Higher Education Academy

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Transforming Assessment In Higher Education

A Case Study Series

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Case Study 14

Where is the protocol?"
Independent thinking increases student engagement in laboratory work: A case study

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Background

Laboratory work plays a central role in the training of students in the process of science. In a typical laboratory class students are presented with a robust protocol and perform experiments where the results are predetermined. This expository style of teaching (as defined by Domin 1999) is commonly used in many institutions (including our own). Activities are designed so that large numbers of students can carry out the same experiment at low cost in a two to three hour time frame. These laboratories are often viewed as "recipe following" or "cookbook" exercises with low cognitive demands (Tobin 1987). The students are not required to plan the investigation and so often attend sessions with little planning and preparation. During the laboratory the focus is on obtaining the "right result". Assessment of lab work is usually via the submission of a report where primacy is given to the fundamental science the exercise was designed to explore as opposed to how to design and execute experiments. The benefits of enquiry and problem based laboratory sessions in teaching the scientific process has been widely discussed (Waldrop 2015) and this case study presents an approach to introducing this type of delivery into a BSc Biomedical Sciences programme.

Approach

The BSc Biomedical Sciences programme at Abertay University is a four year programme delivered by the Division of Science. A twenty-credit module in year three (representing a sixth of the credits for year three) was designed with learning objectives focused on the process of science (defining a testable hypothesis, designing and executing an experimental plan, applying statistical analysis to the evaluation of data) as opposed to specific factual content. These learning outcomes were designed so that skills such as risk assessment and application of statistical analysis could be developed by the students within the context of a practical project. The development of this module was part of a wide-ranging curriculum review by Abertay University.

The students were presented with a scenario which was based on the type of work carried out by Abertay University for SME's. In selecting the scenario several criteria were considered:

- Is there sufficient information readily available (accessible peer reviewed literature) for the students to carry out the task?
- Is it possible to carry out the task at Abertay University (considering safety, cost, timeframe and equipment)?
- Does the task build on and develop the existing practical skills of the cohort?
- Will the task generate data that is amiable to statistical analysis?

The task selected on this occasion was the assessment of the antioxidant content of soft fruit for a soft fruit grower to use in marketing and product development.

Working in assigned groups of four to five the students were provided with key literature and, during an initial tutorial session, were expected to design an experimental plan. The experimental plan was split into two phases for the students. Phase one focused on identifying a suitable means of measuring antioxidant levels and then developing a standard assay protocol (standard operating procedure). In phase two the students were able to define their own objective which had to have commercial relevance (for instance the effect of storage conditions on antioxidant content). The students were expected to complete risk assessments for all reagents and processes. Work for phase one was carried out in three practical sessions and after each session each group was offered a focused tutorial (typically 20 minutes) to discuss the outcome of the laboratory session and plan the next session. These sessions were run with the tutor acting as a facilitator so that students made their own decisions in planning the next session. After three laboratory session each group developed an experimental plan for phase two. To support the development of the plan a number of timetabled tutorials covering experimental design and statistical methods were available to the students. After completion of phase one the first assessment was held. Students were given individual viva's which were focused on their understanding of the laboratory work and experimental plan. The viva questions were structured to identify students who were not actively engaged in the laboratory work. The group size and the nature of the task were designed to reduce the opportunities to act as bystanders. Constructive feedback was given to all students and those who had not been able to articulate understanding of fundamental principles of the exercise were offered targeted additional support (tutorials) by the module team.

Phase two involved the investigation defined by the students. A similar pattern of delivery was used. Each laboratory session was followed by a facilitated discussion on the next steps. The final assessment took the form of a report to the company containing a standard operating procedure for antioxidant measurement, statistical report, executive summary and a page summarising the key biological background. The assessment was an individual submission (using group experimental data) and a proportion of the grade was related to the contribution that each member had made to the laboratory work (as assessed by peers and staff).

To reinforce the value of the transferable skills developed in the module a workshop with a careers advisor was organised and students identified skills and attributes (such as team working, project management core laboratory skills, risk assessment, experimental design), that they had developed during the module. They explored how their experiences in the module could be used to answer typical interview questions and were given the opportunity to practice articulating their answers in a mock interview scenario. This final session was attended by 70% of the students.

Outcomes

During the laboratory session the students were very much more "on task" and engaged in discussing the data they had collected than is normally observed in a laboratory class. There was a clear sense of ownership of the laboratory work. Attendance at the session was 86% (as a % of student laboratory sessions attended compared to total laboratory sessions for the whole group). In feedback (obtained from open ended survey questions) all responding students reported spending considerably more time preparing for these practical sessions compared to other practical sessions.

> "this was OUR practical, which naturally made us give an extra little bit of effort."

Of responding students 50% stated they had a better understanding of the material compared to other practical sessions.

> "I have more understanding before coming to labs now, before I would usually understand why we did something after the lab was done"

The remaining 50% of students indicated that their level of understanding was similar to that achieved in other laboratory sessions even though in this case (in contrast to other laboratory classes) little detailed information was given to the students. We could therefore conclude that all of the responding students perceived that they understood the material as well or better than they would typically understand a more conventional practical exercise. This demonstrates that given a supportive framework the enquiry based approach can lead to similar or better understanding than the expository style of delivery. There is evidence that students value the more demanding learning environment although there is the perceived risk of negative feedback (Chopra et al 2017, Bleske-Rechek 2010).

This case study shows that, given a suitable task and support students are prepared to take ownership of laboratory work and invest significant time and intellectual effort in the process. The selection of an appropriate task is central to the success of the exercise. The task has to be selected so that it builds on the students existing skill set and allows scope for student to have input into experimental design and trouble shooting. Furthermore the scheduling needs to include time for facilitated discussion both before and after the practical session.

The approach could be used in many branches of laboratory science provided that a suitable scenario can be developed. By calibrating the amount of support and detail give in both post and pre practical sessions this approach could be used at across all stages of a programme.

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