[O10] The 'poor Raymond' investigation: a team work exercise to inspire new students

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SUMMARY

'The death of my brother Raymond has shocked and saddened us. But, although the police are treating the case as death by misadventure, we suspect that foul play was involved'. So opens our exercise known as 'poor Raymond', which is tackled by all of our first year chemistry students mid-way through their first semester. Although the exercise has many worthy educational benefits, one aspect of it is the most important – that the students enjoy, and are inspired by, a realistic problem for which their scientific skills and views are valued.

In brief, they are introduced to a storyline in which there has been a suspicious death; in order to persuade the police to look seriously at the case, they have been asked (in groups of about 6 amateur chemists) to scientifically assess three clues that might indicate foul play. They need to decide how to analyze the samples (e.g. a splash on a lab-coat, some pills in a bottle, a liquid found in the locker of the deceased); although they are given some guidance, they must plan the experiments, divide the tasks among their group, and go into the labs to analyze the evidence. Having obtained their results, they submit a short team report, and also meet up with all the other 'amateur chemists' to discuss the results they've obtained. We hope that the students benefit from the following features of the exercise:

- We thoroughly engage them in a plausible storyline that is based in their own subject
- They discover that they already know enough science to be able to tackle a difficult problem.
- They have to go into the labs and design/conduct experiments.
- They learn that there are no 'right' answers (only balance of proof)
- They start to learn how to work as a team.

Most of all, the 'poor Raymond' exercise fires up their enthusiasm in the all-important first year of their degree course.

BACKGROUND TO THE EXERCISE

In common with many degrees in science and engineering, our students arrive at the start of year 1 eager to begin tackling *real* problems in their subject. However, there is a strong tendency for us to use year 1 to simply lay the foundations, ensuring that they learn the fundamental theories and safe laboratory skills, whilst less effort is sometimes given to the essential aspect of inspiring and motivating our students (1). Many courses now use PBL (2) and transferable skills exercises

(3,4) to add variety and extend the range of skills that students develop, and our course is no exception (5). However, it is quite difficult to design material that is suitable for the 1st term/semester of year 1, when students arrive with varied training and limited knowledge within their discipline. We wanted to design an exercise to which everyone could contribute, in which their limited knowledge would be sufficient, that would involve some 'hands-on' science, and for which their views would be valued. We chose a forensic science scenario, but one in which they took on the role of 'capable amateur', trying to amass sufficient evidence to persuade the police to engage 'the professionals'.

STRUCTURE OF THE EXERCISE

The exercise is run over a 1 week period as follows:

- Thursday - 1h lecture slot - Introduction to the exercise
- Monday - 3h lab period - Conduct experiments
- Tuesday - 3h lab period - Conduct experiments
- Thursday - 1h lecture slot - Debriefing (discuss results/submit reports)

WHAT DO THE STUDENTS DO?

Introduction: we carried this out as a role play, with the scene being set, and the exercise presented, by 'the brother of poor Raymond'. The students arrived with no prior information about the exercise, and no hand-outs are given until the scene is set. This tactic helps to really engage the students, who are then divided up into groups of about 6 – in semester 1, one can either reinforce tutorial groups, or help the students to mix by assembling the groups appropriately. The introduction takes about 20 minutes, and then the students are free to plan the experiments as they think best, and/or to agree to meet up later to plan them (see below for the two handouts they receive).

Experiments: the experiments are designed to be too hard to be all carried out within the 2 lab sessions unless the tasks are divided up amongst the group; however, they are short enough that most of the analyses can be carried out in the first lab day, so that they can (often as a group) return to some aspect of the experiments that seemed ambiguous, or for which they would like to obtain additional data. They are asked to prepare a one-page team report for the police, and also decide what steps they might take to preserve the integrity of material that might be re-analysed professionally.

Debriefing: they must not only submit their report, but also be ready give their results to the whole class – not actually too demanding, but it gives them some practice at sharing results with a bigger group. This feedback session is very important, as the students start to make some judgment of the validity/ reliability of their results. We have run it with around 15 groups, and so can select 5 groups to provide their results on each of the 3 experiments, each time checking with the rest of the students to see how much agreement there is. This is effectively the same as repeating the results as an analytical scientist would, although the variation isn't analysed statistically. A key aspect of the debriefing is when the students ask 'what is the right answer?' Although there effectively is a correct solution, in that the samples were prepared artificially, a critical aspect of the exercise is that *the 'correct' answers are the results the students obtain* – to act out the role-playing realistically, there are no 'right answers', just a balance of scientific evidence that leads to a proposal – quite a revelation for many first years!

POOR RAYMOND (HANDOUT 1)

The death of my brother Raymond was a great shock to me, and to all his friends and family. At 20 years old, keen on all racket and team sports, he was found dead at his place of work, MacKenzies Winery, just 3 days ago. Although the inquest has yet to be held, preliminary enquires by the police suggest 'death by misadventure'. He had been taking a mixture of pain-killers and anti-inflammatory tablets (aspirin and ibuprofen tablets found in his pockets) to help him play squash through a shoulder injury, and an adverse reaction with alcohol at a work's celebration apparently led to a fatal reaction. Raymond had already raised concerns with me about the practices of his present employer, for whom he'd worked for a couple of years. Although leaving school at 16 and going straight into a job, Raymond was a bright guy, and the 'Research and Development Assistant' role he took on was little more than a general skivvy. And the firm didn't seem keen or supportive when he wanted to understand about the underlying science, or when he suggested that he might try to obtain a University degree in chemistry after taking A-levels in evening classes.

Yesterday, one of his close colleagues came to see me. Michael Fletcher had worked alongside Raymond, and the two had discussed their concerns about the additives that the company was using to improve the wines they were selling.

To increase the value of the wine, the company was illegally adding flavourings to the vats. Raymond had managed to smuggle some of this liquid into a vial, which Michael had found in Raymond's locker; they suspected that two components were present, which made the wine sweeter and smell more fruity.

In the step to help remove the insolubles from the wine-making process, the company was meant to add innocuous tartaric acid, but Raymond suspected that a more efficient but illegal alternative was being used. Some of this had splashed onto his lab-coat, and Raymond had cut this out, hoping to isolate and identify the additive, thought to be an aromatic acid.

Finally, Michael had retrieved an almost empty unlabelled bottle from the lab bins. It contained a small amount of a white powder. Michael wondered if one of the firm had been worried that Raymond was finding out too much, and had decided to lace his lunch with drugs, hoping he might then fall asleep on the job and so give the firm an excuse to sack him. If true, this had had unexpected and fatal consequences.

The police suspect nothing, so I need to obtain proof of foul play. I'm hoping you can identify the wine additives from the samples collected by Raymond. Also, if the powder in the bottle were to turn out to have the same mixture of analgesics that Raymond had in his bloodstream (path lab results still pending), then this would be an extraordinary coincidence that the police would have to follow up. As trained chemists, you need to:

1. Identify the two components in the liquid additive.

2. Identify the solid on the lab coat.

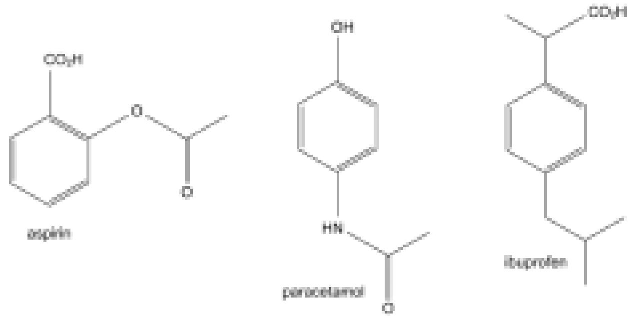
3. a. Gain evidence for the composition of the powder, remembering that ibuprofen and aspirin packets were found on Raymond.
   b. Think about procedures you would carry out to try to ensure that forensic data obtained from the bottle would subsequently stand up in court.

Remember, we're not in a position to carry out a rigorous forensic analysis. What we do want to do is to see if we think Raymond's death was suspicious, and obtain enough evidence to persuade the police to carry out further investigations. In teams of 5–7, you need to plan what you will do, check your method with a colleague (the demonstrators are suitable experts), carry out the analyses next Monday/ Tuesday, and report the results at a meeting on Thursday.

POOR RAYMOND (HANDOUT 2)

A few tips and suggestions

1) Pain-killers that are widely used and readily available include:



Good solvents for running TLCs include diethyl ether, dichloromethane, and ethyl acetate (or mixtures of them). The pain-killers should show up on TLC if developed in KMnO , dil. H_2SO_4 (then heating), or in an iodine tank, but the intensity depends both on the substance and the method of development.

2) Some possible carboxylic acid additives are listed below, together with their melting points:

(L)-tartaric acid	170-172°C	p-anisic acid	183-184°C
benzoic acid	121-122°C	o-chlorobenzoic acid	138-140°C
o-toluic acid	103-105°C	m-chlorobenzoic acid	155-157°C
m-toluic acid	108-110°C	p-chlorobenzoic acid	239-241°C
p-toluic acid	180-182°C	o-acetylbenzoic acid	116-118°C
o-anisic acid	98-100°C	m-acetylbenzoic acid	169-171°C
m-anisic acid	106-108°C	p-acetylbenzoic acid	208-210°C

(Toluic is the trivial name for methylphenyl, and anisic is the trivial name for methoxyphenyl; o/m/p indicate benzene derivatives which are di-substituted 1,2/1,3/1,4 respectively).

Most aromatic acids will dissolve in standard organic solvents like dichloromethane, diethyl ether, or ethyl acetate. Good solvents to recrystallise them from are mixtures of water and ethanol.

3) Possible additives to the wine are listed below, together with their reported boiling points:

methanol	65°C	propane-1,3-diol	214°C
ethanol	78°C	methyl acetate	58°C
propan-1-ol	97°C	ethyl acetate	77°C
butan-1-ol	116-118°C	ethyl propanoate	99°C
butan-2-ol	98°C	prop-1-yl acetate	102°C
pentan-1-ol	136-138°C	but-2-yl acetate	111-112°C
ethane-1,2-diol	196-198°C	pent-2-yl acetate	131-132°C

(What spectroscopic test might help you distinguish alcohols from esters?)

<u>At the debriefing workshop at 11.00am on Thursday of week 7:</u> you will need to have completed a brief ONE-PAGE report (free-hand is fine, but the one page limit mustn't be exceeded), to hand in to the police. You need to explain what you did, your results, your conclusions, and what each member of your team did for the report. It needs to be clear and succinct, as the police will need to discuss your report with their experts. So that we can collate results at the debriefing on Thursday, you need to bring these results with you, and you will be asked to enter some of them in a grid. You will need to be able to comment on your confidence in the results (or why you are not very confident), and also indicate how your results might be made to stand up in court.

'POOR RAYMOND' INVESTIGATION: NOTES FOR DEMONSTRATORS

The students need to devise their experiments, so they are not following recipes. They need to identify the unknowns, which are:

1. The two liquids are ethanol (b.p. 78 oC) and amyl acetate (pent-2-yl ethanoate) (b.p. 131–132 oC); they will have 20 ml in roughly equal amounts. Good groups should obtain IRs, and look up the peaks expected for esters and alcohols.

2. They each have a piece of cloth, which has about 0.5 g of 2-chlorobenzoic acid soaked into it, and dried. They need to extract with a suitable solvent, recrystallise, and obtain m.p. in order to identify it.

3. The TLC is the trickiest part (see details below). They have a 1:5 mixture (wt:wt) of paracetamol:ibuprofen to identify, and need to compare this with samples of paracetamol, ibuprofen and aspirin. Good groups should be able to get a rough measure of the ratio.

TLC is on Merck Kieselgel 60 Fg_{254} aluminium backed plates. Test solutions are made from powdered tablets. For aspirin and paracetamol 100 mg are shaken with 5 ml of propanone. For ibuprofen 100 mg are shaken with 2 ml of propanone.

A solution of diethyl ether, dichloromethane and tetrahydrofuran in the respective portions of 2:1:05 gives R_f values of 0.62 for ibuprofen, 0.45 for aspirin and 0.22 for paracetamol (THF helps reduce streaking of aspirin). The spots can be visualised using a potassium permanganate solution made up of:

Potassium Permanganate	105 g
Potassium Carbonate	10 g
5% NaOH (aq)	2.5 ml
Water	150 ml

Paracetamol produces an instant strong yellow spot; ibuprofen produced a white spot over 2-3 minutes, but aspirin only shows up on heating the plate with a hair-dryer, which bleaches the permanganate and makes the ibuprofen spot difficult to see, so it needs marking with pencil before the plate is heated. Iodine tank and dil. H_2SO_4 (aq) also work, but $KMnO_4$ is best.

ASSESSMENT

The exercise forms part of the transferable skills exercises called 'Communicating Chemistry'. The marking scheme for this is provided at the start of the course, and all exercises receive a letter grade (later converted to a mark). Only those students whose names are on the submitted report receive a grade; similarly, everyone in the group who contributes to the experiments and the report receives the same mark. Other exercises in the communicating chemistry course are carried out individually, in pairs, or in groups.

More details of TLC of Common Painkillers

	Dosage of painkiller per tablet	Wt per tablet	Soluble in $CHCl_3$?	Soluble in Me_2CO?
Aspirin	300mg	0.354g	Yes	Yes
Ibuprofen	200mg	0.462g	Yes	Yes
Paracetamol	500mg	0572g	No	Yes

CONCLUSIONS

Student feedback on the exercise has been excellent, with this part of their course being singled out for special praise. Perhaps a surprise is the efficiency and quality of the results obtained by the students when they are left largely to their own devices! Across the Faculty of Engineering and Physical Sciences, an important aspect of retaining students has been the introduction of 1st year projects, so that the students can actually start applying their discipline to realistic (if not genuinely real) problems early in their degree programmes.

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[O11] Self and peer assessment: a role for learning in higher education

Paul Orsmond

A RATIONALE FOR USING SELF-AND PEER-ASSESSMENT

Writing over fifty years ago Rogers (2003, page 387) outlines the goals of democratic education, he includes such attributes as being '*a critical learner, able to evaluate the contributions made by others and being able to self-initiate actions and be responsible for those actions*'. Further considerations as to the objective of the educational process, a self-determined person, are given by Heron (1988, page 77) '*someone who can set their own learning objective, devise a rational programme to attain them, set criteria of excellence by which work is assessed and assess their own work*'. This emphasis on the 'self' is perhaps not surprising given Rogers (2003, page 389) assertion that, '*a person learns significantly only those things, which they perceive as being involved in the maintenance of, or enhancement of, the structure of self*'. Involvement in the importance of self is central to the self-assessment philosophy. Consider the definition of self-assessment, formulated in a series of questions, given by Boud (1995, page 1) '*How am I doing? Is this enough? Is this right? How can I tell? Should I go further? In the act of questioning is the act of judging ourselves and making decisions about the next step. This is self-assessment*'. This definition of self-assessment encapsulates some of those aspiration of education defined above, whilst at the same time indicating two fundamental requires for self-assessment, the role of criteria (Boud, 1986, page 18; Adams and King, 1995) and feedback (Taras, 2001 and Nieweg, 2004). Other aspiration of the outcome of education may be addressed by peer assessment, which has been defined by Topping et al. (2000 page 150) as '*an arrangement for peers to consider the level, value, worth, quality or successfulness of the products or outcomes of learning of others of similar status*'. Peers can be used in self assessment. Boud, (1995, page 200) discusses how self-assessment should not be seen as a process undertaken in isolation, but as a process where the learner ultimately makes a judgement about what has been learned, and advocates that peer discussion and feedback be built into self-assessment exercises.

SELF- AND PEER-ASSESSMENT AND LEARNING

At the heart of both self-and peer-assessment is the student. Brew (1995 page 24) commenting on the conceptual shift in higher education from a focus on teaching to a perspective in which student learning is central, illustrates the importance of this student centerdness, '*the essence of the learning perspective is that it considers all decisions about teaching and assessment in the light of the impact or potential impact on student learning*'. The importance of the 'student-centred' approach is illustrated from work considering the type of learning students engage with in higher education. Trigwell and Prosser (1991, page 263) show how the quality of student learning is linked to the perceived learning environment. The type of teaching experienced may influence that environment. Prosser *et al*. (1994) showed that teachers use five different ways to conceptualise their students learning and teaching. The importance of these findings were illustrated by Trigwell *et al*. (1999) who demonstrated a link between approaches to teaching and student learning, such as, an information transmissions approach leads to a surface learning in students, and a student-focused approach leads to deep learning in students.

In consideration of the link with between student-centeredness and learning, it may be helpful to consider how assessment may be integrated into the learning process. This is the background to a model for formative learning considered by Orsmond (2004, page 9), where four separate components, student, assessment, learning task, and facilitator are all contained in a learning environment giving a focus referred to as a *Zone of Formative Learning*. Assessment is therefore inclusive in the learning process.

Aspects of this integration between self-assessment and learning have been reported. Hinett (1995) reported how effective close integration can work at an institutional level, in a study, which compared assessment practice at a British University with that carried out at the Alverno College Milwaukee USA. A major difference in the approach to assessment was the use of self-and-peer assessment. At Alverno; each student was actively encouraged to self-and peer-assess. Attitudes ranged from 'it's painful, but it works and I learn more' to 'I like self-assessment because I can reflect back and know I should study more in this area'.

At the British University little value is given to self-and peer-assessment, which means students lack confidence and faith in their own judgements. On self-assessment, some typical comments students made were 'no-one takes it seriously' and 'it is just a hassle' (page 216). Furthermore, students learnt in a prescriptive environment, being told 'you will do this'. They generally validated their work in terms of grades and admitted to getting into the mentality of '*what am I going to get out of this in terms of credit*' (p.213). When asked 'How do you know what is expected of you?' The majority suggested that they didn't really know as '*they never actually say what they are looking for*'. Students also often talked of 'guessing' (page 213). These student responses illustrate the effect of a hidden curriculum, which is defined by Snyder (1971, page 3-4) as the '*difference between messages coming from the formal goals of teachers and their curriculum and other, contradictory messages associated with the means that students find and must use in order to attain high grades*'. A way of overcoming this hidden curriculum is by considering explicit assessment criteria, something that self-and peer-assessment encourages, as Hinett illustrates. Students at Alverno use feedback constructively, to help them to plan their work and to understand how they are developing as learners. Explicit criteria and integrated learning into the assessment process allowed students through self-assessment *to take control of their own learning* (my italics, page. 219).

Self-and peer-assessment can also encourage a deep learning approach, as exemplified by Boyd and Cowan (1985). In this study two groups of civil engineering undergraduates appear to learn in different ways, one group taught in a conventional way, the other group entered a learning contract with they tutor based on self- assessment. This group set themselves individual learning goals; the tutor would provide neither advice nor direction when they did so. However, the tutor agreed to facilitate both the learning to which the students aspired and the assessment by *them* of that learning (page 225). In the second term of study, the students were asked 'What is your real priority in your work this week?' This question was intended to gauge the approaches to learning taking by the different groups. Some of the answers given were:

From the traditional taught students:

10 students wished to be able to answer questions similar to those on the tutorial sheets.

6 students wished to keep up to date with work issued to them.

From the self-assessment student volunteers:

3 students wished to improve their ability to conceptualise viable and distinct solutions to real design problems.

1 student was attempting to integrate both theoretical and practical requirements to give a total approach to designing, using relatively undocumented material.

It was felt that the self- assessment group were demonstrating a deep approach to learning (page 228-229).

There does therefore, appear to be a role for self-and peer-assessment in HE, as both these assessment practise do focus on current learning concerns as well as addressing long held goals of a democratic education.

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Extract from a more extensive paper in preparation (2005)

[O12] Use of a sci-art project to explore the benefits of interdisciplinary collaboration

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INTRODUCTION

The term 'sci-art' refers to a movement that brings scientists and artists to work together on collaborative projects (1). The aims of these projects are various but may involve, for example, the artistic expression of scientific phenomena, or they may be aimed at promoting public engagement with science. A major theme has been to bridge the divide between what are perceived as the two cultures. The term 'sci-art' is not new, having been coined by Bern Porter in his 'Sciart Manifesto' published in 1950 (2). However, in recent years, collaborations between scientists and artists have been encouraged by funding from major institutions, including the Wellcome Trust (3) (from 1996 to the present), and the Sciart consortium (4) (between 1999 and 2002), comprising the Arts Council for England, the British Council (5), the Calouste Gulbenkian Foundation, the National Endowment for Science, Technology and the Arts (NESTA), the Scottish Arts Council, together with the Wellcome Trust.

Between 2003 and 2005, the Faculty of Science and Engineering at MMU was the centre of an extensive building and refurbishment programme. This programme involved the complete refurb-ishment of the laboratory block (see Figure 1), major changes to the main teaching and office block, and the building of a new teaching and IT block. The three main buildings have been linked by an enclosed 'street', with a number of large spaces that would benefit from displays of artwork. Despite inevitable disruption to the work of the Faculty during the building programme, which necessitated removal to temporary laboratory accommodation, the work provided an opportunity to run a 'sci-art' project in which arts and science students were asked to collaborate in the design of an artwork for the new/ refurbished buildings.

Figure 1: A webcam picture of the main John Dalton laboratory building during its refurbishment. The new central IT building is shown on the right.

The aim of the project was to explore the interaction between arts and science students when working together on a collaborative project.

Table 1: Learning outcomes of the project

At the end of the project the student will be able to:

- Work effectively with others in situations requiring collaboration or negotiation
- Apply effective strategies for time management
- Understand and apply a range of research strategies and information retrieval procedures
- Use critical reflection as a means of identifying progress, personal strengths and professional development needs
- Question and explore ideas, issues and theories in a way that demonstrates the development of critical thinking
- Communicate scientific ideas in ways not usually employed by scientists
- Communicate scientific ideas to non-scientists in the process of collaborative work
- Appreciate the creative process as it progresses from concept to outcome

METHODS

The project took place in the academic year 2003/2004, and overseen by a working group consisting of academic staff from both disciplines. The working group felt that the project was most suitable for Level 2 students, and that it should take place after Easter, when most formal lectures were finished.

Expressions of interest were invited from staff and students in the Faculties of Science and Engineering and in the School of Art and Design. Academic staff and students in both disciplines were notified of the project in January 2004 and invited to a preliminary meeting, which in the event was attended by 25 students. At this meeting, the students were informed of the aims of the project, the degree of commitment required, the learning outcomes (see Table 1) and the assessment methods (Table 2). Students were also informed that this was a competitive project, with the winning design progressing to completion. As a result of this meeting 18 students went forward with the project. The distribution of their degree subjects is shown in Table 3. All ‘science’ students were registered within the Department of Biological Sciences at MMU. For these students, the project was undertaken as a unit of ‘Negotiated Self-Managed Study’, which forms an alternative to a period of industrial placement normally completed between April and September. The assessment of this project for the science students is shown in Table 2. For the arts students, participation in this project represented an extra commitment and this was reflected in a modified assessment.

The students were put into interdisciplinary groups of between three and five students. The uneven distribution between students from the two disciplines was monitored but was not felt to be a problem. The students worked on their project for six weeks on a full-time basis. Academic staff ‘mentors’ from both disciplines facilitated each group. Within the group, all students contributed to the project. The students arranged their own work patterns and division of labour. A weekly tutorial was arranged for each group at which academic staff from both disciplines were present. The purpose of these tutorials was to monitor the group’s progress and to support and guide the students where necessary. Group presentations were given at the end of the six week period and were attended by all academic staff involved, as well as the Deans of Science and Engineering and Art and Design.

Table 2: Assessment of Sci-art project*

Component	Advice to students	Contribution to Assessment (%)
Team presentation	A 20 minute presentation in which students present their design, giving the background and rationale for their proposals. During this presentation they should demonstrate evidence of team-based research and should provide team-based visual development worksheets	60%
Individal reflective journal	This should take the form of a diary or 'logbook' of the project, detailing the events which took place, the work achieved and an ongoing **individual** reflection on these events (eg why something was done in a particular way, how it worked out, what you thought of it, would you do it in the same way again etc	20%
Individual evaluative summary of the project	Maximum 500 words	20%

* For the arts students, this project was additional to their course, rather than integral. To avoid overloading the students, they were advised to participate in the team presentation and to carry on their usual practice with regard to their individual reflective journal.

RESULTS

The students eventually settled into four interdisciplinary groups. The students used initial tutorials to explore the difference between ways of working within the two disciplines. In some groups science students visited arts students within their studio space. Observations by 'mentors' indicated that, initially, the scientists, perhaps as expected, were used as sources of information, while the artists supplied the creative input. As the project progressed, the artists began to source their information themselves, while the scientists began to have creative input.

It was also clear that both sets of students had difficulty at the outset, and some anxiety was generated when they could not decide on the theme and medium of their artwork. Some students at this point contemplated leaving the project. However, the knowledge of the six-week deadline helped them to focus, and to accept some level of compromise. With few exceptions, most students worked well together and remained firm friends at the end of the exercise.

THE ARTWORKS

A brief summary of each artwork is given below:

Group1: An interactive piece based on a series of projections flashing in a continuous

Table 3: Distribution of students at project outset

Subject Area	No. of students participating
Biomedical Science	10
Biological Science	1
Photography	2
Embroidery	4
Interactive arts	1

loop with images and words 'randomly' projected. Embroidered images separate the different projections. The students produced a 'mock-up' on CD-ROM for demonstration.

Group 2: An installation based on photographic images hanging from above.

Group 3: A floor-standing dynamic branched sculpture representing and reflecting the branching of fractals and of biological structures. This sculpture, termed 'Chaos' (see Figure 2) was made of a variety of materials and could be added to and changed over time.

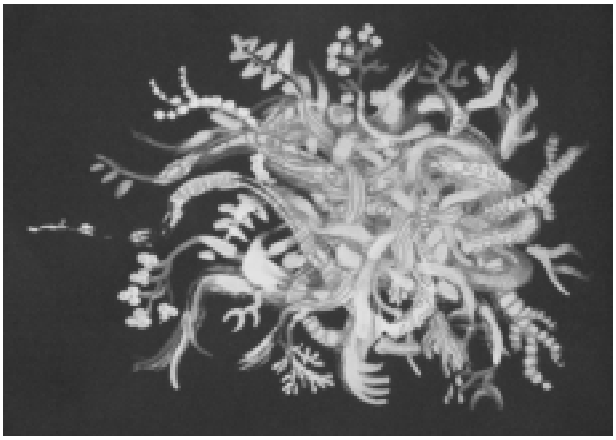
Group 4: This was based on an enormous crystal garden, 'growing' above one of the reception areas. The students provided several examples of home-grown miniature crystal gardens.

The winning design (Group 1) took into account the feasibility of the artwork and of its installation within the space.

REFLECTIONS ON THE PROJECT

The project has had several outcomes beyond a design for the artwork. The individual evaluations showed that the students enjoyed carrying out the project, despite some initial problems and anxieties. The reflective journals, the first produced by our bioscience students, clearly indicated insight into the

Figure 2: Chaos



project and into the difficulties and benefits of working with students from very different disciplines, where ways of working and even language of work were completely different from their own. The academic staff also enjoyed being involved with the project and the opportunity to work within different disciplines. Although the project work lasted only six weeks, staff felt that the students had achieved the learning outcomes and developed new skills as a result. As a consequence, the scientists and artists now have a better idea of each other's working methods and language and this can only be beneficial for both groups.

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[O13] Just in time teaching: a structure blended learning model for science and skills

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Just in time teaching (JiTT) is a blended learning model that aims to use web-based activities prior to a lecture to enable the lecturer to more effectively facilitate learning during class contact time. The web-based activities, called warm-up tasks, are constructed to allow feedback to the lecturer prior to a taught session. This feedback is then used to adjust the structure and delivery plan for the learning activities during face-to-face teaching. Warm-up tasks can be used to establish prior subject knowledge, understanding, perceptions and mis-perceptions, beliefs and attitudes to the curriculum content that will be taught during the contact time. With this information, lecturers can more appropriately structure and deliver the face-to-face teaching session, by working to genuinely promote learning among the students by using the feedback from the warm-up task to inform their approach to the delivery of the curriculum content. Central to the delivery of the face-to-face sessions is the active participation of the students in activities linked to their prior knowledge revealed from their responses to the warm-up task. For example, at its most simple level, a warm-up task may consist of a series of short answer questions to test comprehension of some information; lets imagine a section of text is posted online on the subject of the following lecture accompanied by a series of short answer questions. The students are asked, or required, to email their responses to the questions in advance of the lecture. From the range of responses received, the lecturer can both quantitatively assess the proportion of the students who do/ don't understand a particular learning point and, with appropriately structured questions, qualitatively assess where students are 'going wrong'. Armed with this information, the lecturer can adjust the delivery of the taught materials in the subsequent lecture to meet the known knowledge and understanding of the student group. In brief, JiTT can be used to capture the information that many lecturers try to elicit in a face-to-face session: feedback from the students on what they already know and/or understand of the information being presented; what they believe or think about the subject. With this information available to the lecturer before the face-to-face session begins, he/she is able to deliver a genuinely informed lecture based on knowledge of the subject material and the range of knowledge and understanding of the subject material within the student group. Moreover, the lecturer can share their knowledge of the student group's responses by collating and providing generic feedback during the lecture and thus offer students the opportunity to really see how the lecture is being shaped for them. As such JiTT is a strategy that can enable lecturers to teach effectively to a diverse student body and maximise the learning potential of each individual through student:student interaction during class activities linked to learning outcomes and regular generic feedback between the students and the lecturer. The JiTT model is based around three pedagogic principles: (i) that learning requires active participation; (ii) that learning is actively constructed from prior knowledge; and (iii) that learning requires prompt feedback (Marrs and Novak, 2004).

JiTT was originally developed in the physical sciences in the 1990s (see Novak, Patterson and Gavrin, 1999) and has since expanded in use across a range of disciplines. There now exists a network of JiTT practitioners, largely in the USA, that share their practices and research evidence of the impact of JiTT as a learning and teaching method (see anon, 1999-2003). Increasing evidence from work in the USA, across the sciences, shows these methods to have a wide range of positive outcomes for students, including increased motivation to study and deeper subject knowledge at the end of a course. In the UK, the method is largely untested but could have significant impacts across the curriculum and disciplines. This paper reports on the evaluation of a single JiTT warm-up task and face-to-face contact session developed with support from the HEA Subject Centre for Bioscience Teaching Development Fund. The subject material chosen for evaluating the method was a scientific writing session for third year dissertation students. The dissertation was specifically identified as the vehicle for the evaluation of JiTT as this is a significant component of the undergraduate curriculum across disciplines and across the Higher Education sector. Writing is generally considered a craft: an ability arising from knowledge and mastery of a series of interconnected skills. Much of the previously published literature on the success of JiTT is biased towards the acquisition of subject knowledge, however effective scientific writing underpins the ability to communicate this. It is always explicitly or implicitly assessed and is therefore a fundamental, underpinning competence of all science students, irrespective of discipline. Recent work by McCune (2004) found little evidence of student engagement with feedback and advice from tutors on essay writing: might an active learning method linking delivery to prior knowledge and perceptions of students be more successful?

An extra-curricula two-hour workshop – Polishing the Write-Up – on scientific writing skills was developed for third year undergraduate students and planned for delivery three weeks before the final submission of their Biological Sciences dissertation. The workshop was publicised within the department through notice boards and by email to all (c.100) students registered on any of the dissertation modules. Students were asked to register their interest in attending. When students' registered to attend the workshop they were sent a warm-up activity by return email. The warm-up activity was to read and reflect on the quality of an extract of published scientific writing. This was

Table 1: Students' perceptions of good scientific writing and their own strengths and weaknesses presented in rank order of the three most frequently occurring responses to the warm-up questions.

Characteristics of Good Scientific Writing	Students' self-assessment of strengths	Students' self-assessment of weaknesses
Well structured/ logical organisation of information	Relating and linking points	Pitching the level of detail needed/ assessing the sufficiency of theory and referencing to the literature
Concise	Referencing effectively	Tendency to waffle
Clear/ easy to read	Technical accuracy (spelling, grammar)	Lack of clarity of explanation/ poor sentence construction

accompanied by a series of questions asking the students to define the characteristics of good scientific writing, to comment on the relative strengths and weaknesses of the published extract and their own scientific writing (see Table 1). The intention was to 'know' the students and engage them in reflection prior to the face-to-face session. Students reported that completing the warm-up task took between 10 – 20 minutes.

Twenty-nine students attended the workshop of which 20 sent responses to the warm-up task. The figures are of interest. Firstly, the workshop was extra-curricula, and while timely and relevant to the students, it did not attract the majority of the students to attend. Secondly, of the 29 students that did attend, approximately 2/3 responded to the warm-up task, with potential implications on the validity of the conclusions drawn regarding the opinions of the attendees on what comprises good scientific writing and their own self-assessment of strengths and weaknesses that were used to determine the delivery mode and to frame the relative allocation of time to the topics selected for the workshop. It is worthy to note that there are mechanisms within a formal curriculum to ensure 100 per cent return, such as linking completion of warm-up tasks to assessment, but this approach was not appropriate for this study.

The workshop content was developed and publicised prior to receiving student feedback from the warm-up task. However, the delivery mode and allocation of time to various topic areas was modified in the light of the students' responses. The responses to the questions in the warm-up task were collated and themed in relation to the workshop topics and presented to the students as anonymised, generic feedback during the workshop. The workshop comprised five main topics: (1) an activity in pairs to identify the keywords and the 'storyline' of a piece of written work; (2) a lecture on theoretical models and practice in academic communication and scientific writing; (3) small group activities to define and assess the readability of scientific writing; (4) a tutor-led discussion interspersed with short activities offering advice on how to proof-read and edit; and (5) a lecture and an activity for individuals on the role and rubric's for titles and abstracts of scientific research reports. In all the activities, students worked with a section of their own draft text. At the end of the workshop participants' opinions were collected using an open-question feedback sheet to explore their perceptions of JiTT as a teaching method for scientific writing. Views on the warm-up task, the workshop topics, the structure and delivery of the learning materials and how these impacted on their subject knowledge, confidence and planned future learning behaviours were collected. Twenty-six students completed the feedback questionnaire.

Students reported positively on the value of the warm-up task. They commented that it encouraged them to think about their own writing and what constitutes effective scientific writing, it made them think about what they wanted to get out of the workshop, it provided information on the workshop aims and it made the workshop personal as the workshop was clearly focused on the topics highlighted by students as areas of relative weakness in the warm-up activity. There was only one negative comment which described the warm-up activity as "not too helpful." The largely positive feedback from students on the value of the warm-up activity is consistent with similar feedback collected by Marrs and Novak (2004) using a Likert scale questionnaire. In their large sample of 485 students exposed to warm-up activities as vehicles to learn subject knowledge, 87% of students rated the warm-ups as very useful.

Participants were asked if the workshop had met their learning needs by addressing their perceived weaknesses. 78% of respondents felt it had: many identified specific concerns that had been addressed and 30% of respondents commented that attendance had changed their perception of their own weaknesses. Comments included:

'Addressed the areas I was worried about-very helpful'

'Helped to understand where I could change things'

'Highlighted the fact I've a lot more work to do yet. Made me aware of areas that need addressing that I hadn't thought about'

'Increased my awareness of my weaknesses and why they are weaknesses'

'It addressed my sentence structure and the way I use words'

'Helped iron out problems with how to write abstract. Addressed other weaknesses'

Despite some of the comments from students on how they were reappraising their writing skills in response to the workshop, participants reported that attendance at the workshop had increased both their knowledge of scientific writing skills (92% of respondents) and their confidence in their ability to write effectively (83% of respondents). Comments included:

'I feel more confident at evaluating my work'

'More aware of what and how to write'

'I will have more confidence thant I did to change words and make statements'

'Made me realise how bad my writing is, but motivated me to improve it and gave me the tools to use'

'In some areas it has [increased my confidence]*, in others I feel less confident as I thought they were good already'*

Finally, all but one respondent said attendance at the workshop would change the way they developed and worked with their draft dissertation prior to the final submission for assessment. Most commonly, respondents said they would: review sentence structure (29%); review the readability of the text (25%); change their method of proof-reading (25%); review word choice (21%) and reduce woffle (21%).

The use of an open-question approach in this study has allowed a rich demonstration, in the participants' own words, of how the JiTT approach to learning about scientific writing skills presented them with new knowledge, which they assimilated, and how this empowered them to feel confident to tackle their subsequent independent work when redrafting their texts. It has also identified how the JiTT approach transformed 30% of the students' perceptions of their existing strengths and weaknesses. This information was not sought by a direct question and thus the proportion of students reporting that their self-perception has changed may well be an underestimate. These students revised their self-perception of their skill level, often downward, however there were no less confident in their ability to undertake the writing task ahead of them than students who did not report that they had revised their self-perceptions (Table 2).

In addition to collating student views on the linked warm-up task and subsequently tailored face-to-face session, fourteen of the workshop participants provided and gave consent for sections of their draft and final dissertation to be used for further, detailed textual analysis to explore how students worked with and modified their draft text during the three weeks following the workshop prior to the assessment submission date. The intention was to quantitatively assess the impact of the workshop in relation to the students' assertions of their likely subsequent priorities when redrafting and revising their texts.

Two areas, sentence structure and readability, were identified for comparison between the draft and final submission texts as these were the areas that were most frequently reported

Table 2: Student evaluations of the impact of the workshop on their confidence to write effectively. Categories devised from qualitative comments and illustrative comments are provided. N=24.

Category of Comment	Students reporting modified self-perception of their skill level	Students making no comments on changes to their self-perception
Confidence has increased	5 'Definitely!'	13 'I feel more confident at evaluating my work'
Some increase in confidence	1 'In some areas it has …'	1 'A little but maybe more support needed'
No increase in confidence	1 'No'	1 'No'
Not clear of impact on confidence	0	2 'I hope so'

by workshop participants that completed the feedback questionnaire as areas of practice they would review after the workshop. They also closely matched the perceived area of weakness in writing identified and ranked highly by students prior to the workshop:'lack of clarity of explanation/ poor sentence construction'. Paired sections of text, comprising thirty contiguous sentences excluding any headings or sub-headings, were selected from the draft and final submission texts. Identifying standard measures to assess these parameters appropriate for scientific writing within Higher Education, where such skill performance is rarely explicitly assessed, was an area of difficulty. Sentence structure was analysed by looking at the shortest, longest and mean sentence length. The text sections were analysed for readability using the McLaughlin test, which predicts the reading age required for full comprehension.

While it was clear that all the students whose work was sampled had reworked their text, and this had involved modifications to sentence structures, sentence length, word choice and punctuation, attempts to draw conclusions across the sampled student work from the measures taken were very limited owing to the very personal nature of how students worked with and modified their texts. This was possibly exacerbated by the small sample size. One of the few general points that could be identified was the contraction in the range of scores across the sample between the draft and final texts for a number of the measured variables including shortest sentence length (4-14 draft; 5-12 final); longest sentence length (31-113 draft; 31-87 final); mean sentence length (16-32 draft; 16-30 final); and readability (16.7-22.4 draft; 16.8-22.1 final). While this demonstrates that individual students were attending to sentence structure and readability in their rewriting, changes in all measures were non-directional across the sample. What emerges is that students made idiosyncratic and personal changes that are difficult to assess with integrated, quantitative measures of performance to enable comparison with other students' work. An alternative, qualitative approach to explore how students worked with and modified their draft text, such as interviews or a further follow-up questionnaire, may have provided more information on whether students' subsequently acted out their intentions identified from the open questionnaire, but this would also have failed to identify the impact of their behaviours as measurable changes in the quality of their written work.

In conclusion, this paper has reported success in applying a simplified model of the blended learning technique, just in time teaching, to scientific writing for dissertation students. The majority of students valued the warm-up task and the subsequent face-to-face workshop and reported that the method had met their prior learning needs, in some cases, changed their perceptions of these, increased their knowledge, skills and confidence. All the students identified areas for further work and development to improve their draft dissertations. An assessment of paired student draft and final submission texts showed that all the samples had been modified although few generalities could be made that applied across the full sample except for a trend of reduced variability in the ranges of the measured variables to assess sentence structure and readability.

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