

# ENGAGING STUDENTS WITH PROBLEM BASED LEARNING

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**Abstract:** This paper provides an example of how the problem-based learning approach can be adapted to a technical discipline, using a case study implementation of problem-based learning on a Masters-level Drilling Engineering course at Heriot-Watt University. It also details the two electronic elements that were used to enhance the course – mind mapping software and online asynchronous discussion – and describes the results of the course evaluation.

## 1. INTRODUCTION

Problem-based learning (PBL) has been used in higher education for over forty years as a method of teaching the practical application of knowledge in a real-world setting. It originated in the field of health in the 1950s and has since been used as an effective educational technique in many other disciplines, for example business (Foster & Gilbert, 1991) and law (Winsor, 1991). Boud & Feletti (1991) define problem-based learning as ‘a way of constructing and teaching courses using problems as the stimulus and focus for student activity. It is not simply the addition of problem-solving activities to otherwise discipline-centred curricula, but a way of conceiving of the curriculum which is centred around key problems in professional practice.’

Problem-based learning is used to refer to a number of educational techniques, the common denominator being the use of problems. Barrows (1986) defines a taxonomy of problem-based learning methods ranging from problem-based case studies used in lectures to totally student-centred reiterative problem solving where students evaluate their own problem-solving abilities.

There are a number of commonly accepted characteristics that are common to problem-based learning courses:

- Use of a real-life, complex, ill-structured, cross-disciplinary problem, with any number of correct solutions.
- The problem is presented to the students without direct instruction of how to solve it; however, resources and scaffolding are made available for the students to solve the problems themselves.
- Students work in small groups, with the help of a facilitator.
- The problem is used as the focus from which the learning is structured.

There are several advantages of problem-based learning over traditional teaching. It takes account of how students actually learn, with the focus being on activities rather than knowledge gained encouraging deep rather than surface learning; it teaches learners how to learn for themselves, carry out research and find new sources of knowledge; it situates the learning in the context of a real-life situation; it increases learning engagement and interaction with the learning material; and it encourages an appreciation of teamwork and the value of others. The disadvantages of problem-

based learning are that it involves a large cultural change, both for students and teachers; it can be a daunting and time-consuming task to restructure existing courses; and the problem-based approach may be more difficult to implement in certain types of course.

Problem-based learning is typically most suitable for courses that allow for ill-structured problems – those that are complex, multi-faceted, open-ended, and with no fixed solution. However, not all courses contain problems of that type; the Drilling Engineering module run at Heriot-Watt University is part of a highly-technical, intensive masters conversion degree where the majority of typical problems are of a mathematical nature and will have a single correct solution. This paper examines how the problem-based learning methodology can be adapted to be appropriate for a course of this nature.

## **2. IMPLEMENTING PROBLEM-BASED LEARNING IN DRILLING ENGINEERING**

The Drilling Engineering course is part of the Masters of Petroleum Engineering Degree, and was the only course within this degree to implement a problem-based learning approach. The course involves: fundamental design concepts; design criteria and specifications; equipment specifications; theoretical tools; quantitative data; and practical considerations and constraints, and is heavily factually based, involving numerous procedures. The problems used are often not open-ended and usually have one accepted solution, which does not fit with the accepted implementation of problem-based learning.

This issue was countered in the following way: students were presented with more tightly structured problems, but instead of working directly towards solving the problem, they were first asked to brainstorm what they thought they needed to know to be able to solve the problem. They were asked to detail their solutions using mind maps. This meant that valuable discussion and debate could take place because although there may only be one correct solution in this discipline, there may be a number of different ways of getting there.

The problem-based learning Drilling Engineering course was based around a series of problems, approximately one for each week of the course. Students were randomly divided into groups at the start of the term and asked to work in the same group for the duration of the course. Each week the groups were presented with a new problem, which they were asked to discuss and identify the possible solution paths using mind mapping techniques, then discuss and solve the problem. Work was expected to take place both inside and outside the classroom. The overall implementation of PBL for each problem in this course is as follows:

- The tutor presents a problem.
- Students brainstorm possible ways of approaching the problem.
- Students produce a mind map of their approaches.
- Students adapt the mind map in consultation with the tutor.
- Students develop the solution.
- Students present the solution for scrutiny.

In practice, as many students were completely new to the subject and felt uncomfortable with pure problem-based learning, so a short overview of each topic was provided in class by the lecturer.

Two software tools were used to enhance the problem-based learning experience:

- Mind mapping software. This was available as freeware and was made available to students as a straightforward way of setting down and sharing their ideas.

- Online discussion forum. Problem boards and private group boards were set up to allow students to communicate on- and off-campus. It was mandatory that one member of each group post the completed mind map for each problem to the discussion forum.

At the start of each session, before the new challenge was given, a group would be selected to present their solution, and common misconceptions and feedback from the discussion forum would be discussed as a class group.

The following diagram (Figure 1) summarises the process used to implement PBL in Drilling Engineering.

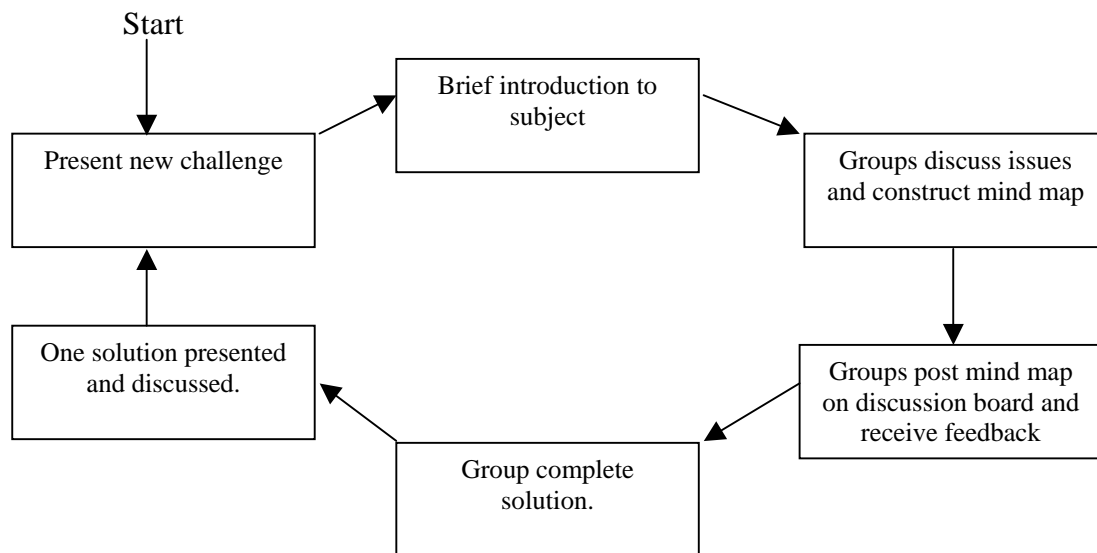


Figure 1: PBL Implementation Model

The role of the tutor in problem-based learning is greatly changed from that of the traditional lecturer. Lim, Tan & Klimas (2001) state that ‘the instructor may have to guide the learners when they are lost; prompt them when they miss the point; motivate them to search for information; perform demonstration or modeling when they have no clue on how to proceed; mediate a discussion among them; resolve conflicts among them; or even inject a controversial point to provoke thinking.’ The role of the tutor is that of a facilitator, enabling the process and encouraging the students to apply critical thinking to the problem. The tutor also monitors and assesses the process, but does not comment on content relevance. A key task for the tutor is to present the problem in a credible context that makes the problem relevant to the learner and encourages learner engagement. This problem presentation should not suggest a solution or tell learners how to go about finding a solution; it should also not seem unrealistic or trivial.

### 3. EVALUATION

The criteria which were used to assess the effectiveness of delivering the Drilling Engineering course using PBL were:

- the average mark in the examinations when compared to when the course was delivered using lectures and tutorials;
- the number of students failing the course;
- a survey of the reaction of the students.

In this trial the average mark in the examinations was not significantly different from previous years and approximately the same proportion of students failed the examination. This provides evidence that using the problem-based learning methodology does not put students at a disadvantage as compared with conventional teaching. However, the reaction of the students to the delivery mode was generally very favourable and the feedback from the lecturer was very favourable.

The students were surveyed at two points in the course: after three weeks, and again just after the final examination. As the evaluations were completed in the classroom, response rates were 100% of those present (41 out of 45 for evaluation 1, and 33 out of 45 for evaluation 2). The lecturer was also asked to keep a diary after each session to highlight issues.

In both questionnaires students were presented with a likert-type attitude scale containing a number of statements and asked to define the extent to which they agreed or disagreed.

Students felt strongly that they were learning skills that would be useful to them in later life, but there was some concern about how this related to what they needed to know for the end-of-course examination. They felt that it was very valuable to work with other students in a group, and that discussing problems with others made them understand issues more deeply and gain a broader understanding of the subject. However, students also strongly felt that problem-based learning was more difficult and more time-consuming than traditional classroom-based teaching.

The most positive reaction by the majority of students was to the mind mapping techniques and software, which were appreciated as a good tool for representing and sharing ideas, with a large majority of students stating that they would use mind mapping in the future (Figure 2).

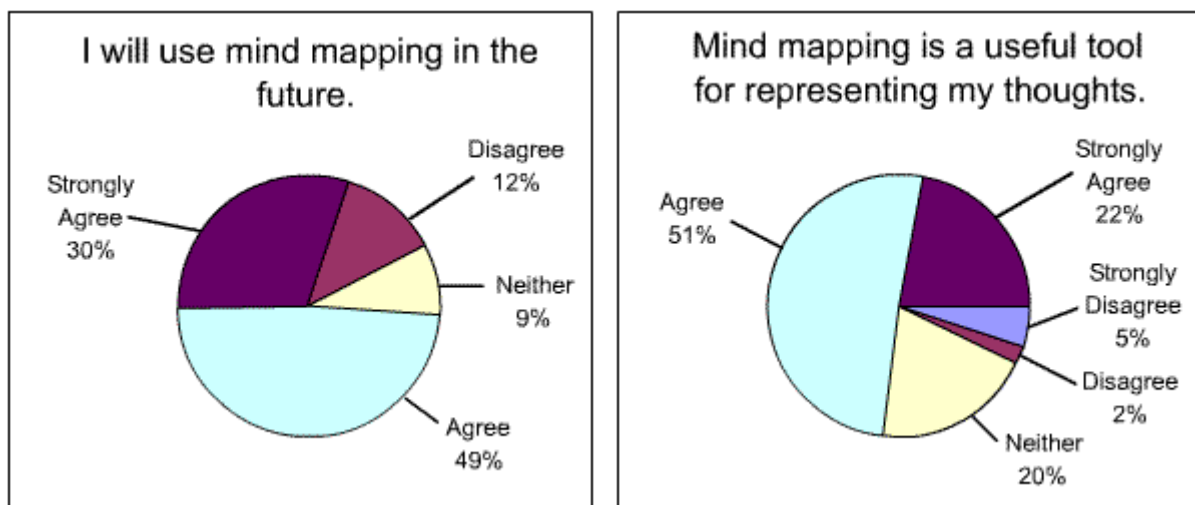


Figure 2: Reaction of the students to mind mapping

While students also appreciated the need for group work and communication, many felt that the online discussion software did not particularly help them to do this (Figure 3) and there was very much a mixed reaction to the usefulness of this software. The discussion forum was seen as a useful way to share ideas and resources with the class, but was not used much for groups to discuss within themselves. This is almost certainly because groups met frequently in class, but would be much more important for distance learners using problem-based learning.

## 4. CONCLUSIONS

Problem-based learning was seen as a useful way in which to teach, and although some students were apprehensive about a new method of working, which was not used in any other areas of the course, the vast majority thought that it was a worthwhile way to learn. The nature of the subject is such that it can be very difficult to get started on a problem when you know absolutely nothing about the subject domain. It was for this reason, and to counter students' apprehensions, that mini overview lectures were introduced at the start of each session, and it would be recommended that any future course of this nature use them.

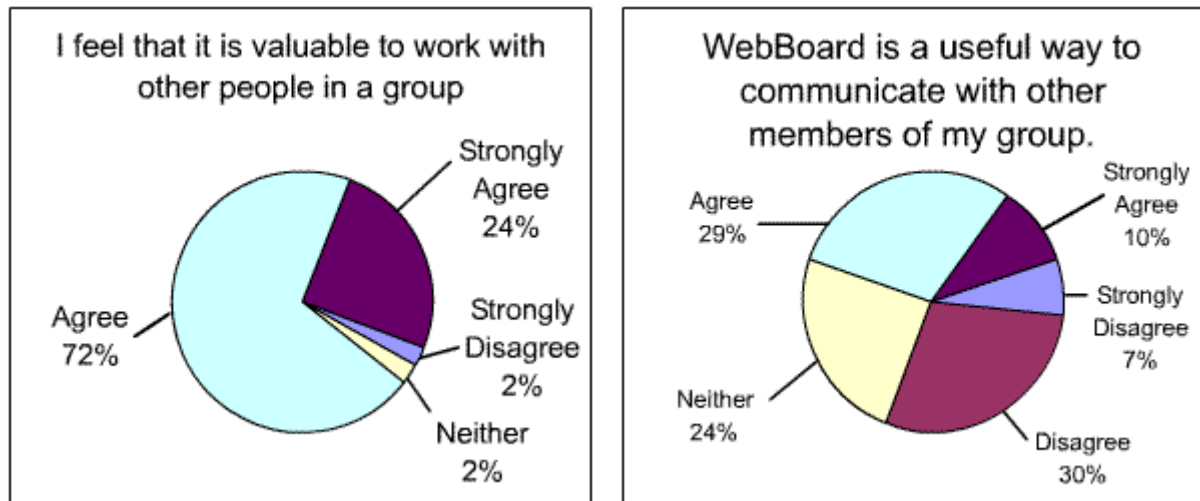


Figure 3: Responses to use of the discussion forum

There were problems with students not relating material that they were learning during the problem-based sessions to the final assessment – a closed book examination. Although there was no significant difference in the average mark of the study year and those of previous years, many students were concerned that they were not learning the right material to pass the exam. In future, it would be recommended that the method of assessment tie in more closely with the method of teaching.

Although problem-based learning certainly has its benefits, it is a significant cultural change and the amount of time it takes to implement should not be underestimated. It is also crucial that staff are committed to implementing this type of learning.

The mind mapping and techniques and software introduced in this course were greatly valued by students, the majority of whom said that they would continue to use this technique. The online discussion forum was not used by all students, but nearly 40% did find it a useful tool, and it increased learner choice about how groups wished to communicate.

PBL may not at first appear to be suitable for teaching engineering subjects since it normally draws on ill-structured open-ended problems. In this trial however it was found that problems could be formulated and presented in such a way that PBL techniques could be taught and practised in this domain.

## REFERENCES

- Barrows, H. S. 1986. A taxonomy of problem-based learning methods. *Medical Education*, 20/6, 481–486.
- Boud, D. & Feletti, G. 1991. *The Challenge of Problem Based learning*. Kogan Page: London.
- Foster, S. F. & Gilbert, A. 1991. Experiences with Problem-based Learning in Management and Economics. In Boud, D. & Feletti (Eds) *The Challenge of Problem Based Learning*. Kogan Page: London.
- Lin, C. P., Tan, S. C. & Klimas, J. 2001. A Problem-Based Approach to Web-Based Corporate Learning. *Journal of Instructional Science and Technology*, 4/1, 1–14.
- Winsor, K. 1991. Applying the Ideas of Problem-based Learning to Teaching the Practice of Law. In Boud, D. & Feletti (Eds) *The Challenge of Problem Based Learning*. Kogan Page: London.