

## Problem-based Learning in the Engineering Subject Network at UHI

### Summary

This case study covers a six month European-funded project which aimed to enhance the skills and knowledge of engineering students by increasing the use of problem-based learning (PBL) in the curriculum, in particular at the HNC and HND level. Technology is used to enhance the problems and to provide immediate feedback to students and staff. The literature shows that well-designed and facilitated PBL activities encourage independent learning skills, problem-solving skills, and collaborative skills, all of which are crucial graduate attributes for engineers of the future.

Once they reach degree level (years three and four), Engineering students at UHI are expected to undertake collaborative project work, work which in many cases is introduced in the form of a problem scenario. However, similarly to other institutions, teaching staff at UHI noted that students who studied HNC and HND units are relatively unprepared for such activities.

### About the Institution

The University of the Highlands and Islands (UHI) is the UK's newest and most northerly university. UHI is made up of 13 partner colleges and research centers and has around 50 local learning centers covering a geographical area larger than Belgium.

The project was developed by the University's newly established Educational Development Unit (EDU). As part of the Learning and Teaching Department, EDU is working closely with the University's programme teams to build capacity to develop and deliver high quality, accessible, learning experiences for UHI student by:

- Developing new blended learning teaching resources
- Developing staff who will use the new resources and delivery models

The high quality resources developed by this project aim to encourage students to become independent thinkers and provide them with an enhanced portfolio of graduate attributes suitable for employment in the 21<sup>st</sup> century

### The Challenge

The challenge was to introduce the concept of problem-based learning, in particular at the HNC/HND level, to the Engineering Subject Network at UHI and to prepare staff to facilitate such activities.

At UHI, the typical student route to an honours degree in Engineering is by studying for an HNC, then an HND, followed by a further two years of degree level education. There are several differences in the teaching and assessment approaches and the expectations placed on students between HNC and degree. In the final two degree years (years 3 & 4), students at UHI are exposed

to a problem-based learning approach. However, it is felt that some students who reach this stage are under-prepared for critical thinking activities associated with problem-based learning because of the different assessment methods employed to meet SQA performance criteria in HNC and HND units.

In order to get the most from problem-based learning, students need to be able to think independently, discover crucial information without being directed to it, collaborate with others and present conclusions on their findings. These skills can be developed retrospectively when students reach their third year but the Subject Network felt it would be far more beneficial to all concerned if these skills were developed gradually from the time students arrive to begin their studies. PBL, done well, has the potential to encourage the development of independent learning skills. Therefore, the materials produced by this project needed to be of high pedagogical quality (e.g. complex problems delivered in stages with detailed feedback available at all points, in order to catch any misapplication of theory early). To ensure this a variety of quality control measures were put in place (including two stages of peer review). The possibility of collaborating with local employers in both the creation of scenarios and facilitation was also considered to ensure the material was relevant, appropriate, current and of high quality.

The current economic climate is reflected by the curriculum redesign programme which is being implemented at UHI at the moment. One advantage of the form of problem-based learning produced by this project, where materials, facilitation and interaction are online, is that it changes the delivery model from face to face to blended. One caveat was that the teaching staff wanted a means of tracking student progress and answers. We used two institutional tools: Blackboard and Wimba Create to successfully achieve this goal; Wimba Create for online delivery and Blackboard for tracking.

Any project which aims to transform a delivery model across an institution will face barriers to its success and this one was no exception. Challenges included the need for buy-in from staff which was further complicated by the dispersed nature of UHI's partner colleges. Although a large portion of the development work in this project would be undertaken without meeting teaching staff in person it was deemed that in order to achieve initial buy-in, face to face meetings were essential. The project planned to use existing staff materials as much as possible, to maximize ownership and staff engagement with project developments. An active feedback loop was put in place and maintained to offer staff high quality just-in-time resources and ongoing support and staff development (the EDU has a dedicated Academic Skills Developer), in order to guarantee a high degree of confidence in the materials and readiness to deliver.

## **The Activity**

The project was owned by the Subject Network Leader for Energy and Technology, with the project management undertaken by the Educational Development Leaders. Liaison with the faculty was the responsibility of the Academic Development Advisors who were specialist within the engineering discipline. Further support was provided by the wider project team of development and administrative staff.

### **The development process:**

Suitable units and modules were identified by the Subject Network Leader and a number of themes that span across them were chosen. Themes included Mechanical Engineering, Electrical Engineering, Materials, Design, Control & Reliability and Renewable Energy. All engineering staff were informed of the project and Curriculum Managers were asked to publicise and support the project. Staff willing to engage with the project were asked, where possible, to provide existing resources (to help to maximize buy-in) and work with project staff to develop ways of enhancing

the materials. If staff were interested but did not feel they had enough time to actually help create materials, they were asked to become peer reviewers.

The material development was an iterative process consisting of initial concept, word document, initial peer review, enhancement, development into Wimba package, further peer review, adjustment, testing, upload to the VLE and finally further staff and student review.



### Application of technology:

PBL objects can be defined as self-contained learning activities relating to key concepts, where an element of problem-solving is present. They may be either solo or group tasks. A variety of technologies were used to enhance the materials that were created to make them as engaging as possible.

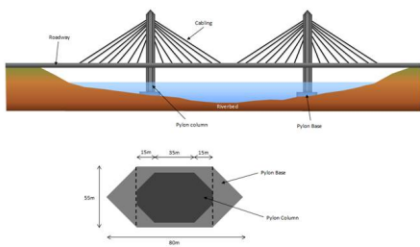
- A Word template was devised to ensure consistency and pedagogical good practice, which laid out the activity for students in a helpful, logical way.
- Wimba Create was chosen as all teaching staff have access to it, and with some tweaking can generate some good looking and interactive online content.
- Images were used, the majority of which were sourced from Flickr with Creative Commons licenses.
- Animations were created in-house, either by EDU developers or ADAs.
- Microsoft Office products were sometimes used in conjunction with recording software.
- Flash activities were embedded within PBL materials and created in-house with passcode protection for staff control.
- WIKI and mind-mapping software for EDU project staff was used and found to be hugely beneficial tools for those involved in the creation of the resources.

Completed PBL objects were uploaded to the VLE and stored for re-use in a central repository, as were templates for a Student's guide, Teacher's guide and generic induction material on problem-based learning. Accessibility considerations were addressed and reasonable adjustments built in as far as possible.

New Forth Road Bridge Proposal

**Problem part 1**

As a local engineer you have been hired by a local newspaper, they have not yet decided if they are going to support the decision for the new bridge or oppose the plans. It is your job to investigate some of the basic, yet key, factors from an engineering point of view and report back to the newspaper, which will then make a decision based on your findings.



As the plans are for a cable-stayed bridge (shown below) the construction of the bridge will primarily be of reinforced concrete, consisting of two pylons. The pylons will sit on the floor of the River Forth (cross-section shown below); however, some concern has been raised regarding the degradation in stability of the river bed. From an investigation that has been carried out, by a geological survey and dive team, you learn the river bed would be able to support 84 psi safely.

Having seen the plans for the proposed bridge, you know that the total mass of the bridge would come to  $384 \times 10^6$  kg, the mass of both pylons will be  $190 \times 10^6$  kg, and the mass of the cables over both pylons would come to  $76 \times 10^6$  kg. The mass of the roadway section alone is not available but 40% of the roadway section will be supported by the land on either side of the river.

1. Calculate the pressure one pylon exerts on the river bed. Will the riverbed be able to support the pressure of this column safely?
2. How would road traffic affect the pressure on the base, given that there will be four lanes of traffic and that the span of the bridge will be approximately 2.5 Km?

**What to do now:** Ensure that you have understood what is being asked to calculate. All the formulas required are given in the **List of Relevant Formula**.

Blackboard Test: Once you have worked out your answers to the questions above, visit the New Forth Road Bridge PBL Problem part 1 test to record your answers.

After doing this return to the PBL and continue with Problem Part 2. Your tutor will advise you when you can have access to the passcode so you can view full solution for Problem part 1.

## The Outcomes

### Impact staff and students:

The project is on schedule to create approximately 40 problem-based learning resources, averaging 7 hours student engagement each. As they are themed, these resources can be used in more than 30 different units and modules, which are delivered from as many as 6 different academic partners across the UHI.

### Sustainability:

The units and modules are run at 6 UHI partner colleges. The PBL resources will be uploaded to the UHI Toolkit (see case study – Making sharing easy within an HE institution) as well as the Virtual Learning Environment, where all teaching staff can access them. As a legacy many of the staff development resources created for this project, including an ‘Introduction to Blended Learning’ module, various guides, Toolkit resources and the Professional Development Planner (PDP) will also be made available to all teaching staff following the conclusion of the project.

One of the desired outcomes of the project was that through staff engagement and staff development, teaching staff would not only feel confident to use problem-based learning, but that they could in future create problem-based learning materials of their own.

### Adherence to quality standards, control & monitoring:

The process that has been put in place, such as the initial agreement on concepts and themes, review of draft Word documents and full staff and student peer review surveys, mean that there is a high degree of confidence that the material created is fit for purpose and set at the right level for HNC/D students.

### Efficiencies:

As the PBLs are designed to be used online, out-with the classroom and are suitable to be used in place of a tutorial session, there is the potential to improve efficiencies in terms of maximizing the benefits of face-to-face time. Automated feedback enables a higher degree of learner autonomy and can improve overall performance and help to reduce remediation time.

New Forth Road Bridge Proposal

Part 1 solutions

1. Q - Calculate the pressure one pylon exerts on the river bed.

Enter the lockcode provided by your tutor:

**Solution**  
 Firstly, the mass of one pylon and all that it supports must be calculated;

Total mass of the bridge =  $384 \times 10^6$  kg  
 Mass of both pylons =  $190 \times 10^6$  kg  
 Mass of all cabling =  $76 \times 10^6$  Kg  
 Mass of roadway = ?

Calculating the total mass of the roadway;

$$384 \times 10^6 - (190 \times 10^6 + 76 \times 10^6) = 118 \times 10^6 \text{ kg}$$

Calculating the total mass that one pylon supports;

[Description]

## Lessons Learnt

The development of problem based learning resources hinges around a suitable 'problem' or 'scenario'. The best source of those problems often is with teaching staff. Gaining high levels of engagement with staff, however, was difficult for various reasons and the development team was disadvantaged because of this. Alternative sources (including SQA exemplars) had to be found which has impacted on the development time. It also has a potential impact around staff 'buy in' to the resources and their use of them in the future, although this has not been fully explored at the time of writing. With hindsight, in order to prevent this happening in future projects staff, at all levels, should have been engaged before project commencement.

All staff who engaged with the project were offered the opportunity to undertake an SCQF Level 7 module called: An introduction to blended learning. Few managed to find the time, however they will continue to have access indefinitely. To increase uptake of similar staff development opportunities in the future the issues of staff time should be addressed and reward for professional development could be considered

Technologically, the project would have benefitted from having a dedicated assessment engine. This would have been a far more efficient and effective method of allowing staff to track student progress.

## Useful Links

Brief introductory article, What is problem-based learning? De Gallow (University of California, Irvine) <http://www.pbl.uci.edu/whatispbl.html>

De Gallow links on to: Samford University:

CTLA Archives: <http://www.samford.edu/ctls/archives.aspx?id=2147484112>

The Regional Support Centre Scotland supports the development of educational e-learning. We may refer to specific products, processes or services. Such references are examples and are not endorsements or recommendations and should not be used for product endorsement purposes.

Samford also links to an ebook of PBL examples from McMaster University (generally accepted as the creators of PBL) <http://www.fhs.mcmaster.ca/pbls/writing/index.htm>.

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