Teaching Systems and Synthetic Biology to Chemical Engineers

Talking About… Learning & Teaching: Case Study 012

University of Birmingham

Start Date: Autumn 2007

Students: 4th year UG / PGT (Level M)

Cohort size: ~50 per annum

Approach: Enquiry-based learning (EBL); group work

Discipline: Chemical Engineering

Scope: One-week 10 credit level M module

Learning Environment: lecture, seminar, computer labs, independent learning

Impact: EBL approaches are being expanded across Chemical Engineering teaching

Design Team: Serafim Bakalis (Birmingham Research Fellow), Liam M Grover (Senior Lecturer), Tim W Overton (Lecturer)

Introduction

This learning design was implemented to teach Chemical Engineering students the importance of Systems and Synthetic Biology, two areas highlighted by the Royal Academy of Engineering, the Institution of Chemical Engineers and the research councils as being essential for the future of the discipline. Students did not engage well with a previous incarnation of this module, partially due to not being able to see the relevance of the subject to their future careers.

Learning Design

The objectives for the learning design were to increase **engagement** and allow students to see the **relevance** of the topic to their studies. As such, the module was designed around **enquiry-based activities**, for both groups and individuals.

Since students taking the module are of a variety of academic backgrounds, they require background information about the field of synthetic and systems biology. Some of this material is delivered by introductory lectures on day 1. However, a block of material on experimental tools and methods (previously delivered in a lecture) was changed to EBL delivery, with groups of students being asked to prepare a short presentation describing a tool or technique in the discipline to their peers on day 2. Lecturers fed back on these presentations and filled in any 'gaps' in the student presentations. Tutorials were also introduced, where students utilised mathematical and analytical skills developed as part of their core chemical engineering training to solve typical systems biology problems using cluster and metabolic flux balance analysis.

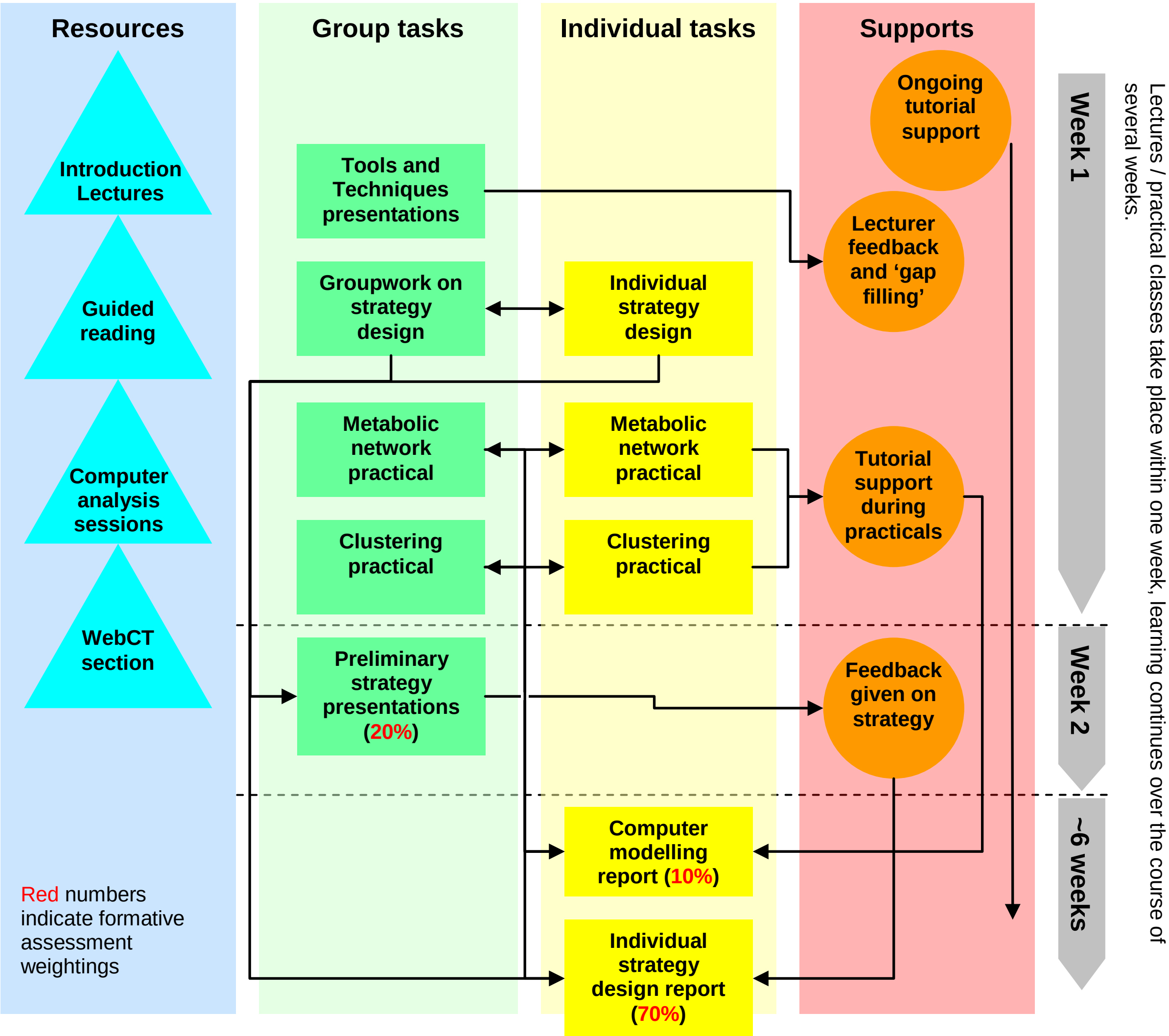
The major activity in the module was a problem concerning the production of a high-value chemical, which was introduced on day 2 of the module. Students were randomly assigned to teams of five and asked to apply their knowledge of systems and synthetic biology to solve the problem. They were asked to prepare a group presentation detailing their preliminary strategy a week after the module. Formative feedback was given following the group presentations, which students used to plan their individual written strategy design reports. A proportion of the week was timetabled as **free time**, primarily to be used for preparation of the group presentations; the lecturers were available for consultation on an *ad-hoc* basis. The lecture-based contact hours were low, but the structure of the module allowed teaching staff to respond to the students needs on an individual basis thus putting the learners at the centre of the learning experience.

Critically, **assessment** of the module was fully aligned with the learning outcomes and EBL activities. The assessed aspects were: the group preliminary strategy presentation (20%); the computer modelling report (10%); and the individual strategy design report (70%). The latter report assessed all module learning outcomes, and drew on material in introductory lectures, computer classes and the tools presentation sessions. This assessment strategy is likely to promoter deep learning; indeed, we found that students went into the subject area deeper than they would if the material was delivered by didactic lecture.

Summary

Overall, the changes reflected our efforts to move away from teacher-centred to a student-centred, problem-based approach. This has been successful in both increasing student engagement and improving satisfaction (as evidenced by oral and written student feedback) as well as enhancing transferable skills. These positive outcomes reinforce the theory that engineering students learn best by doing.

Temporal Plan: Learning Design Sequence



Student Learning Outcomes

By the end of the module the student should be able to:

- Describe how advances in molecular biology are important for the formulation/biochemical engineer as well as the biologist;
- Explain how the technologies and tools developed in this area can be used to enhance progress in engineering; and
- Demonstrate an awareness that the engineer must be able to communicate and work with scientists from other disciplines.

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