2010

# Improving the Undergraduate Laboratory Learning Experience Through Redesigned Teaching and Assessment Strategies Integrating Transferable Skills and Focusing on Feedback.

Julie Dunne
*Technological University Dublin*, julie.dunne@tudublin.ie

Barry Ryan
*Technological University Dublin*, barry.ryan@tudublin.ie

# Improving the Undergraduate Laboratory Learning Experience through Redesigned Teaching and Assessment Strategies, Integrating Transferable Skills and Focusing on Feedback

**Julie Dunne and Barry Ryan,**
**School of Food Science and Environmental Health**

Contacts: Julie.Dunne@dit.ie and Barry.Ryan@dit.ie

## Abstract

This project aimed to improve the laboratory learning experience for undergraduate science students, focusing initially on first and third year cohorts, through specific objectives. Firstly, to incorporate novel teaching and assessment methods, including student led laboratories, in-house produced instructional videos, "Clickers" audience response devices, and pre-practical on-line multiple choice questionnaires (MCQ) assessments. Secondly, to develop timely feedback mechanisms, including peer review, tutor face-to-face and audio feedback, online automatic feedback, and report checklists. Finally, to imbed transferable skills into the laboratory including group work, communication skills (written and oral), organisation and project planning, health and safety, and preparedness for laboratories, final year projects and placement.

Pedagogical evaluation was through anonymous MCQ and independent academic facilitated discussion forums. The main benefits were students who are better prepared, both for basic undergraduate laboratories and for independent research-based final year projects; continuity in the development of transferable skills; improved assessment quality though constructive alignment and appropriate feedback; and improved student satisfaction through engagement and feedback. The key recommendations arising from this study are: to encourage preparedness for practical sessions; harnessing technology to engage students through interesting pre-practical activities; to encourage an improved culture of feedback, including mechanisms such as podcasts, which also "feed-forward"; and to encourage a culture where value is added to modules by actively incorporating transferable skills into all student activities and assessments, rather than a "bolt on" approach.

**Key Words:** assessment, transferable skills, feedback, laboratories

## Introduction

Traditional or *expository* laboratory teaching methods, where students follow a given procedure to obtain a pre-determined outcome will allow students to manipulate equipment, learn standard techniques, collect and interpret data, and communicate the finding in a written report (Bennett and O'Neale, 1998). However recently there has been debate on the merits of these methods. The level of critical thinking required for performing the experiment, and the consequent deep learning achieved is low, and there is no opportunity for creativity or contextualisation (McDonnell, O'Connor and Seery, 2007). Furthermore, the environment required for co-operative learning, which requires students learning together with peer tutoring, towards a common goal, is not facilitated by traditional laboratories (Eilks et al., 2009).

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 (Bennett, Seery and Sovegjarto-Wigbers, 2009). 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 than any other single activity in preparing students for employment, and has been highlighted by the IBEC Education and Skills survey (McGann, 2010) as a skill which needs to be developed further in third level graduates.

## Outline of the Project

With regards to the first year cohort, a redesigned assessment strategy was implemented for a basic lab skills module to specifically target the problem areas of scientific observation and report writing over the course of an academic year. To support this approach the module content, both lecture and laboratory, was redesigned to better align to each other and also to help the student to "*construct"* their own learning. This redesign placed a higher emphasis on continual assessment of lab preparedness, improved the students report writing skills through a reduced number of reports accompanied by formative, constructive feedback and focused on the correct laboratory technique within the laboratory environment.

To prepare the students for their laboratory sessions each student was given the complete laboratory manual at the start of each semester. The manual linked to additional resources, including lab instructional videos which were produced in-house, and available through *Webcourses,* the Institute's virtual learning environment (VLE). The students were also required to complete short, graded multiple choice quizzes targeting the important theory behind the upcoming laboratory. The MCQ was automatically graded and provided instant feedback to the student on each question.

To support the development of their communication skills, the students initially reported individually on short distinct sections of a typical scientific report and received one-to-one feedback. Following on from this, students worked in small groups to produce four group reports over the course of a 12 week semester. Each report was graded by the lecturer and one-to-group feedback was given. The students also anonymously peer assessed (APA) each other's contribution to the group report. Upon completion of the APA process, the lecturer facilitated a discussion which was used to suggest improvements for future reports. To align learning outcomes and the assessment of lab skills the students' practical, problem solving and report writing skills were assessed by an end of year laboratory-based exam which incorporated both technical and communication components.

The third year component of this joint project involved the re-structuring of Food Chemistry laboratory practicals associated with two related modules, with the aim of adding to the learning outcomes of traditional laboratory teaching methods through redesigning learning activities, implementing appropriate and timely feedback processes, and integrating transferable skills including group work and presentation skills. In the first module students worked in groups to "run" the practical for the rest of the class. The method was provided to the group, who then researched the necessary theory to provide the pre-practical presentation. The group was responsible for liaising with the technician to requisition the necessary chemicals and equipment for the experiment. They were also accountable for the safety aspects. On the day, they were in charge of organising the lab, and explaining the theory, the method, and afterwards, the calculations. The process was repeated in the second module; however the group was also required to devise its own experiment, and its members were guided through suitable literature to aid this process. In both modules, anonymous peer marking of group members was a component of the assessment.

Group laboratory report submissions were a feature of these modules. Weekly face-to-face feedback sessions allowed representatives from each group to peer review and discuss the written reports of all groups, and to get expert feedback from the teacher. A generic scripted summary of this feedback was recorded by the teacher using *Audacity* software, and the audio podcasts made available to listen directly or download from the Institute's VLE. This was used in preparation of a final individual lab report. The assessment also included a group scientific poster group. A two-hour feedback session incorporating peer and teacher feedback on draft posters was organised ahead of final submissions.

**Aims and Objectives**

The aim of this joint project was to maximise the learning associated with undergraduate laboratories for first and third year students by redesigning and aligning assessment and teaching strategies, devising and implementing appropriate and timely feedback processes, and integrating transferable skills at key stages in the curriculum. The student groups were selected based on their participation in suitable modules lectured at Dublin Institute of Technology, School of Food Science and Environmental Health. The first year cohort consisted of students taking the following modules: Laboratory Techniques and Computer Applications, DIT Module Code: TFCH1007 and Foundation Organic Chemistry, DIT Module Code: TFCH1003. The third year group comprised of students talking Food Chemistry I and II, DIT Module Code: TFCH3011/12

The aim of this project would be achieved through the following objectives:

| **Objective One:** Incorporation of Transferable Skills | |
|---|---|
| **First Year** | **Third Year** |
| laboratory preparation (video & MCQ) | team work |
| scientific observation | communication |
| technical manipulation | project planning |
| scientific reporting/writing | preparedness for final year project |
| laboratory safety | employment preparation |

| **Objective Two:** Redesigning Assessment Practices | |
|---|---|
| **First Year** | **Third Year** |
| pre-practical on-line assessment | student led laboratory practicals |

| **Objective Three:** Focus on Feedback | |
|---|---|
| **First Year** | **Third Year** |
| peer feedback | peer feedback |
| tutor feedback | tutor feedback |
| on-line, instantaneous feedback | audio feedback |

## Summary of Main Findings

**First Year Group**

*Laboratory Preparation*
The main purpose of the on-line multiple choice quizzes was to prepare the students for the upcoming laboratory session. The students participated fully with the on-line quizzes (100% completed at least 8 out of the 10 quizzes). The vast majority of the students, 94% and 91% respectively, felt the quizzes were user friendly and gave them enough time to complete. Of those surveyed 77% felt better prepared for the upcoming laboratory after completing the quiz, noting that they felt more familiar with the lab (equipment, concepts, aims, etc.) after competing the MCQ and that this helped remove anxiety from coming into the lab.

Student opinion from the evaluation forum gave further insight into the possible reason behind why almost one quarter of students, after engaging with the lab manual and quiz, did not feel better prepared for the lab. The main problem evidenced was scientific calculation – the general student consensus being "*We feel like we were thrown in at the deep end*".

Students felt motivated to read the manual before going into the lab: "*Sometimes when you read it* [the lab manual]*, it's just words on a page, but when it's in a question you have to think about it*". Indeed, if there was no MCQ associated with the lab manual the students "*would have just skimmed over the lab manual*" as with other lab based modules. The reduced number of reports per semester was also popular with students; one student noted that "*it sounds like we are lazy, but its actually not!*" and that fewer reports mean that "*the lecturers have more time to go through* [the lab report] *with you*". Students also engaged more with the in-house produced laboratory videos than with the lab manual as a method of preparation for the upcoming lab session (76% compared to 53%).

*Skills Development*

The student responses were very clear that the content of the module, and the skills they learnt, were appropriate to their course. For example, 91% of those surveyed could see the relevance of the techniques they learnt in this module to other modules in their course. Furthermore, 96% and 92% respectively felt more confident in the application of the skills learnt and collection data during a typical lab. Here the critical technical skills are highlighted (e.g. instrument calibration and usage), in conjunction with transferable skills such as data recording and observation.

The aligned nature of the module (lectures aligned to labs and subsequently the real world connection) was observed by 83% of the students. Students commented that "*the lab work helped me to understand the lectures and visa versa*" and "*I could see the application of some of the labs in the real world*". Students were comfortable working individually or in groups, although initially group work was resisted by the students; "*We did not know what to do, we had never worked in groups this size before ... we were out of our comfort zone*". Students appreciated the importance of group work, noting that "*We will be working in groups after college, so it's important we learn how to deal with it now*".

*Report Writing*

In the module redesign the number of reports was reduced from twelve to four per semester. Overall the module scores improved modestly (5% for Semester one and 9% for Semester two) compared to the year previous to the module redesign. Students observed the benefit of peer involvement (86% perceived benefit of working with peers) which almost matched the confidence of the student in producing a good quality scientific report (79%). Students noted the lecturer facilitated feedback session as important: "*I learnt what I had to do to improve my section of report from discussing reports written by my groupmates*".

*Feedback*

Invariably the students were encouraged by receiving feedback. The vast majority of students (91% and 90%) felt that the MCQ on-line feedback was helpful, and improved their understanding even if they got the answer wrong. Student comments included "*feedback was really helpful, it was the best part*".

Almost all students (96%) felt that the lab report feedback was beneficial, with 98% of students commenting that one-to-one or small groups were the best way to give feedback. The students were motivated by the feedback and their perceived improvement in their report-writing skill: "*you see your marks rise every week ... you're aiming for 10/10 in your last one* [report]". Some 96% of students noted that they tried to implement the feedback points in subsequent reports and consequently 82% of students noted that their scores improved over the course of the year. Furthermore, the majority (84%) of students noted that their reports improved in other lab based modules also and 81% of students felt more engaged by the alternative assessment strategy and module redesign.

**Third Year Group**

*Transferable Skills and Preparedness for Work Placement and Final Year Projects*
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. All students agreed 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 that literature must be adapted for class experiments, which will be critical for students' preparedness for final year projects, where adapting the literature and experimental design will be the norm.

Overall, almost all students (94%) believed they were better prepared for final year projects, with one suggesting the experience was "*like a stepping stone towards final year projects*". Furthermore, the majority of students believed that the project has increased their employability skills, including teamwork, organisation, communication and research. Interestingly, 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.

*Feedback*
Perhaps the most welcome aspect of these modules from the student perspective was the provision of varied, timely and relevant feedback. 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. Particularly successful was the podcasted feedback. The students in this study mostly agreed (89%) that 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. 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."*

*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"*. Students particularly welcomed the opportunity to re-submit the group poster following the poster session within two weeks. This is in line with best practice in assessment and feedback according to Nicol and Macfarlane-Dick (2006) and Black and Williams (1998), 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'"*.

*Room for Improvement: Feedback Sessions*
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.

Surprising, only about half the group (54%) thought that the project 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.

## Research Outcomes

Research outcomes from this project will be applicable Institute-wide to all practical based modules. In brief, the benefits to both the student and the academic are several fold and are summarised below along with key recommendations arising from the project evaluation.

*Benefits*

1. Students who are better prepared; both for basic undergraduate laboratories and for independent research-based final year projects.
2. Continuity in the development of transferable skills resulting in increased employability.
3. Improved assessment quality though constructive alignment and appropriate feedback.
4. Improved student satisfaction through engagement and feedback.

*Key Recommendations*

1. Encourage preparedness for practical sessions, harnessing technology to engage students through interesting pre-practical activities suited to level and stage.
2. Encourage an improved culture of feedback, including innovative feedback mechanisms such as podcasts, which also “feed forward”.
3. Encourage a culture where value is added to modules by actively incorporating transferable skills into student activities and assessments, rather than a “bolt on” approach.

## Future Work

The project currently focuses on first and third year students in individual modules; however it is self-sustaining as it can be rolled out across all years and all practically based modules without further resource requirements. It will be particularly effective if there is a critical mass of staff engaging. The fellowship team are available for discussion with all staff, and indeed have already been approached by staff interested in applying the model to their modules.

Further research funding to sustain this project will be sought through:

- National Digital Learning Resources (NDLR) which supports research into sharing of digital/online resources, which will be generated in this project through pre-practical videos and associated Respondus MCQ quizzes;
- National Academy for Integration of Research, Teaching and Learning (NAIRTL) Grants Initiative which supports integration of Research, Teaching and Learning.

This funding would allow the project to be further developed, and permit collaboration with others both in DIT and elsewhere. Going forward, collaboration within DIT is important in the overall rationalisation in DIT structures, and economy in provision of Science delivery.

## Acknowledgements

The project was supported by the LTTC in general and Fionnu Kelly specifically.
Instructional videos were prepared in-house with the support of Roy Moore of the Telematics Facility, DIT.

## References


Bennett, S.W. and O'Neale, K. (1998) Skills Development and Practical Work in Chemistry. *University Chemistry Education*, (2) 58–62.

Bennett, S.W., Seery, M.K. and Sovegjarto-Wigbers, D. (2009) Practical Work in Higher Level Chemistry Education. In I. Eilks and B. Byers (eds) *Innovative Methods in Teaching and Learning Chemistry in Higher Education*. London: Royal Society of Chemistry, pp. 85–102.

Black, P. and William, D (1998) Assessment and Classroom Learning. *Assessment in Education,* 5 (1), 7–71.

Eilks, I., Markic, S., Bäumer, M. and Schanze, S. (2009) Cooperative Learning and Peer-tutoring in Higher Level Chemistry. In I. Eilks and B. Byers (eds) *Innovative Methods in Teaching and Learning Chemistry in Higher Education*. London: Royal Society of Chemistry, pp. 103–122.

Mc Donnell, C., O'Connor, C. and Seery, M.K. (2007) Developing Practical Chemistry Skills by Means of Student-driven Problem Based Learning Mini-projects. *Chemistry Education Research and Practice*, 8 (2), 130–139.

McGann, K. (2010) IBEC Education and Skills Survey, IBEC, October 2010.

Nicol, D. and Macfarlane-Dick, D. (2006) Formative Assessment and Self-regulated Learning: A Model and Seven Principles of Good Feedback Practice. *Studies in Higher Education,* 31 (2), 199–218.