in the later years of undergraduate study, bringing with it a concomitant need

for students to adjust to unfamiliar study demands as well as to refine their grasp of ways of thinking and practising in the biosciences. This is a noteworthy finding because past studies of processes of adjustment to changed study demands have tended to focus on the transition from school or college to university (see for example Wall et al., 1991; Richter, 1997; Nardi, 2001). However, some recent studies (Vermunt and Verloop, 1999; McDowell and Sambell, 1999) have begun to highlight the tensions which can arise when students subsequently encounter less accustomed forms of teaching and assessment, and this dimension of students' experiences of teaching-learning environments would seem to merit fuller scrutiny, particularly from the standpoint of congruence.

Finally, it should be emphasised that the present paper reports work-in-progress rather than a completed investigation, and its findings should be considered as provisional. Further data-gathering is underway in two of the three final-year biosciences course units, surveying the subsequent cohort of students with particular attention to the impact of initiatives, devised in collaboration with departmental partners, to enhance the quality of student learning. Complementary analyses are also being undertaken, 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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¹ 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.