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PUTTING THE STUDENT IN CHARGE: ADDING VALUE TO THE FOOD CHEMISTRY LABORATORY THROUGH STUDENT GENERATED EXPERIMENTS, INTEGRATION OF TRANSFERABLE SKILLS, AND PEER AND AUDIO FEEDBACK

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Abstract

This paper describes the implementation of an alternative laboratory practical for a group of third year BSc Nutraceuticals students. The main objectives were to prepare students for the more independent final year research project; to incorporate innovative approaches to feedback; and to integrate key employability skills into the curriculum. These were achieved through building the skills required to ultimately allow students working in groups to research, design and run a laboratory for their class. The project involved innovative approaches to feedback, including weekly feedback sessions, report checklists and audio feedback podcasts. The feedback has been particularly well received, and there is evidence that it will be reusable and will 'feed-forward' to other modules. The author, and the students in general, believe the group are more prepared for final year research projects and work placement owing to the redesign of the laboratory assessment.

Keywords: Chemistry laboratory, feedback, feed-forward, podcast, group work, employability, self-directed learning

1 INTRODUCTION

The aim of this project was to redesign the practical element of stage three Food Chemistry in a BSc Nutraceuticals degree programme, however the rationale for the redesign could also be transferred to almost any year three science subject. Year three does not receive as much attention in educational research as other years, particularly compared to the first year experience. Nonetheless, it is an important year, after which students must be prepared to enter semi-independent research in the form of fourth year projects. Many students are ill-prepared for this leap from traditional, recipe style practical laboratories to research. This is owing to the nature of traditional verification or expository laboratory teaching methods [1], where students follow a given procedure to obtain a pre-determined outcome. This alllows students to manipulate equipment, learn standard techniques, collect and interpret data, and communicate the finding in a written report [2]. While there is merit in this approach in achieving certain learning outcomes, the level of critical thinking required to perform the experiment, and the consequent deep learning achieved is low, and there is no opportunity for creativity or contextualisation [3]. Additionally, co-operative learning, which requires students learning together with peer tutoring, is not facilitated by the environment of the traditional laboratory [4]. A more ideal approach integrates application of knowledge to solve problems, group work, and an opportunity to design experiments, including consideration of the safety aspects [5]. This approach has been incorporated into chemistry education, both in second year mini-projects in this institute, as described by McDonnell [3], and elsewhere in other examples described therein.

Furthermore, the group work element is particularly important not only in relation to the socio-constructivist perspective on learning, but also because group work probably comes closer to any other single activity in preparing students for employment, and has been highlighted by the IBEC Results of Employer Survey, 2003 as an essential transferable skill. Indeed, the focus on development of key employability skills is increasing in the third level sector in general, with the needs of the employer as well as the graduate under consideration in the development of curricula. The importance of this in chemistry education is highlighted by the dedication of a Special Issue of Chemical Education Research and Practice focusing on the areas in the curriculum and the pedagogies which best support life-long learning [6]. More broadly, Yorke describes employability in terms of management of self, others, information and task [7]. This includes personal qualities such as

self-awareness, self-confidence, independence, adapting to new challenges, initiative; core skills such as information retrieval, critical analysis, creativity, written and oral communication, including explaining; and process skills such as problem solving, prioritising, planning, and applying subject understanding. This publication describes a project which aims to incorporate all of these aspects into the third year of a BSc Nutraceuticals degree, thus preparing students both for final year research projects and for subsequent entry to the workplace. The project involved innovative approaches to feedback, including weekly feedback sessions, report checklists and audio feedback podcasts.

2 METHODOLOGY OVERVIEW AND IMPLEMENTATION OF RE-DESIGNED FOOD CHEMISTRY LABORATORIES.

Food chemistry is broken into two modules, Food Chemistry I delivered in semester 1, and Food Chemistry II in semester 2. The practical element of the modules is worth 40%. There were 31 students enrolled in Food Chemistry I (a module co-taught with another class group), and 19 in Food Chemistry II.

2.1 Food Chemistry I

The task: Working in groups of 4 or 5, students would take turns to assume the role of the instructor, and plan, organise and run a laboratory session for the rest of the class. The task involved the following duties:

- Health and Safety risk assessment
- Researching the background of the experiment
- Preparing a pre-practical presentation, including introduction to the practical, the method, and the safety
- Liaising with the technician/lecturer to organize consumables/ equipment/ glassware
- Giving the pre-practical presentation
- With the assistance of the lecturer, aiding the smooth running of the lab
- Giving post-practical session, including managing results

This represented a significant change in student activity, compared to their other modules, both in their current year, and in their previous years. To account for this and to prevent undue stress, in the first semester the student groups were allocated an experimental method. The experiments were known to operate successfully in the teaching laboratory in question.

2.1.1 Assessment and Feedback for Food Chemistry I

The breakdown of assessment for Food Chemistry I is presented in Table 1. The peer assessment required students to complete a form evaluating their group members on a scale of one to four for aspects specifically relating the their performance in the group work, and included: attended meetings, actively participated in activities, helped others, helped to keep to the task timeframe, had positive attitude and was respectful of others views, and contributed to the final presentation.

Table 1. Assessment of Food Chemistry I

Assessment		Weighting
Running the lab	Overall planning and organisation, pre-practical presentation	30%
	Anonymous peer assessment	20%
Laboratory reports	Weekly group laboratory reports (six in total)	20%
	Final individual laboratory report	30%
Total		100%

Feedback:

- Weekly feedback sessions. Each group submitted a laboratory report in advance of this one hour session. All groups received a copy of each report. Each week a representative from each group participated in the feedback session. Peer review of each report was followed with expert feedback from the lecturer.
- At the end of the module, the feedback from the weekly sessions was summarised and recorded by the lecturer, and made available to the students in the form of MP3 podcasts available on their *Webcourses* Virtual Learning Platform in advance of their final individual laboratory report.
- Face-to-face feedback with the groups immediately following their running the lab, discussing their performance throughout the process.

2.2 Food Chemistry II

The task: Once the students had successfully completed the module Food Chemistry I, and had developed the skills required to organise and run an allocated experiment, the process was repeated in semester 2 with Food Chemistry II. Here however, the emphasis was fundamentally different in that the students were charged with developing their own experiment. Groups were supported by the lecturer in their search of relevant literature, including the Association of Analytical Communities (AOAC) resources, standard food chemistry books, and appropriate journals. Students were also given a list of available equipment. In the first three weeks of the module students were guided towards choosing an appropriate experiment, and helped to transform methods from the literature into suitable experiments for a three hour laboratory. Much of this work was done during normal laboratory hours, but also required a considerable amount of self-directed learning. When a method deemed suitable on paper was agreed between student groups and the lecturer, students were given the opportunity to trial the experiment, to resolve any problems, and to know what to expect when running the lab for the whole class. As for Food Chemistry I, this required a risk assessment, and liaising with the technician to requisition consumables.

2.2.1 Assessment and Feedback for Food Chemistry II

The breakdown of assessment for Food Chemistry II is presented in Table 2. In this module, a group poster presentation was introduced as a means for students to record and present the whole process of designing the experiment, and also present the overall class results for their chosen experiment.

Table 2. Assessment of Food Chemistry II

Assessment		Weighting
Running the lab	Use of literature, and effort towards experiment design, organising and running the lab	30%
	Anonymous peer assessment	20%
Written reports	A group poster presentation	30%
	A single individual laboratory report	20%
Total		100%

Feedback:

- Weekly face-to-face feedback on how the process of using the literature, and choosing an appropriate experiment was provided to each group
- A feedback meeting was held with each group immediately after their experiment session

- The MP3 podcasts available on their *Webcourses* Virtual Learning Platform was again useful in preparing the individual laboratory report
- A comprehensive report 'checklist' was provided, and had to be checked, signed and submitted along with the individual report. Included on the list to check was the requirement for peer second reading of the report
- The two hour poster session involved peer feedback by all students on each poster, followed by lecturer feedback. Following this, groups were given the opportunity to re-submit the poster before a score was awarded

2.3 Student group

The student group were selected based on their enrollment in TFBC3011 Food Chemistry I and TFBC3012 Food Chemistry II, Dublin Institute of Technology, Academic Year 2010 2011.

These modules together cover Food Chemistry and Food Analysis. Further information on these modules can be found at www.dit.ie/coursewise

2.4 Recording of Podcast Feedback

The feedback on writing laboratory reports which arose from Food Chemistry I weekly Feedback sessions was summarized and scripted into the following sections:

Introductory note on purpose of feedback, General formatting and language, Aims and Objectives, Introduction section, Methodology section, Results section, Discussion session, Conclusion session.

The podcasts were between two and four minutes, and were recording using the free to download *Audacity* software, and saved as MP3 files. These were uploaded directly to the *Webcourses* virtual learning platform, and could be listened directly using Windows Media Player, or downloaded to an MP3 player or Smartphone.

2.5 Poster resources

Students were directed to poster templates freely available on the internet (e.g. Harvard Medical School, and others) and also to a *Study and Communication Skills Guide for the Chemical Sciences* [8]

2.6 Pedagogical evaluation

Pedagogical evaluation took the form of an anonymous evaluation sheet which requested students to disagree or agree with several question, and also allowed a comment to be recorded (n=31 and 19 for Food Chemistry I and II respectively) and an independent academic facilitated discussion forum (n=9 and 7).

3 RESULTS:

Table 3: Student evaluation summary for Food Chemistry I

Section	Question	% Agree	% Disagree
Running the lab	Running a lab helped me to understand how to plan an experiment	92	8
	Running a lab helped me to better appreciate Health and Safety issues	69	31
	Running a lab was more challenging than recipe style labs	92	8
	Running a lab helped improve my employability skills such as team work, organisation, communication and research	92	8
	Running the lab helped to improve my presentation skills	54	46
Group Work	When I was part of the group running the lab I was more engaged and motivated with the experiment than recipe style labs	80	20
	In general, groups' ability to run the lab seemed to improve by gaining from the experiences of previous groups	96	4
Feedback	Reading the reports of peers was a useful way to learn	100	0
	The Feedback sessions were useful to attend	100	0
	The whole group benefitted when a group member attended a Feedback	73	27
	The Audio Feedback on Webcourses was useful in preparing my final	92	8
	The Feedback (audio and sessions) will help with other module reports and assessments	100	0
Assessment	The marks allocation of the assessment is satisfactory	88	12
	The peer assessment was a good way to assess certain elements of group work e.g. commitment and participation, contribution to organisation, contribution to presentation	88	12

Table 4: Student evaluation summary for Food Chemistry II

Section	Question	% Agree	% Disagree
Choosing, designing and running the lab	Choosing our own experiment made the literature (journals, AOAC, books) more relevant and meaningful	100	0
	Choosing and designing our own experiment helped to motivate me to engage with the literature	94	6
	I was given enough time, support and relevant resources to allow me to choose, evaluate and plan the lab to run for the class	89	11
	It was very important to have a chance to try out the experiment ourselves	100	0
	Designing our own experiment for the class was challenging	89	11
	Designing our own experiment for the class was too stressful for me	17	83
	Food Chemistry I was a good preparation for this module	100	0
Assessment	The poster is a useful method of assessment	78	22
	The poster session including peer discussion of all the posters, and lecturer feedback, has helped me if I have to do a poster in future	100	0
	I am more comfortable with peer assessment this time around	83	17
	I am satisfied with the overall assessment of the module	100	0
Feedback	I was given sufficient feedback throughout the module	89	11
	I found the podcast feedback was a useful tool in preparing the individual lab report	89	11
	The checklist was helpful in preparing the individual lab report	94	6
Employability and preparation for work placement and final year projects	The module further helped improve my employability skills such as team work, organisation, communication and research	94	6
	I was more comfortable with group work this time around	83	17
	I feel better prepared for the work placement due to the way the labs were run this year	94	6
	I feel better prepared for my fourth year project due to the way the labs were run this year	94	6

4 DISCUSSSION

4.1 Overview

The practical element of a pair of associated Food Chemistry modules was redesigned to add value to the traditional laboratory experience, and to bridge the gap between traditional laboratory practicals ordinarily in first three years of undergraduate study, and the supervised semi-independent research

normal in final year projects. The redesign retained the development of skills which traditional 'recipe style' labs achieve, including allowing students to manipulate equipment and learn required laboratory techniques. Indeed many of the experiments particularly in Food Chemistry I were the same 'tried and tested' methods of a traditional lab. Importantly, '*to change the experience, you don't need to change the experiment, just what you do with it'* [9]. The reform aimed to improve the student experience by providing students with the opportunity of putting the literature into context, in a supported setting, thus applying their knowledge to design their own experiment. This approach has been successful, with all students agreeing that choosing their own experiment had made the literature more relevant and meaningful, while almost all (94%) considered that designing their own experiment motivated them to engage with the literature. Students realised the difference between the methodology available in the literature, and how this is adapted for class experiments, with one claiming '*you don't realise when you've always been given the method [in a lab manual], but when you go to the literature, it's like 'this is not in English!' and you have to look up three papers to get a single method'*. This realisation will be critical for student's preparedness for final year projects, where adapting the literature and experimental design will be the norm. During the course of the modules the students worked with the lecturer and technical staff to overcome problems in transforming the literature into a practical method suitable for use for the class as a whole. Most students (89%) felt they were given enough support and resources for this purpose, while all agreed that having a practice lab was critical. One student commented that '*if things go wrong, help is there, but you are not spoon-fed with the answer to the problem*' while another believed that the best part of the module was *'learning how to be independent and stand on our own two feet in the lab'*. Further preparedness for final year projects included safety risk assessments, requisition of laboratory consumables and organising the lab in advance of running the class practical. Food Chemistry I was used to develop these skills in advance of Food Chemistry II, as it was believed that it would put undue stress on the students to learn these in tandem with experimental design. This approach seems to have been successful, with the majority of students believing that running the lab in the first semester helped them understand how to plan an experiment (92%) and appreciate the Health & Safety issues (65%). The figure for Health & Safety is lower than expected. This is because an assessment in a Health & Safety module had already dealt with laboratory safety, and therefore students felt they already understood these issues. However presumably if this assessment had not been carried out, this figure would be higher. Clearly, almost all students (94%) considered that, week after week, they were learning from the mistakes of previous groups. By semester two, all students believed that Food Chemistry I was a good preparation for the more challenging task of Food Chemistry II, with relatively few (17%) believing that designing their own experiment for the class was too stressful for them, with one commenting that '*it was a bit stressful, 5 on a scale of 1-10, more stressful than a traditional lab, but we gained a lot more from it'* while another believed it to be '*a healthy stress'*.

4.2 Feedback

Perhaps the most welcome aspect of these modules from the student perspective was the provision of varied, timely and relevant feedback, with frequent comments that it was the best feature of the modules. Petty discusses the meta-analyses of Hattie and Marzano, which claim that feedback is the single most powerful moderator to enhance student achievement [10]. All students agreed that reflecting on their own reports, reading the reports of peers and discussing them with the lecturer at weekly feedback sessions was a useful way to learn. According to Higgins, rather than a list of assessment criteria, '*feedback may need to be more dialogical and ongoing. Discussion, clarification and negotiation between student and tutor can equip students with a better appreciation of what is expected of them*' [11]. One student remarked that *'you look at it* [peer report] *and think 'now I can see where I'm going wrong".* This is consistent with the belief that effective assessment should allow students to become confident in making judgements about their own work, which ultimately takes account of the long term purpose of learning [12]. While many students (73%) did believe the whole group benefitted from a member attending a feedback session, there is room for improvement here. There was some breakdown with passing on the information from the session to the group as a whole, and this would need to be addressed in future, perhaps by students recording the minutes and emailing them to their group and the tutor.

Particularly successful was the podcasted feedback. The use of technology in providing feedback is still under-utilised, with podcasting feedback in its infancy; however studies have reported positive results from audio feedback [13]. According to Durbridge [14] there are advantages of audio over printed media as comprehension is enhanced by the spoken word, adding clarity and meaning, and improving cognition. It is also consistent with appealing to different types of learner, as described by

the VARK modal by Fleming [15]. In other studies, students report that the most useful podcasts are those which give summaries and guidelines [16]. The students in this study mostly agree (89%) and believe it was useful in preparing their final report with one commenting '*It's such a simple thing, but it's so effective. I still use it for different subjects'*. Together with the report checklist, which students also mostly believed (94%) to be useful for this module's written report, there appears to be a form of 'feed-forward' or remediation feedback, which allows students' self-regulation, and to develop greater skills in self-evaluation [17]. All students agreed that the feedback provided would help with the assessments and reports in other modules, with one stating that *'I have put the checklist on my wall. If you follow it, you can't forget anything'.*

4.3 Assessment

Overall the students were satisfied with the assessment of the modules under review. The poster assessment was generally well received (78%) with students commenting that '*the poster made looking at someone else's group work more interesting than a set of ordinary lab reports'*. Some students however felt that the poster may not be relevant as they may never have to produce a poster in the future. Students particularly welcomed the opportunity to re-submit the group poster following the poster session within two weeks. Despite it not being required, and complaints of a heavy workload in other modules, all groups opted to re-submit the poster. This is in line with best practice in assessment and feedback according to Nicol [18] and Black & Williams [19], both suggesting that students should be able to engage in activities which help to close the gap between current and desired performance. Students felt '*looking at other's posters helped me to see where we went wrong, and what we did well and it was great that we got a chance to resubmit it*' and '*it was good that she* [the lecturer] *didn't just say 'yeah, you should have put that in', but instead said 'right, off you go and make the changes'*.

4.4 Preparedness for final year projects and work placement

Overall, almost all students (94%) believed they were better prepared for final year projects due to the way the modules were run, with one suggesting the experience was '*like a stepping stone towards final year projects'*. Furthermore, the majority of students believed that Food Chemistry I and II (92 and 94% respectively) has increased their employability skills, including teamwork, organisation, communication and research, in agreement with Bennett and co-workers who note that the learning outcomes from non-traditional laboratories are transferable in nature, and can be applied to a wide range of activities beyond the immediate task [5]. Surprising, only about half the group (54%) thought that it had improved their presentation skills, but on further examination, this was because they either felt they were already good at presenting, or because they had not actually been part of the presenting team. In future, the latter could be improved by suggesting that all students must present at least a small part of the presentation. Interesting, one student commented that '*we looked at running the lab like it was a job'* while another described how she '*talked about this module in my interview for work placement. It made me feel like more of a grown up person, not just a student'*. Clearly, the students consider the experience to be more authentic and relevant to the workplace.

5 CONCLUSION:

The aims of this project were broadly met, with the successful implementation of an alternative laboratory practical for a group of third year BSc Nutraceuticals students. The main objectives were to bridge the gap between the skills gained from traditional laboratories, and those required for the more independent final year research project; to incorporate innovative approaches to feedback; and to integrate key employability skills into the curriculum. These were achieved through an iterative approach, building the skills required to ultimately allow students working in groups to research, design and run a laboratory for their class. The feedback has been particularly well received, and there is evidence that it will be reusable and will 'feed-forward' to other modules. Both the author, and the students in general, believe the group are more prepared for final year research projects and work placement owing to the redesign of the laboratory assessment.

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