Using real-word problems to teach Biosciences within an interdisciplinary framework

I. Background

I started teaching on the University of Leicester's (UoL) Natural Sciences (NS) programme in 2010 and shortly after was given responsibility for the biology curriculum within the programme. The programme's curriculum covers Biology, Chemistry, Physics and Earth Sciences and is delivered through problem-based learning (PBL) using interdisciplinary real-world problems. PBL is *'a student-centred method of teaching in which students learn by investigating real-world problems and, working in groups, seek out the tools necessary to solve them'* (Raine and Symons, 2012). I was particularly excited about using this approach to deliver a bioscience curriculum as research shows PBL has positive benefits in both terms of long-term retention of learning and transferable graduate skills (Strobel and van Barneveld, 2009).

The coordination of the bioscience curriculum was a new role, and so I initially conducted a review of the content and delivery to ensure a coherent biological programme of study. This led to a number of developments, two of which are detailed in this case study:

- Creation of novel real-world bioscience problems
- Scaffolding the PBL process for bioscience problems

PBL in action: workshop (2015)

II. Creation of novel real-world bioscience problems (rationale for this development, staff and student perspective)

After my first year delivering the programme's Evolution module my evaluation of the assessment and reflections on the teaching indicated a lack of student engagement at the appropriate academic level and dissatisfaction with the module. In PBL the "problem hook" is particularly important (Savery & Duffy, 1995) and the existing problem ("Select a topic in evolution suitable for a short podcast") didn't fully engage and challenge the students to explore the topic in sufficient depth or ensure learning outcomes were met. During the re-development process I was introduced to Dr Sinead Drea who was interested in introducing material on macroevolution of plants. Together we developed a novel problem ("Cultivated maize is proposed to be a domesticated form of the wild Mexican grass. If domestication of maize is thought to have occurred only 5000-10,000 years ago how can a grass of such different morphology have developed so quickly?") and an aligned assessment in the form of a group creation of a textbook chapter, providing the students with practice at communicating developmental concepts to non-academic audience. This innovation introduced more sophisticated material and concepts. To support this I produced novel materials to

guide their independent research and the PBL workshops. This development proved to be a formative pedagogic experience for both Sinead and I, giving me confidence to design further PBL scenarios and Sinead an insight into this approach:

> *"Working with Sarah was a revelation in terms of informing my own teaching as well as the positive impact it had on the learning experience for the students. I have taken what I learned about PBL and module design and applied it to my teaching in Biological Sciences where the PBL and flipped learning approaches are not as common."*

In the module evaluation 90% of the students agreed that the PBL sessions I wrote and facilitated "increased my understanding of the material".

Following this development I have conceived two other bioscience problems and aligned authentic assessments, both of which have resulted in markedly increased student satisfaction and appreciation of their learning in respective modules:

Area	**Problem Hook**	**Assessment**
Astrobiology	Using the assigned planetary body from our solar system, show the potential habitats in which life could have evolved and whether that life could still exist today.	Academic Poster and Presentation
Cell Communication	Imagine you are a protein engineer interested in rewiring a cell to perform a new function. Explain the function, its significance and how you plan to do it.	Grant proposal

III. Scaffolding the PBL process (rationale for this development, staff and student perspective)

My other key area of attention has been the delivery of PBL itself. I reviewed the implementation of the bioscience elements of the PBL and devised a more constructivist approach aimed at making it easier for students to engage with and take ownership of the learning process (Gretton et al. 2014). I also worked with my counterparts in Physics and Chemistry to review their elements. The more "scaffolded" approach I established included:

- Provision of electronic documents including details of recommended textbooks, reading topics and online resources
- suggested questions to guide preparation and discussion in workshops
- increased detail in intended learning outcomes and allocation of outcomes to workshops
- weekly learning questions and feedback tutorials

As the programme increased in its intake, I instigated a re-assessment of the programme's tutorial system. Up until this point students submitted responses to questions which were marked and returned to the student prior to a one-hour feedback session.

However, I observed this system suffered from a number of flaws:

i) the volume of marking reduced the opportunity to provide detailed feedback
ii) students often attended the tutorial feedback session without their feedback; in some cases it was clear they had not engaged with (or even read!) the feedback
iii) one hour sessions did not allow time to go through all questions, only those the majority of students had significant issues with.

Any new system needed to complement the student-centred approach of the programme and a presentation at a HEA STEM meeting inspired me to consider how a variation of peer marking could address the issues outlined above.

I devised a new system with tutorial questions divided into two sections:

i) questions that could be easily marked by peers in groups
ii) more sophisticated questions that would benefit from written feedback.

Existing questions were divided /repurposed into these two groups. The in-session marking process requires students to discuss their given answer in pre-allocated groups, answers are then discussed as a class and marks recorded. The length of the tutorial session was increased to allow all tutorial questions to be discussed.

This system was introduced across all three years of the programme. Initially some students in their final year were sceptical (expressing disapproval of "doing the staff's job for them" or raising concerns about other students seeing their marks). Upon reflection, the rationale for the changes was not well disseminated and from this I learnt the importance of including the students in discussions on programme development at the earliest possible stage. However, the changes themselves have been successful and attitudes towards them changed. Attendance at and engagement in tutorials has increased, average exam marks have increased across the majority of modules (10/14 modules; with a mean increase of 7.3%) and when anonymously surveyed later, cohorts that had experienced both systems stated the new system was more effective in terms of learning gain (43% rated "new tutorials" highly effective compared to 35% for previous tutorials).

IV. Issues

As I discuss in Gretton et al. (2014) a PBL approach to delivering science curricula can be challenging, and it doesn't work for every student, particularly for those who don't engage or who maximise their social activities during term and their studies during vacations (Edmonds, 2008). My research has identified that the role of the PBL facilitator is particularly important. Additionally my practice has shown the need to ensure appropriate implementation for the context, this requires carefully monitoring of engagement and learning gain.

V. Benefits

In addition to perspectives on the specific developments outlined earlier in this case study I have also conducted research into the benefits of using authentic assessments to develop transferable skills (see presentations). When students were surveyed **all** participants stated that the course had increased their confidence in the following:

- Independent learning
- Research skills
- Problem-solving

Alumni were also interviewed as part of this research. All were able to identify transferable skills developed on the programme they had used in further study or the workplace. The quotes below typify the responses:

"With hindsight, PBL has been 'spot-on'."

"I have realised just how many skills that the course have instilled in me."

These benefits have been noted by the NS external examiner:

> *"The students have a definite sense that they are experiencing 'workplace learning'…The range of assessments is unlikely to be bettered anywhere in the country."*

and by UoL's Associate Director of Career Development

> *"The unique, engaging and authentic way in which the Programme uses academic study to prepare students for lives as successful graduates is an example I share with the broader University."*

VI. Reflections

I believe that we need to challenge ourselves as educators to ensure that we are designing curricula that not only deliver content but also provide opportunities to develop key graduate skills. The increased proportion of the population entering higher education means a significant number of graduates will not become academics or even work in their discipline area. PBL and authentic assessments can offer one, very effective, approach to skills development. However, I'll leave the final thoughts on this approach to the students themselves:

https://www.youtube.com/watch?v=aRtNVVNWS10

VII. Publications/ Dissemination

Presentations:

- Scaffolding PBL : HEA STEM 2013, ESERA 2013
- Embedding Employability through Authentic Assessment: EURO SOTL 2015, HEA STEM 2016, HEA Employability workshops (Greenwich, Leicester) 2016

Gretton, S., Raine, D., and Bartle, C., (2014) Scaffolding problem based learning with module length problems. E-Book Proceedings of the ESERA 2013

References

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Savery J. R., Duffy, T. M. (1995) Problem based learning: An instructional model and its constructivist framework. Educational technology 35 (5), 31-38, 2434.

Strobel J. and van Barneveld, A., (2009) When is PBL more effective? A meta-synthesis of meta-analyses comparing PBL to conventional classrooms, Interdiscip. J. Prob.-based Learn., 3, 44–58