

Promoting Student Participation in Scientific Research: An Undergraduate Course in Global Change Biology

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Introduction

Three years ago, I¹ was asked to design a series of laboratory-based practicals for a second-year undergraduate course in global change biology at Queen Mary University of London (QMUL). From my own experiences as an undergraduate, and from assisting with practical classes during my postgraduate years, I was aware that the tendency in teaching practical exercises in the life sciences is to “feed” students prescribed information, which is then repeated from year to year. Typical formats for practical classes included video presentations, identifying organisms under microscopes with the use of guide books, and highly scripted experiments investigating, for example, how changes in salinity affect osmotic regulation in intertidal organisms. These formats are logistically simple for the lecturers, technicians, and demonstrators to organise year after year, once the initial investment has been made in designing the course. Many of the classes I took part in were quite enjoyable and informative, yet they were also detached and covered broad, seemingly unrelated themes from each course. Typically, the experiments were demonstrated by the academic staff, with the students then repeating and writing them up. This approach effectively characterised the students as technicians whose goal was to learn established lab techniques, rather than as researchers whose goal is discovery (Chang, 2005). When I look back on my student days, the practical exercises that stand out were the occasions towards the end of field courses when we were invited to design a small project that put to use the skills we had acquired. The excitement of original thought and experimentation, however simple, enhanced the experience beyond all other forms of learning in those courses.

On reflection, I decided that I wanted the Global Change Biology course to take the best from these two approaches to learning: getting the students to engage in and contribute to original research whilst operating within a logistically feasible and repeatable framework that addressed key aspects of experimental ecology, global change biology, and scientific writing. To do this, I enlisted the help of my co-authors (and also Teresa McConlogue in the formative stages) from the Thinking Writing team at QMUL, who had initiated a research-based learning and writing project across the institution (www.thinkingwriting.qmul.ac.uk). Together, we developed a set of interlinked practicals (laboratory classes) that provided the students with an overview of the scientific process: an introduction to hypothesis testing and experimental design, carrying out an original experiment, an overview of basic statistics to analyse the data

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collected, writing up the experiment in the form of a scientific paper, peer review, and eventual “publication” and oral presentation of the research (Table 1).

Table 1 *Outline of Practical Classes on the Second Year Undergraduate Global Change Biology Course at Queen Mary University of London*

Week	Activities
2	Overview of experimental design and hypothesis testing Literature review (computer-based) Development of experimental hypotheses Overview of basic statistics with computer practical on real data
3	Experimental set-up Overview of writing in the style of a scientific paper Overview of introduction & methods and peer review assignments Papers assigned to students for oral group presentations
5	Oral group presentations Individual and group feedback from academic staff
10	Take-down of laboratory experiment Contextual reiteration of statistical analysis and scientific writing Feedback on introduction & methods and peer review assignments Overview of final reports

Note. The practicals are interspersed with 12 weeks of formal lectures on different aspects of global change biology.

Underpinning our work were a number of principles related to knowledge, learning, and disciplinary thinking and writing. For example, rather than seeing knowledge as discrete, finished, and factual, we construed it more as “a process of construction” or enquiry, and this enabled us to see students as participating in knowledge construction (Brew, 2006). In line with this, we also saw “thinking” not as the product of individual minds (the lecturer’s, or particular students’), but as something that would emerge through situated practices and activities in which a “community” of people engage (Gee 2000)—in this case the class, not just in a single year but over a number of years. Further, we reasoned, following Ivanič (1998) and Dressen Hammouda (2008), that students would not learn to write and read meaningfully in their discipline of biology, unless they were enabled to participate in practices that would begin to develop their disciplinary identity. Here, we linked identity to what Gee (1990) called the Discourse (capital “D”) of the discipline, understood as “ways of being in the world, or forms of life that integrate words, acts, values, beliefs, attitudes, [and] social identities” (p. 142). How language is used in the discipline to make sense—its discourse (lowercase “d”)—is always shaped by, as well as shaping of, its larger Discourse.

This report from the field will outline some of the key themes and values we addressed in the design and teaching of the Global Change Biology course and how the students engaged with and responded to them. It includes their enculturation into research thinking, experimental practice, writing and reading research, peer review, and inheritance.

Background to the Course

The Global Change Biology course explores the biological consequences of climate change, land use change, pollution, and biodiversity loss during 22 hours of lectures and 12 hours of lab-based practical classes. The assessment consists of 4 pieces of coursework (an oral group presentation, a multiple choice question examination on literature sources, a scientific report, and a peer review exercise) and a written final examination. The course is available to second-year undergraduate students doing a degree in the biological sciences at QMUL. Eligible

students are expected to have completed modules on the diversity of life, conservation and the environment, and ecological and environmental techniques during their first year at the university. The course was first run in 2012, growing from 27 active enrolments that year, to 33 in 2013, and 39 in 2014.

Enculturation into Research Thinking

Due to my fears about the logistics of allowing the students to formulate their own experiment, my initial plan was to teach the basics of experimental design and then hand the students a design that fitted with what we could easily establish in the laboratory. However, my collaborators from Thinking Writing convinced me that this would be succumbing to the very trap I was trying to avoid: it would cut the students out of discovering a research hypothesis and curtail their sense of participation in the experiment. They argued that these elements were actually the key to what we were trying to achieve in making the course “research-based” (Jenkins, Healey, & Zetter, 2007; Lambert, 2009). So instead, I tried to find a balance between a logistically feasible laboratory experiment that could be implemented in a short space of time and one that would enable students to contribute to the thought processes. I opted for a scaffolding approach, in which I could direct the students towards a general framework with carefully chosen examples and explanations, but within which they would develop the overall concept and hypotheses of our experiment.

First, I presented a brief overview of my own research, which investigates the impacts of warming on natural communities (O’Gorman et al., 2012), and then encouraged the students to make an observation about the impact of warming on an important ecosystem function. When I asked around the class what those important functions might be, the students suggested primary production, carbon sequestration, and decomposition. I gave them 30 minutes in the practical class to search the internet for published studies that examined warming impacts on these ecosystem functions. They quickly began to notice a trend: warming was associated with an increase in the decomposition rate of organic matter, irrespective of whether the study had been performed in marine, freshwater, or terrestrial environments (Table 2).

Table 2 *Literature Review Carried Out by QMUL Students in January 2012 to Investigate General Patterns in the Response of Decomposition Rate of Organic Matter to Warming*

Response of decomposition rate to increasing temperature	Marine	Freshwater	Terrestrial	Total
Increase	6	8	9	23
Decrease	1	0	1	2
No change	0	1	1	2
No. of studies	7	9	11	27

I pointed out to the students that all the studies they had collated had examined this response in terms of the particular ecosystem that was of interest to the authors. None had systematically manipulated temperature in a range of ecosystem types simultaneously or measured decomposition rates on similar organic substrates in each environment. The students were surprised at this and thought it could be a good angle for their experiment. The next step was to construct a model, i.e. an explanation or theory for why we might have observed the trend. To help with this, I gave the students a hypothetical example for context. I told them about a beekeeper who observed that his bees were producing more honey if they were associated with areas of his field that had lots of flowers; other parts of his field had very few flowers and the bees were unproductive. The model that he proposed to explain this variation in flower density was that areas of the field with few flowers might have low nutrient concentrations. I asked

the students what might be causing what they themselves observed, and they suggested that organisms would use more energy in a warm environment and so would need to eat more food to survive. And so our model became that the increased metabolic demands of detritivores (organisms that eat decayed matter) in warmer environments might have led to greater consumption of organic matter.

To formulate testable hypotheses (i.e. predictions based on the model), I returned to the beekeeper. I explained how he used his observation about the flowers and model about the nutrients to propose that there would be a positive relationship between the density of flowers in his field and nutrient concentration. He could then test this prediction by randomly throwing a quadrat (a small wooden frame with a known area) around his field and repeatedly measuring both flower density and nutrient concentration within the quadrat. Using their own model, the students predicted (1) that there would be an increase in the decomposition rate of organic matter at higher temperatures and (2) that this increase would be consistent across different ecosystem types. To test these hypotheses, we needed an experiment that manipulated temperature and ecosystem type. At this point, I took over planning the finer details of the experiment: I chose simple aquatic microcosms (small plastic tanks), where we could manipulate the salinity of the water to vary the environment among freshwater, brackish, and marine. In the next class, we would place amphipods (aquatic insects that like to eat dead matter) together with dried alder leaves in the plastic tanks and then place them in special rooms where we could control the temperature of the environment. We would then measure the decomposition rate by looking at the change in the dry weight of the alder leaves as a result of breakdown by bacteria and amphipods. The design of this experiment, illustrations of the microcosm set-up, and key organisms used can be seen in Figure 1.

The conceptual framework of observation-model-hypothesis-experiment is a logical progression (Underwood, 1997), critical to the design of ecological experiments from which we can draw reliable conclusions. Involving the students in the conceptual process of designing the experiment gave them a context and meaning different from simply being told that these steps are important and must be learned. Students commented that by breaking the process into illustrated steps, they were able to understand the simplicity of looking for a pattern and logically discussing why it might occur. They mentioned how they could clearly see the components of the pattern that needed to be manipulated and measured in a controlled way, and why removing the variability and the confounding effects of the collection of studies that constituted that pattern was important. The students also seemed encouraged by the thought that they would be the first ones to test for generality in the response of an important ecosystem function to warming in a systematic way.

We felt that the students were beginning to develop a sense of themselves as legitimate participants in a disciplinary process of knowledge construction (Wenger, 2008). They were perhaps shifting from seeing knowledge as something already given or handed down by authoritative experts—in this case within an institutional hierarchy—to something that is made within disciplinary communities. Through their involvement in generating original research questions, they were beginning to acquire some of the values, attitudes, and beliefs of the Discourse of this community (Gee, 1990) and the way that its identity is shaped, socially situated (Barton, Hamilton, & Ivanič, 2000), or indeed bound up within these social hierarchies.

Experimental Practice

The students established and processed the experiment over two laboratory practicals separated by seven weeks. In these classes, the academic staff were able to engage them in the terminology of experimental design, the biology of the organisms, the ecological processes at play, logical reasoning for some unexpected observations, and improvements that could be

made to the experiment. There was no formal structure to this learning process or lecture notes. Rather, we encouraged the students to think as they were doing and found that they were inquisitive and open to dialogue as they put the experiment together and saw it through to its end point.

We highlighted how the observation-model-hypothesis-experiment framework is

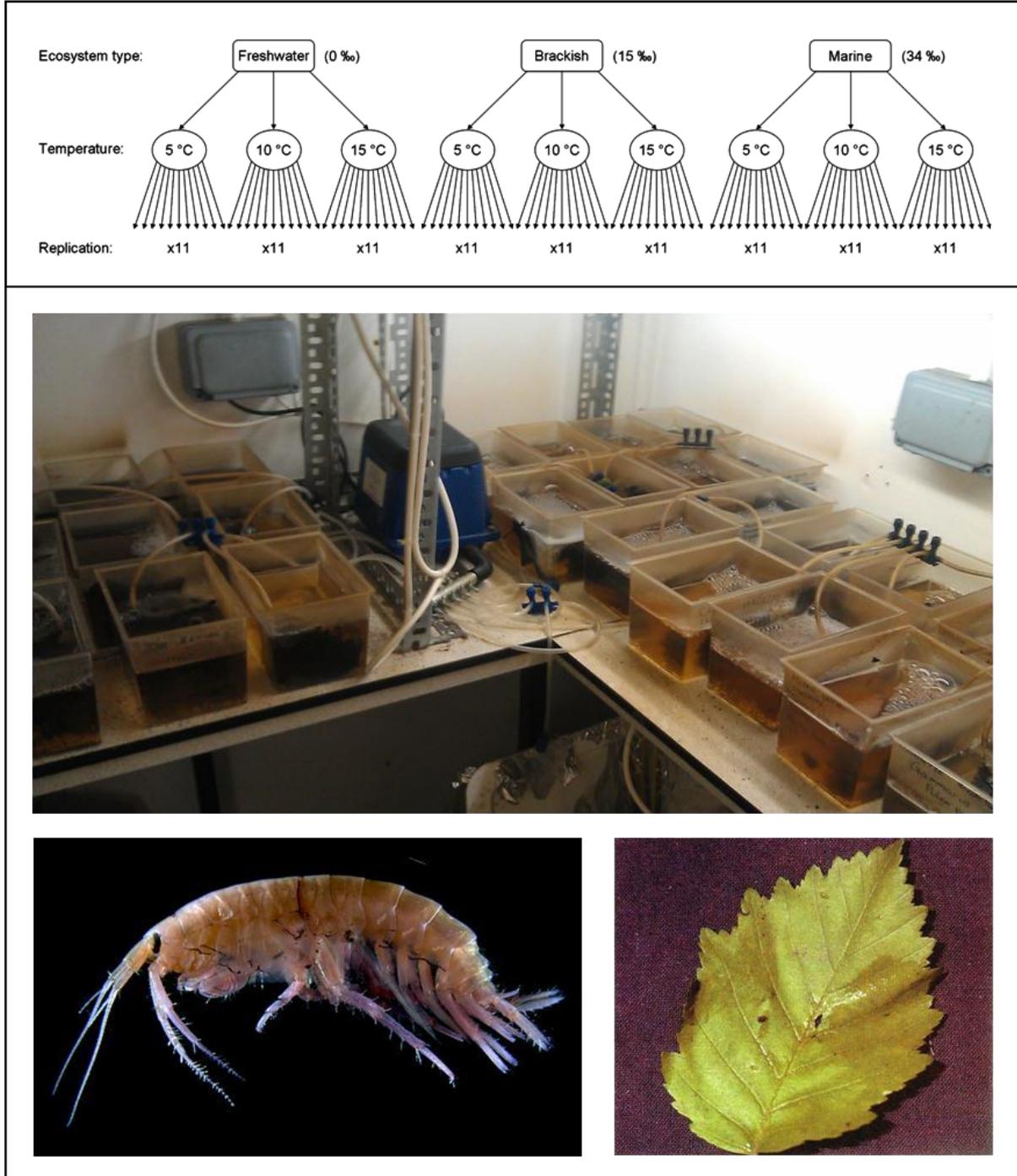


Figure 1. Design of a laboratory-based microcosm experiment carried out by QMUL students in 2012 to investigate the effect of temperature and ecosystem type on the decomposition rate of alder leaves. The experimental design framework is given in the top panel, with the experimental microcosms and air bubbling system in the central photograph. Images of the amphipods (as main detritivores) and alder leaves (as dried organic matter for decomposition) used in the experiment are shown in the bottom panels.

ongoing, and encouraged them to make visual observations about the experiment, formulate further models to explain the observations, and suggest follow-up experimentation in their final reports. Again, the example of the beekeeper became useful to illustrate how this process works in a different experimental context. The beekeeper found a positive relationship between nutrient concentrations and flower density, but he realised that there could be factors other than nutrients affecting flower density, e.g. exposure to grazers or availability of water. The positive relationship became his new observation, with his new model that nutrient limitation *causes* variation in flower density. To definitively test this, he established empty plots in different areas of his field; he directly manipulated nutrient concentration, with half his plots at ambient levels and half of them enriched; he then monitored flower growth in the plots. This further elaboration of the beekeeper's methods reinforced the logical framework of experimental design and hypothesis testing and helped the students to think actively about the direction of their own research.

Writing and Reading Research

Having begun to participate in the practices by which knowledge is constructed in the discipline, students next began to learn how that knowledge is represented in rhetorical ways that the community recognises and to which it can respond—that is, to write in the genre of the scientific report (Bazerman, 1989; Swales, 1990). The only structured teaching during the practicals re-emphasised the progress and knowledge gained to date and provided input and guidance on writing a scientific report on the experiment (see Table 1). To maintain the research-based learning focus, I situated my overview of scientific writing in the context of the students' own research. They had already started to review the literature as part of developing their experimental hypotheses (and to prepare for their group presentations), so I described how to summarise these papers into a broad background to the field before narrowing to the processes and questions of interest to their experiment. I encouraged the students to list themes and ideas they thought were relevant. I then explained how ending the introduction with the focused set of hypotheses that they generated in the first practical would help to create a road map for the rest of the report, with methods explaining how to test those hypotheses, results highlighting the findings from those tests, and the discussion articulating the interpretation and wider context and significance of the findings. To teach them basic statistics in order to analyse the findings, I created a replica dataset to what they would produce from their experiment. Again, the students were encouraged to learn by doing, actively working through the analytical steps with this data in a computer practical. Pursuing the notion of a community of practice (Lave & Wenger, 1991), I encouraged the students to help each other with any issues performing or interpreting the analysis, as in a true research community, while also providing one-to-one guidance over the course of the practical.

Traditionally, the oral presentation is a summative assessment that comes at the end of the course, once the research and report have been completed. However, rather than wait until the end to teach the students about oral presentation of their research, I used the presentation as a more formative opportunity for them to learn about important scientific papers in global change biology and become more familiar with the rhetorical moves that typify the structure of scientific reports. The class was divided into groups of four, with each group reading one paper and presenting key features of the introduction, methods, results, and discussion sections and the paper as a whole. With a multiple-choice question examination on the papers to follow, students were asked to listen to all the presentations and learn about each study from their peers. They were encouraged to ask questions and participate in a discussion about the strengths and weaknesses of the studies. With students having participated in a research process themselves and having learnt explicitly about the rhetorical functions of the dominant genre, we hoped that they were in a better position to question the studies of others. The

academic staff also offered constructive feedback on their performance, collectively and individually, to help them improve their ability to communicate and critique scientific research. The assumption here was, in part, that learning collaboratively about published scientific research would make the students more likely to retain the information than if they simply read the papers in advance of the examination.

Peer Review

The report writing phase was divided into stages: first, students submitted a draft of their introduction and methods sections, which was then peer reviewed; second, they could rework their introduction and methods sections in response to the comments of their peers and academic staff, while adding in the results and discussion sections. For the peer review activity, students were put into pairs and asked to provide feedback for their classmate's report by commenting on the text and answering a series of questions (see Table 3). As the students were not experienced in making judgements about the writing of their peers, the task was scaffolded by questions directing them to pay careful attention to different aspects of the text, describe their features, and then judge their success (Sadler, 2010). This iterative approach aimed to allow students time to step back from their writing and to see it as a process, while also giving the academic staff a sense of their progress and speeding up the final marking.

Table 3 *Sample of the Questions Posed to the Students to Structure Their Peer Review of a Classmate's Introduction & Methods Assignment*

#	Peer review question
1	Has the writer given a concise overview of the broad issues this area of research addresses? What does he or she see as the broad issues?
2	How has the writer organised his or her review of the literature? Has he or she dealt with one research article at a time or picked themes across papers to explore?
3	How easy is it to follow the writer's line of thought in this section? Is there anything you would change, move around, or expand on to improve it? Please be specific.
4	How many papers has the author referred to? Are they all relevant in your opinion? Are there any papers missing that you think should be there? If so, explain why.

In focus groups and interviews, students commented that although they were in the second year of their degree, the guidance they had received on writing lab reports to date had been quite minimal and not very helpful, a finding echoed by Bailey (2009). The peer review exercise, however, helped them to think critically about another student's writing and to deal with and respond to critical feedback on their own writing. It also began to give them a feel for what counts as quality in scientific writing and to benchmark themselves against this (see Table 4). These responses reflect what has been reported in other studies of how peer assessment is experienced (McConlogue, 2014; McConlogue, Mueller, & Shelton, 2010; Nicol, 2010). Our aims in the peer review were not to emulate the process that, for example, professional scientists experience when submitting journal articles, but to give students a taste of what this might entail. We hoped to give them a sense of how scientific knowledge is grounded and distributed in the day-to-day social practices and technologies of scientists (LaTour, 1991; Lave & Wenger, 1991), whilst helping them to make explicit and discuss the rhetorical structures of scientific papers. These structures are typically taken for granted by practising scientists, but can be unfamiliar and challenging for those who are learning to participate in a scientific community for the first time.

To promote constructive critique, I assured the students that their grade for the introduction and methods sections could not decrease in the final report and so their fellow

students would not be penalised for any criticisms they made; however, they themselves would be penalised for having nothing to say. A clear effort to improve the final report in line with the recommended changes was also met with an improved grade, providing the students with an incentive to engage in the exercise. Many of the students reported asking their classmates to read their final report before submission for an additional (ungraded) critique and suggested that, because of its positive impact on their writing, they would employ the technique in future college assignments.

Table 4 *Quotations from Students Participating in a Focus Group About the Peer Review Activity*

Student	Quote from focus group on peer review exercise
1	"I found it incredibly useful getting a peer review back from a fellow student ... it's less terrifying because they're in exactly the same position" "Writing the peer review for somebody else who'd done a very good job was like peering over someone's shoulder ... not necessarily stealing, but remembering ideas for later on" "I think it opened up the entire class, it made everyone talk to each other"
2	"Having people say, 'this doesn't make sense, you need to make it easier for someone to understand' made me scrap what I'd written, start again. So, that was really useful" "When you're asked to comment on someone's work, you realise where the flaws are in yours as well ... you'll be more critical of your own work"
3	"Sometimes you're not very critical of yourself because you don't want to have to re-do it all over again, but you can be with someone else's work ... which, in theory, should translate to your own work"

Inheritance

To provide an element of continuity to the module, I used the same basic framework in subsequent years of the course, i.e. students carrying out a literature review to make an observation about an aspect of global change that could be manipulated in an original laboratory experiment. A key element that also remained was the involvement of the students in deciding what form the experiment should take, based on their construction of a model and formulation of testable hypotheses. Thus, in the second year of the course, the experiment changed: the students read about the experiment performed by the previous year's class and opted to tease apart the relative importance of the amphipods and the bacteria in driving the decomposition trends that were observed. They used a similar experimental design to that shown in Figure 1, but with the presence or absence of amphipods as an additional experimental factor. Then, in the third year of the course, the group was particularly interested in investigating the effect of nutrient enrichment on decomposition rate, after observing in published studies that nutrients typically stimulated decomposition rate. This approach has maintained the logistical feasibility of the course by utilising the same general experimental infrastructure each year, whilst ensuring that the students can delve deeper into mechanisms highlighted by previous classes, investigate different aspects of global change, and build on the accumulating research findings.

Participation in the Thinking Writing team's research-based learning and writing project enabled me to fund the development of a module website (www.rblw.co.nr), which gives an overview of research-based learning, background information to major drivers of global change, and information on previous classes (see Figure 2). In line with the ideas of Chang (2005) for turning an undergraduate class into an evolving research community, I also "publish" some of the best reports from each year on the website. These reports serve as

secondary literature for future classes and play a critical role in showing each new cohort what their predecessors achieved, what they identified as the experimental issues, and where they saw room for improvement. Unlike many texts that are written for assessment purposes (to achieve a grade), these student texts actually contribute to the development of knowledge and therefore have a disciplinary as well as an educational function. Through the website, each cohort builds on or inherits the research of previous classes in order to address new questions and fill the gaps in existing knowledge.

SBC203 Global Change Biology:
A research-based learning & writing approach

Where to?

- Home
- Project Overview
- Global Change Drivers
- Scientific Writing
- Peer Review
- Previous Classes
- Contact

1
day until
Lab experiment set-up

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Home

The practical component of the SBC203 Global Change Biology course at Queen Mary, University of London was developed by [Dr. Eoin O’Gorman](#) in Dec 2011 as a research-based learning and writing initiative. The course aims to teach students about experimental hypothesis formulation and testing, encouraging them to design and implement original laboratory experiments on global change themes. They learn how to write in the style of a scientific paper, engage in peer review, and present scientific findings during the practical series. Each new cohort of students builds on the work carried out by the previous classes, whose reports (published on the website) act as an inheritance mechanism in the form of secondary literature. The initiative is supported by the [Thinking Writing](#) team at QMUL.

SBC203 course calendar for 2014

Today: [←](#) [→](#) Wednesday, January 22

Thursday, January 23	2:00pm Practical #2
Thursday, February 6	2:00pm Practical #3
Friday, February 21	5:00pm Intro & Methods assignm
Friday, March 7	5:00pm Peer review deadline
Monday, March 10	9:00am MCQ examination
Tuesday, March 11	MCQ examination
Wednesday, March 12	MCQ examination

Events shown in time zone: London [Google Calendar](#)

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[style](#)

[peer review](#)

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Figure 2. Screenshot from the module website for second-year undergraduate teaching at Queen Mary University of London. This technology-enhanced learning environment provides background information on research-based learning and writing, global change drivers, and content from previous cohorts of students. The material on the website acts as an “inheritance mechanism” for subsequent classes on the course.

Student Engagement and Performance

Student engagement with the course has been high in all years, with post-module feedback indicating that satisfaction ranged from 78% in 2012 to 84% in 2014. Out of seven grading criteria, access to good learning resources scored the highest, emphasising the value of making previous course content, student experiences, and secondary literature available on the website. Many students commented on the importance of the help they received with scientific writing

and the improvement in the quality of the reports in light of the critical feedback from classmates and staff. Peer review was one of the most well-received elements of the course (see Table 4). Interestingly, the improvement from initial to final submission once feedback was incorporated increased from the first year of running the course (ANOVA: $F_{2,96} = 6.96$, $p = 0.002$; see Table 5), with a significant improvement in both 2013 (Tukey's test: $p = 0.044$) and 2014 (Tukey's test: $p < 0.001$) when compared to 2012. This improvement in student performance was also evident in the average grade for the final report, which has increased with each year of the course (albeit non-significantly; ANOVA: $F_{2,96} = 1.18$, $p = 0.312$; see Table 5). We recognize that the complexity of learning disciplinary thinking and discourse means that we cannot make strong claims about causal connections between our research-based learning approach and the quality of students' written work. However, we can speculate that these improvements may be a result of the growing body of secondary literature and student content available on the website, an improvement in our understanding of what students need in order to perform well, and a refinement of the successful elements of the course with each new year.

Table 5 Data on the Performance of Students in Each Year of the Module

Year	No. of students	Peer review improvement	Final report
2012	27	4.5 ± 5.8 %	62.6 ± 7.4 %
2013	33	13.7 ± 14 %	63.7 ± 10.8 %
2014	39	18.0 ± 18.4 %	65.7 ± 6.5 %

Note. The number of students that submitted reports is provided, along with the percentage increase in student grades between the initial and final submission of the introduction & methods assignment in response to the peer review exercise. The % mark for the final report is also given for each cohort of students. Means \pm standard deviation are provided in each case (note that the range of scores for the final report in each year was approximately 53-84%, with most students scoring 60-70% on their report).

Reflective Teaching

The collaborative dimension of the work has given us, as instructors, valuable opportunities not just to reflect but to extend the level of critical reflection on our practices. Drawing on Kreber and Cranton's work (2000), Brew (2006) framed a "multi-dimensional model" for reflecting on knowledge and the curriculum. This model is composed of three levels: the instrumental or technical, the communicative, and the emancipatory. At the instrumental level, reflection is concerned with the teaching content, such as the teaching methods for a given course design. Reflection at the communicative level addresses "the processes leading to particular strategies"—in other words, whether the course design was effective or not. As Kreber and Cranton (2000) stated, here "the focus is on learning about and sharing others' ideas and perceptions, including negotiating meaning with them" (p. 484). Last, the emancipatory level questions the premises of teaching itself, such as "why the teacher teaches the way they do" (Brew, p. 110).

The work on this course encompasses all three levels of reflection. The shift from a more traditional, transmission approach to teaching, based on lectures and lab-based practicals demonstrated by academic staff and technicians, to an enquiry-led approach stems from questioning the ways that students learn to participate in disciplinary communities and how this learning is related to the instructor's role and authority. One of the most critical challenges appears to be convincing students that they really can contribute to and conceptualise an original experiment. In the first year, efforts to scaffold the exercise often verged on leading the students into a particular line of reasoning or hypothesis, partly because of their general

reluctance to voice their opinions, but also because of a lack of confidence from me as an instructor in whether they would settle on a viable experiment. The sharpest students saw through my uncertainty and remained sceptical throughout the process, undermining the sense of a true enculturation into research thinking for the entire class.

Reflection on the processes, or the communicative level, helped us to realise that we needed to look more carefully at the student assessment of the module. The default student questionnaires associated with courses at the university are insufficient to get specific feedback on techniques employed in the module. Equally, the collection of qualitative and quantitative data presented here is not evidence for the effectiveness of teaching and nor, as Brew (2006) argued, “does the process of acting on that evidence to effect changes in the teaching” (p.109) constitute a scholarship of teaching. In the final year, we started to run focus groups and interviews with students on particular elements of the course in an attempt to address this issue and to generate ideas for further improvements in subsequent iterations of the module.

Thinking about the course design at an instrumental level helped us to improve our mechanisms for getting the students to think critically about their own and other students’ work. Recognising that their only guidance in responding critically is effectively through instructor feedback on the written exercises, we initiated a brief writing workshop towards the end of the fourth practical in the third year of the course. Here, we asked the students to work in pairs to redact a piece of text so that they removed all redundant information. We then displayed the text on a projector screen and implemented their collective changes, discussing any misunderstandings about the process. Several students commented that the exercise gave them a new strategy for critically reading a piece of writing, one that they would employ in their final reports.

Conclusion

Increasing student satisfaction and performance on the course underline for us the value of building a student research community that incorporates an inheritance mechanism as a means of learning scientific practices in the biological sciences. The course has achieved our aim of enabling students to participate in “the ways academic staff themselves research and learn in their discipline or professional area” (Healy & Jenkins, 2009, p.28), giving them the kind of research experience that the USA Boyer Commission argued in 1999 should become “the standard” across the higher education sector. This includes the discovery of a research problem, the formulation of hypotheses, the design and execution of an experiment, and the iterative processes of writing, review, reading, research, and rewriting. Much of this work is collaborative, with both current peers and past peers, and in anticipation of future peers. The “inheritance mechanism” (Chang, 2005) that is designed into the course allows the student learning not to be fully bound by the institutional constraints of, for example, summative assessment and the semester-long course unit. Peer review also contributes to students learning to make judgements that would hitherto have been the preserve of the academic (Bloxham, 2009; Sadler, 2010; Shay, 2005). Eventually, I hope that their work may be developed into a multi-authored published article; if this becomes possible, it will mark a significantly changed relation between students and academics from that which I experienced earlier in my career.

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Notes

¹Throughout the paper, "I" refers to the first author, Eoin O'Gorman, whose course we are describing. "We" refers to all three authors—the collaborative team involved in thinking through the course design, etc.

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