

## Problem Based Learning (PBL) - A Case Study From Environmental Sciences

Simon Belt  
University of Plymouth

### Abstract

*The use of case studies in the context of Problem-Based Learning (PBL) is described. A rationale for the use of a problem-based approach is given together with some key features that arise. Two case studies are described briefly in terms of their relevance to an interdisciplinary subject area (Environmental Sciences), their content, some operational aspects, and their applicability in the teaching of key skills. Some positive features of using this style of teaching are discussed with reference to student feedback and tutor observation. In addition, the impact of using a problem-based approach on, e.g. time and other resources, is also highlighted. These are considered to be particularly relevant within the contexts of students' expectations of teaching and assessment, demands on tutors' subject knowledge, and access to information sources.*

### Introduction

During the past few years, I have read a number of articles describing the use of Problem based Learning (PBL) as a teaching method in Higher Education. In most cases, I have found these to be interesting, informative and helpful in terms of developing new material. However, I believe that too often, PBL is described as a mode of teaching that is largely restricted to certain subject fields and employed in a limited number of institutions. In addition, attempts to define PBL in terms of underlying ethos and demonstrable practice can lead to contradictions, and attempts to discriminate between PBL and Problem-Solving are usually contrived. I suspect that statements such as "PBL is most widely used in . ." or "PBL is most widely adopted at . ." are not really true and certainly not helpful. It seems much more likely that PBL methods are ubiquitous although their employment may not be so overt. In any case, as academic tutors, science-based or otherwise, let us focus on those things that we are trying to achieve - an effective learning environment for our students.

Working with problems is one way to achieve this since it represents a normal mode of activity in everyday life. Of course, not all students learn in the same way and thus, a variety of methods is a sensible approach. However, with careful design, a problem-based approach has the potential to appeal to a large number of students for the following reasons:

- Working with 'real-life' situations generates interest and maintains enthusiasm;
- Knowledge and understanding of subject material is reinforced;
- Group working can enhance transferable skills;
- Solutions are not restricted to strictly 'correct' answers;
- Unfamiliar or controversial problems require judgement and decision-making, etc.

### Case Studies

The use of problem based case studies provides an effective strategy for helping students to acquire many of the skills that are required of them. A case study involves problem solving within a real life or work-related context. Other features of a case study include an interactive style, the development of personal skills and the opportunity to use reflection as part of learning (Pontin et al, 1993). The two case studies that have been developed at Plymouth are both based on incidents that took place in the UK.

### The Legacy of an Abandoned Mine

The first of the case studies is concerned with the discharge of acidic mine water from an abandoned mine after excessive rainfall. Following a description of an initial scenario that is presented to the students, the overall aim is presented (viz. to propose a short and long-term monitoring and clean-up strategy). The whole study is broken down into four tasks, which collectively require the students to consider a wide range of topics that are typical of the environmental sciences. Thus, amongst other things, chemical processes are linked to underlying geology, analytical and treatment methods are researched and a numerical model is developed based on a limited data-set. Students work in groups of 4-6 and the entire case study is tackled over a 5-10 week period to allow for sufficient research of each topic. The material is also sufficiently flexible to allow for use over a shorter period if desired (e.g. for MSc or short-courses). Each topic is assessed by means of a report together with an oral presentation. The audience for the presentations ranges from non-experts to invited speakers from a local industry or agency. In assessing the work, it is the responsibility of the group members to ensure that individual contributions are recognised. An evaluation of this can be achieved either by peer-assessment or by analysis of the minutes of meetings. Further details of the operational aspects of the case studies including skills profiling can be found elsewhere (Belt and Phipps, 1998).

### Implications of a Warehouse Fire

The second study focuses on a fire in a warehouse containing two chemicals - a herbicide and a potential oestrogen-mimic (Belt et al, 1999). The major environmental concern relates to the subsequent release of the chemicals into a local river. The case study has a similar structure (individual tasks, timescale, etc) and series of activities to The Legacy of an Abandoned Mine (vide infra), but differs in a number of ways. Firstly, unlike the first study, the students are not presented with an initial scenario. Rather, they are given some data from which they have to deduce the details of an incident which has taken place (the time, cause and immediate effects of the fire). Thus, the first problem is to deduce what the problem is! Each group member receives a number of data cards containing information that is either key, supportive or irrelevant in terms of solving the problem. By compiling and discussing the data as a group within a restricted time period, a solution is presented and then discussed. The purpose of this exercise is to act as an effective 'ice-breaker' and to raise awareness of group working skills (not simply who is going to do what, but how information will subsequently be shared, evaluated, etc). It also provides a suitable means of introducing the general theme of the case study. There are no 'rules' to follow and greater emphasis is placed on the post-activity reflection than the solution itself. This is achieved by a discussion with the tutor, followed by group (assessed) and individual reflection records. Other features of this case study involve making judgements based on extremely recent and 'old' literature, a consideration of the legal aspects of the incident and the employment of negotiation skills and budgeting within a restricted timescale.

### Positive Features and Other Considerations

The use of case studies allows for many of the features of PBL to be implemented. Students are presented with challenging problems and they need to employ and develop a range of skills in order to succeed. They appreciate the opportunity to work with 'real-life' issues, but it is also important that there is a significant amount of relevant subject material. The problems themselves may be open-ended or well defined. In this latter and probably more familiar case, other features of PBL can be introduced involving e.g. management within the time constraints, working with limited data sets, scientific estimating, etc. In all cases, the general philosophy is the same - to encourage students to think for themselves and ask the types of questions that one needs to ask when presented with a problem (What do I currently know? What will I need to know? How will I obtain the information and what will I do with it when I have

it ?, etc). For many students, this can represent a significant or possibly even a new challenge, often requiring help from the tutor. However, as the PBL approach becomes more familiar, an increasing amount of help comes from other group members. Thus, the group teach each other and the level of instruction from the tutor diminishes as the students assume more and more responsibility. These, and other commonly perceived benefits have been discussed in detail elsewhere (see Introductory article in this publication).

It is probably also worth drawing attention to some other features of PBL that prospective users may wish to consider. To do this, I will refer to the "Warning Triangle" of Student response, Tutor time and Resources as illustrated in Figure 1 below:

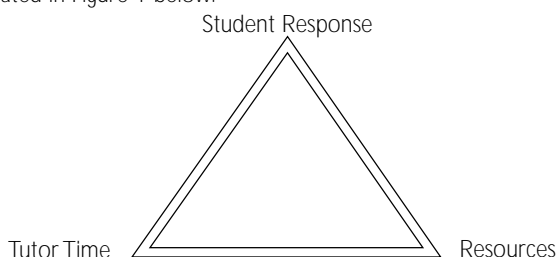


Figure 1: The "Warning Triangle"

When asked to reflect on their experiences, students are virtually unanimous in their opinion that PBL (case studies here) has been an effective and enjoyable approach to learning. However, as an observer of their experiences, it is clear that this is not always true, particularly in the early stages. In addition to working with the problem itself, students need to adjust to changes in expectations and learning culture. In general, students are much more familiar with (and therefore happier with) well-defined problems, data sets, expected deliverables, etc. They are also used to being 'taught' within an accepted framework. It is therefore recommended that the PBL principles are given careful attention at the beginning of a case study. One way to achieve this is by comparison or analogy with more familiar (e.g. social) situations. Secondly, although PBL is considered a means of ensuring that learning is more 'student-centred', tutors should not underestimate the additional time that can be associated with it. The open-ended or more flexible format places a higher demand on the tutor in terms of structuring the tasks and understanding the relevant material since students tend to ask a wider range of subject related questions. It is therefore not sufficient to base a PBL exercise around e.g. a single text. The time-consuming nature of PBL can also require some sacrifice of 'core' subject material, though some evidence suggests that this type of student-centred activity leads to a greater understanding of what is covered (Wenzel, 1999). Further, since the role of the tutor can shift from a traditional provider of information to facilitator, (s)he will often need to address questions from students who are looking for ways of reverting to a more familiar approach - "I can do what you want me to do if you just tell me what to do!" Establishing and maintaining credibility is key in this regard, and this can be time-consuming. The potential reward of course is that the tutor is able to devote more time to monitoring a student's progress. Thirdly, PBL encourages a greater use of potentially costly information sources including texts, journal articles, electronic sources and other personnel - I have known for a local expert on a topic to receive twenty phone calls within a week and this does not go down too well! A simple check with the tutor (e-mail) can go part way in alleviating this problem.

In summary, I have found that case studies can provide an effective and enjoyable way for students to develop key skills within a context-based framework. The two studies outlined here have evolved over a number of years, mainly as a result of piloting and analysis of student feedback. This on-going evolution continues in all senses to be a challenge.

## References

- Belt, S. and Phipps, L. (1998) Using Case Studies to Develop Key Skills in Chemists: A Preliminary Account, *U. Chem Ed.*, **2**: 16-20
- Belt, S. Clarke M. and Phipps L. (1999) Exercises for chemists involving time management, judgement and initiative *U.Chem.Ed.*, **3**: 52-58
- Pontin J. Arico E. Pitoscio Filo J. Tiedeman P. Isuyama R. and Fettis G. (1993) Interactive chemistry teaching units developed with the help of the local chemical industry. *J. Chem. Ed.*, **70**: 223-226.
- Wenzel T. (1999) Does Problem-Based Learning sacrifice content and fundamentals? *Anal. Chem.*, **71**: 693A-695A.

## Acknowledgements

I would like to thank Lawrie Phipps and Mike Clarke for researching and developing different parts of the case studies and to all the students at Plymouth and other UK universities who have taken part in the piloting process. I also acknowledge the University of Plymouth and Project IMPROVE (HEFCE) for funding. The further development of this case study project has recently been generously supported by the Analytical Trust Fund of the Royal Society of Chemistry.

Simon Belt

Department of Environmental Sciences  
University of Plymouth  
s.belt@plymouth.ac.uk

## Challenging the Teaching Convention in Geography Using Problem-Based Learning: The Role of Reflective Practice in Supporting Change

Adrian Chappell, University of Salford

### Abstract

*The nature of higher education has changed considerably in recent years. The growing emphasis of student-centred learning requires a redefinition of the relationship between lecturer and student and a concomitant shift away from lecturer-focused teaching. Problem-based learning (PBL) is a student-centred learning strategy that promotes a greater responsibility and motivation for learning than conventional approaches in Geography. An introspective examination of the rationale, requirement and implementation of teaching and learning was conducted by several members of the Geography Division at the University of Salford. This reflective practice was instrumental in the identification of several pertinent difficulties that inspired the investigation and development of a framework in which to tackle some of them. In addition to the importance of student-centred learning in Geography, the PBL framework is believed to be useful for reaching a compromise between training and education and to ensure that fieldwork is integrated into the curriculum. An example of the implementation of this framework is provided here for a module for level 3 undergraduate students. A brief discussion of the institutional constraints on implementation is provided.*

### Introduction

*"Schools teach you to imitate. If you don't imitate what the teacher wants you get a bad grade. Here, in college, it was more sophisticated, of course; you were supposed to imitate the teacher in such a way as to convince the teacher you were not imitating." Pirsig (1974)*