November 2001 Special Edition Two

ltsn
Learning and Teaching Support Network
Geography, Earth and Environmental Sciences

Planet

Special Edition

Case Studies in Problem-based Learning (PBL) from Geography, Earth and Environmental Sciences

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What is PLANET?

PLANET is the bi-annual publication of the LTSN Subject Centre for Geography, Earth and Environmental Sciences. Its aims are to:

- Identify and disseminate good practice in learning and teaching across the three disciplines of Geography, Earth and Environmental Sciences and present examples and case studies in a "magazine" format.
- Provide a forum for the discussion of ideas about learning and teaching in the three discipline communities.
- Provide information for readers on Subject Centre activities and on related resources, conferences and educational developments.

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Case Studies in Problem-based Learning from Geography, Earth and Environmental Sciences

Editorial

Helen King, LTSN-GEES

The idea for this publication arose from an LTSN-GEES workshop on "Motivating and Engaging Students in Active Learning" held in February 2001. At the workshop, Problem-Based Learning (PBL) was highlighted as a useful framework for active learning. The participants found the examples show-cased at the workshop particularly useful as ideas which they could adopt or adapt. Additionally, interest was expressed in the principles of PBL as a framework for developing interactive, team-based learning opportunities.

Interactive, team-based learning opportunities is a rather round-about way of saying 'team projects', a concept with which we are very familiar in Geography, Earth and Environmental Sciences (GEES). The use of the language of PBL as a means of describing and developing such activities has the potential to provide opportunities for us to pause for thought, reflect on, rationalise and enhance our current approaches to learning and teaching. The main aim of this publication, therefore, is to discuss team project-type activities within the context of PBL through specific examples of practice. More specifically, the aims of this publication are to:

- introduce the concept of PBL;
- discuss how this approach may be incorporated into Geography, Earth and Environmental Sciences;
- provide some examples of its use in order to support staff to reflect on their own practice; and
- provide guidance for staff considering implementing a PBL approach.

The collection of six case studies is introduced by two articles discussing the background to PBL. In the first, Maggi Savin-Baden outlines the philosophy of and general issues related to PBL. For readers with an interest in the history of PBL, the second article (Honeybone et al) describes this in more detail before discussing a 'hybrid' model of PBL. The concept of 'hybrid' PBL relates to the notion that the 'pure' PBL model is a specific definition of curriculum structure as well as a learning and teaching philosophy; a hybridised PBL model is based on the philosophy of PBL but argues that the technique may be used in individual teaching sessions (tutorials, modules or parts thereof) even if the remainder of the curriculum takes a more 'traditional' approach.

The discussion over the definition of PBL is a common one amongst curriculum developers and PBL advocates, and it is easy to get caught up in the semantics. However, as Simon Belt suggests in his paper: "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.....As academic tutors...let us focus on those things that we are trying to achieve - an effective learning environment for our students."

In her introduction, Maggi suggests that "Problem-based learning is thus an approach to learning that is characterised by flexibility and diversity in the sense that it can be implemented in a variety of ways in different subjects and disciplines in diverse contexts." This is clearly illustrated in the six examples of practice in this publication. They cover a range of topics from the geochemical implications of an abandoned mine to the distribution of World Bank funding. They also cover a range of learning sessions, from a short icebreaker-type exercise to a level 3 module within a PBL-based curriculum. The authors discuss the various issues associated with implementing PBL, including the advantages and pitfalls. The main issues which I see arising from their experiences are:

Staff development

"Effective staff development is now perceived to be one of the keys to successful implementation of problem-based learning " (Savin-Baden). Indeed it is key to the implementation of any new learning and teaching method. An individual member of staff wishing to include PBL as part of their teaching may share ideas with colleagues, read various publications, attend workshops and so on. Alternatively, if a department intends to implement PBL as a part of larger-scale curriculum development then opportunities must be made to allow staff to discuss the issues (see Adrian Chappell's article, for example). Whichever mode is adopted, it is possible that expertise may already lie within your institution; liaison with your local educational development unit (or equivalent) is often the best means of tapping into this.

Student training

"PBL is challenging and demands of the learners a sound understanding of knowledge that has been researched and explored and an ability to evaluate and critique information" (Chappell). This approach to learning is likely to be very new to most students and it is important that they are given guidance as to what is expected of them, explanations as to why they are learning this way and opportunities to develop the skills they might require. Michael Solem emphasises this training need in his article and mentions that his students are given opportunities to learn to work together through the introduction of "cooperative learning activities in lectures" and through Internet-based research exercises.

'Letting go'

"In most PBL type learning exercises, allowing students to pursue inappropriate avenues is allowed to a certain extent. Making mistakes and realizing these errors often reinforces the correct information" (Alexson & Kemnitz). The traditional model of teaching is one of ensuring students have the correct facts; PBL challenges this by introducing a more 'real-life' mode of learning in which one may make mistakes. It is crucial, however, that students have the opportunity to reflect on and adapt their work in order to build on successes and learn from mistakes. Honeybone et al emphasise the need to be aware of the learning process and suggests that it "starts from an understanding of how students learn".

This is likely to be a new approach for both staff and students: "students in the new system had to learn for themselves for the first time, and if they failed to take hints or advice, had to learn from their mistakes. Their discussion sessions were less structured than those I had facilitated in the past. I had to be prepared to let them make their own mistakes and recognise that different kinds of insight would flow from the much freer student centred model" (Perkins et al).

Real life

As suggested above, PBL offers a mode of learning which might be considered closer to real life. This real-life link is two fold: firstly, the projects or problems used often reflect or are based on real-life scenarios (as are most of the examples in this publication); secondly, the processes of team-working, research, data collection, critical thinking and so on are those which will be of use to the students in their further career: "for students to be active lifelong learners, they need to be able to transfer their learning skills to the situations they will subsequently meet in their working and social lives" (Honeybone et al).

Another 'real-life' aspect of learning through PBL is the realisation that there are not necessarily answers to everything and that tackling a problem requires more than rote-learning a series of facts. Again, this might challenge the 'traditional' approach to teaching with the lecturer being all-knowing and 'transferring' the facts to the students. In our jobs as geographers, earth scientists or environmental scientists it is not uncommon for us to not know some fact or another, however, we have developed the skills which allow us to find it out (be it conducting experiments, analysing data, reading journals, consulting colleagues or merely looking it up in the dictionary!). Admitting to students that we don't always know the answer can feel risky - will we lose our credibility? - but by supporting the student in finding the answer for themselves, we have the potential to provide them with valuable skills training as well as deeper, and possibly more extensive, learning.

To Summarise

The intention of this publication is to provide information on PBL, rather than to advocate it as 'the only way to teach'. However, the processes and issues involved in learning and teaching through PBL are transferable to other types of learning environment. To quote Chris Lee:

"In summary, therefore, PBL postulates that:

1) Learning through problem solving is much more effective for creating in a student's mind a body of knowledge that is useable in the future, than didactic traditional methods of learning.
2) In life / industry, problem solving skills are more important than factual memory recall alone."

Further Sources of Information

In addition to the references quoted in the articles, further sources of information and examples of practice can be found at:

- Your institution's educational development unit (or equivalent)
- LTSN-GEES PBL Enquiries: The team working with the LTSN-GEES Environmental Science Senior Advisor has considerable expertise in PBL and can offer advice and information for anyone in Geography, Earth and Environmental Sciences. Contact Marianne Hall: m.hall@herts.ac.uk
- LTSN-GEES Resource Database (contains examples of practice from Geography, Earth and Environmental Sciences) http://www.goodpractice.gees.ac.uk/
- "A Staff Resource Book to Support Earth Science Learning and Teaching in Higher Education"
  A few hard copies are available from LTSN-GEES or the handbook can be downloaded for free from the LTSN-GEES web-site: (http://www.gees.ac.uk/Resbook.pdf). This contains some examples of practice on PBL in forensic geology, geophysics and mineral exploration and exploitation.
- Hertfordshire Integrated Learning Project (HILP)
  http://www.herts.ac.uk/envstrat/HILP/
  "HILP is a multi-disciplinary consortium covering eleven subjects at the University of Hertfordshire, led by the Department of Environmental Sciences. One of the most significant facets of the HILP project is the development of Problem-Based Case Studies. The purpose of such studies is to provide students and staff with a number of situations and exercises which may be used in the design, development and support of Problem-Based Learning (PBL)."
- LTSN Generic Centre Project on Problem-based Learning
  Project details: http://www.ltsn.ac.uk/about/prob_based.asp
  PBL web-site: http://heracles.coventry.ac.uk/pbl/

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The Problem-Based Learning Landscape

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Introduction

Problem-based learning is an approach to learning that has grown in breadth and depth across the world since the 1970s, yet the bulk of the literature concentrates on practical applications of problem-based learning in particular settings rather than on the examination of the complexities and challenges involved in its application. Problem-based learning is increasingly being seen as a means of managing knowledge explosion, since curricula can no longer expand to cope with such demands. As a result students involved problem-based programmes are increasingly being equipped to 'manage knowledge' rather than being expected to have assimilated it all before entering employment.

There have been many debates about what counts as problem-based learning and how it may and may not be used in higher education. In this article I will begin by describing the background and development of problem-based learning, argue that there is a difference between problem solving learning and forms of problem-based learning and then suggest that it is possible to use problem-based learning in a variety of ways within curricula.

Background to Problem-based Learning

It is possible to trace the origins of problem-based learning right back to early forms of learning that demanded the diverse kinds of problem-solving and problem management that we can see in problem-based curricula. Socrates presented students with problems that through questioning enabled him to help them explore their assumptions, their values and the inadequacies of their proffered solutions. More recently the work of Dewey (1938) has influenced the way in which knowledge is perceived - not as something that is reliable and changeless but as something that is an activity, a process of finding out. Dewey's challenge to the world of science - that we are the very stuff and substance of the world and as such we must work from the middle of a situation in which our most reliable beliefs are at best imperfect or inadequate - is that we are not spectators, but agents of change. Dewey's perspective was thus a pragmatic stance towards knowledge. He argued that knowledge was bound up with activity and thus he opposed theories of knowledge that considered knowledge to be independent of its role in problem-solving inquiry. His views on this were played out in practice by his emphasis on learning by doing, which can be seen as essentially a problem-solving approach to learning. The fact that much of what Dewey proposed is now largely taken for granted in many areas of higher and professional education can perhaps be said to be a measure of his success.

Problem-based learning was popularised in the 1960s as a result of research by Barrows (Barrows and Tamblyn, 1980) into the reasoning abilities of medical students. Their research stemmed from a desire to develop in medical students the ability to relate the knowledge they had learned to the problems with which the patients presented something they found that few medical students could do well. Yet when Barrows and Tamblyn undertook their study, which in many ways could be said to have alerted the world of higher education to problem-based learning, they probably had little real understanding of the world-wide impact it would still be having decades late. What they highlighted were clear differences between problem-solving learning and learning in ways which used problem scenarios to encourage students to engage themselves in the learning process; problem-based learning.

Yet the attraction of problem-based learning and its uptake in the 1970s and 1980s in Canada, Australia and the Untied States, and in the late

1980s in the UK, seemed to lie not only in its timely emergence in relation to other world-wide changes in higher education, but also because of new debates about professional education. These related to a growing recognition that there needed to be not just a different view of learning and professional education, but also a different view about relationships between industry and education, between learning and society and between government and universities. Such debates continue today.

Problem-based learning or problem-solving learning: a vital distinction

There is currently confusion about the difference between problem-based learning and problem-solving learning. Problem-solving learning is the type of teaching many tutors have been using for years, where the focus is upon giving students a lecture or an article to read and then a set of questions based upon the information given. Students are expected to find the solutions to these answers and bring them to a seminar as a focus for discussion. In some curricula students are given specific training in problem-solving techniques, but in many cases they are not. The focus in this kind of learning is largely upon acquiring the answers expected by the lecturer, answers that are rooted in the information supplied in some way to the students. Thus the solutions are always linked to a specific curricula content which is seen as vital for students to cover, in order for them to be competent practitioners and/or eligible to receive an honours degree. In this kind of learning the role of the facilitator is largely focussed on examining the students' knowledge through Socratic methods. The solutions are therefore clearly bounded by the content and guided by the facilitator.

Problem-based learning is different. The focus here is in organising the curricular content around problem scenarios rather than subjects or disciplines. Students work in groups or teams to solve or manage these situations but they are not expected to acquire a predetermined series of 'right answers'. Instead, they are expected to engage with the complex situation presented to them, and decide what information they need to learn and what skills they need to gain, in order to manage the situation effectively. There are many different ways of implementing problem-based learning, but the underlying philosophies associated with it as an approach are broadly more student-centred than those underpinning problem-solving learning. This is because students are offered opportunities, through problem-based learning, to explore a wide range of information, to link the learning with their own needs as learners and are encouraged to develop independence in inquiry. Problem-based learning is thus an approach to learning that is characterised by flexibility and diversity in the sense that it can be implemented in a variety of ways in different subjects and disciplines in diverse contexts.

Using problem-based learning in various ways within curricula

There are many ways of implementing problem-based learning in curricula and what you do depends upon a number of issues.

- The organisational support for problem-based learning;
- The discipline in which you want to use it;
- The extent to which staff are prepared to implement problem-based learning;
- The provision of staff development.

1. The organisational support for problem-based learning

There is little point in attempting to implement problem-based learning wholesale across a curriculum unless you have got support for this approach to learning within the wider structure of the university. This may sound incredibly negative but without support and funding it is difficult, hard work and demoralising. Universities who provide staff with time to develop the curriculum and materials, along with monies to bring in experts to help seem, world-wide, to be much more successful that those that do not.

2. The discipline in which you want to use it

Many people have suggested that it is easier to implement problem-based learning in some disciplines rather than others. The argument is often made that it is easier to use problem-based in applied disciplines such as health and engineering. However colleagues in maths and physics say it is possible there too. Many of the arguments about the use of problem-based learning in different disciplines relates to the traditions of the discipline, ways of teaching, views about knowledge and the space available for small group work.

3. The extent to which staff are prepared to implement problem-based learning

Implementation of any innovation or change in curricula is hard work and time consuming, whether it is the introduction of Web CT, action learning, new forms of assessment or problem-based learning. To implement an innovation such as problem-based learning you need commitment from staff. This does not demand that everyone has to be a problem-based learning facilitator, but it does mean that most people have to agree to its implementation. If it is imposed on staff then they can become very effective saboteurs. Implementing problem-based learning also often feels risky because it demands a shift away from designing curricula around chunks of content. Instead, learning is centred around problem situations - lectures, labs and tutorials are value added.

4. The provision of staff development

Effective staff development is now perceived to be one of the keys to successful implementation of problem-based learning. A workshop approach, with the incremental development of cohorts of facilitators, seems to develop a sense of cohesiveness amongst the groups of facilitators and is a valuable source of support and advice for the teaching staff (Murray and Savin-Baden, 2000; Savin-Baden, 2000). The key issue seems to be one of ensuring that contentious issues are debated in an open forum and that dissent is tolerated and managed, thus avoiding the situation of two or more opposing camps expending more energy defending their own standpoint(s) than contributing to the development of the curriculum. Thus recommendations that have resulted from research and practice, are:

- Preparation of facilitators needs to start as early as possible, at least one year in advance of the commencement of the programme/ module in which problem-based learning is to be used;
- The development of trigger materials should involve all groups of staff contributing to the delivery of a particular module;
- Learning resources are vital to the success of problem-based learning and related departments need to be involved from the outset;
- Faculty support is vital to the success of introducing problem-based learning into the curriculum;
- In depth discussion of assessment methods should be a key component of any staff development programme.

In conclusion

Problem-based learning can help students to see that there are not straightforward answers to problem scenarios, but that learning and life takes place in contexts, that affect the kinds of solutions that are available and possible. Learning such as this is not just a simple method of solving problems, but it helps people to learn how to learn and to link learning with their own interests and motivations. Problem-based learning is an approach to learning that can offer students opportunities to develop independence in inquiry and the ability to contest and debate. For staff it can offer a means of responding to the problem of ever increasing pressures on curriculum content and for implementing teaching that is grounded in the world of work which can stimulate students to engage with the complexity and diversity of everyday problem situations.

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Using Problem-Based Learning to Develop Graduate Skills

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Introduction

The Hertfordshire Integrated Learning Project's [1](HILP) model for developing Graduate Skills is based on the integration of skills development with academic content using problem-based learning (PBL) as the integrative mechanism. This paper considers how, in modified form, it can be used as one of the principal means of implementing an explicit embedded approach to skills development in the curriculum. The modified form, developed to suit local conditions and requirements, is referred to as the HILP hybrid PBL model.

What is Problem-Based Learning?

PBL is an approach to learning and teaching that encourages the development and application of problem-working strategies and the acquisition of disciplinary knowledge bases and skills by placing students in the role of problem-workers[2]. The emphasis may vary between attention given to the process of problem-working to greater attention being given to the solving of the problem. Students usually work in small groups on specific problem-based exercises supported by relevant case study material and tutor expertise. The problem has to be analysed in terms of underlying principles, mechanisms or processes through group discussion and the study of relevant resources. PBL is often introduced at an early stage of the HE learning process and problems presented are appropriate to the level of study. At this early stage tutors usually need to provide a substantial amount of scaffolding and guidance. During subsequent years, problems may increase in complexity and tutor scaffolding decreases culminating in a final year project.

It has been suggested that PBL can be a very effective learning method in that it is a vehicle for stimulating academic study that enables the natural acquisition of transferable and discipline-specific skills. Through PBL activities students are expected to develop the ability to:

- identify information to understand the problem;
- identify resources to be used to gather information;
- pose questions;
- formulate and test hypotheses;
- make decisions;
- generate possible solutions;
- analyse solutions;
- present solutions/conclusions orally and/or in writing.

Students are also encouraged to engage positively in the learning process by:

- directing their own learning;
- being active, reflective and critical learners;
- thinking deeply and holistically;
- extending learning beyond the presented situation (the 'problem') into new areas whereby some transfer of skills may take place.

In other words, students are being given the opportunity of acquiring a range of skills, often with a discipline-specific slant, and to understand their importance in a wider context.

Of special relevance to HILP is the stress that much of the literature on PBL puts on the process of learning and then on its indivisibility from content. Barrows and Tamblyn (1980) for example, define problem-based learning as "the learning that results from the process of working toward the understanding or resolution of a problem. The problem is encountered first in the learning process." Margetson (1997) then develops the link with content by arguing that within the education system "content and process are like two blades of a pair of scissors. Unless the blades function together properly, they don't work". In PBL content and process are treated as an integrated whole, stimulating knowledge, understanding and skills development. The Centre for Problem-Based Learning at Illinois Mathematics and Science Academy advocates PBL because it "....simultaneously develops both problem solving strategies and disciplinary knowledge bases and skills." (IMSA, 1998). It can also be argued that PBL encourages students to achieve those higher educational objectives defined by Bloom et al. (1956) as the intellectual skills of analysing, synthesising and evaluating.

It is in the light of these arguments that HILP has adopted PBL as the key learning mechanism for integrating skills development with academic content and why learning how to learn skills (e.g. self-assessment, self-reflection) have been included in the self-management category of its Graduate Skills Menu[3].

The Development of Problem-Based Learning

Interest in implementing PBL in Higher Education (HE) curricula appears to have occurred at a time when the purpose of HE and its relationship with 'outside' worlds of business, industry and society has been challenged and changed. In her discussion on the origins of PBL, Savin-Baden (1998) maintains that "the growing popularity of PBL in the late 1970s and 1980s could be said to be aligned to a more global philosophy which recognised that there needed to be not just a different view of learning and professional education, but also a different view about relationships between industry and education, between learning and society and between government and universities."

How and where problem-based learning originally developed has been reported differently. Alavi (1995) reports that in its modern form, PBL has been a distinctive method since the 1950s, when Case Western Reserve University began developing a problem-based course in its medical faculty. However, the development of the 'medical school' model, centred on problem-based tutorials, is more often attributed to the Faculty of Health Sciences at McMaster University, Canada, around 1965 where its originators were apparently influenced by the case-study method as developed at Harvard Law School in the 1920s (Schmidt, 1993). The Harvard Medical School adopted a 'hybrid model' of PBL by integrating problem-based tutorials with traditional lectures, labs and conferences in order to accommodate a variety of learning styles (Armstrong, 1998).

PBL's stronghold has traditionally been located in medicine and both the University of Newcastle in Australia and the Rijksuniversiteit Limburt at Maastricht in the Netherlands have now developed a problem-based curriculum. More recently, however, interest has spread into areas of the health sciences such as nursing, occupational therapy, physiotherapy and social work as evidenced by the workshop sessions at the 1997 International PBL conference held at Brunel University, Middlesex. There are also more isolated cases of PBL being introduced into disciplines such as chemistry, biology, engineering and architecture, and at the University of Delaware the use of PBL is currently being expanded from science and technical courses to social science and humanities.

Changing views about the relationship between education and wider society have found expression in terms such as 'learning communities' and 'lifelong learning'. For instance, in the view of the National Committee of Inquiry into Higher Education (NCIHE, 1997) "The aim of higher education is to enable society to make progress through an understanding of itself and its world: in short, to sustain a learning society."

PBL's role in developing the learning society advocated by the NCIHE seems to be gaining increasing credibility within the British academic system. For example in the call for papers for the 4th Northumbria Assessment Conference (held at the University of Northumbria at Newcastle) , PBL was described as "a new curriculum approach designed to develop the qualities needed in the learning society" and identified those qualities as "being able to continue to learn and adapt throughout life, and being able to evaluate, synthesise and create rather than simply reproduce conventional ways of doing things."

For students to be active lifelong learners, they need to be able to transfer their learning skills to the situations they will subsequently meet in their working and social lives. This ability to transfer skills is seen as involving a meta-skill that it is particularly difficult to develop when learning takes place in narrow discipline-based contexts. However, Drinan (1991) believes that PBL can help to overcome this difficulty and assist the extension of learning to new situations.

PBL: The Philosophy

The underpinning PBL philosophy is that problems drive the learning process which starts from an understanding of how students learn (for example, learning styles and motivational factors) and gives them the responsibility of deciding what they need to know, in other words a student-centred approach. The curriculum is therefore developed from this student-centred perspective - indeed, a departure from the didactic 'transmission' model of learning and teaching where tutors provide students with knowledge. Another strand of PBL's philosophy is that learning should be a shared process and that collaborative learning between students working together in small groups facilitated by a tutor should therefore be encouraged.

There appears to be a clear relationship between PBL and current pedagogical theories. Firstly, the notion of a deep approach to learning is a concept that has gained much support over recent years. An individual who adopts a deep approach sees learning as making sense and seeks to develop an individual understanding (as opposed to the adoption of a surface approach where learning is seen as reproduction of knowledge). Drinan (1991) argues that PBL generates the desire and ability to think deeply and holistically. Gibbs includes PBL in his list of strategies for fostering a deep approach to learning - an approach he defines as "one where the student attempts to make sense of what is to be learnt, which consists of ideas and concepts. This involves thinking, seeking integration between components and between tasks, and playing with ideas" (Gibbs, 1992).

It is considered that students who adopt a deep approach to learning will show evidence of the higher levels (ie 4 and 5) of Biggs' SOLO (Structure of the Observed Learning Outcome) Taxonomy in the work they produce. PBL encourages students to perform at these higher levels. The levels of Biggs' SOLO taxonomy (Biggs and Collis, 1982) are:

- Level 1 (Prestructural): use of irrelevant information, or no meaningful response;
- Level 2 (Unistructural): answer focuses on one relevant aspect only;
- Level 3 (Multistructural): answer focuses on several relevant features, but they are not coordinated together;
- Level 4 (Relational): the several parts are integrated into a coherent whole: details are linked to conclusions, meaning is understood;
- Level 5 (Extended abstract): answer generalises the structure beyond the information given: higher order principles are used to bring in a new and broader set of issues.

Not only is PBL associated with pedagogical theories such as the deep approach, but it appears firmly rooted in an understanding of the way people learn developed by cognitive psychology. Norman and Schmidt (1992) demonstrate the positive relationship between PBL and the principles of cognitive learning in Figure 1.

The principles of cognitive learning	PBL's cognitive effects on the student
The prior knowledge people have regarding a subject is the most important determinant of the nature and amount of new information that can be processed.	Activation of prior knowledge - the initial analysis of a problem stimulates the retrieval of knowledge acquired earlier.
The availability of relevant prior knowledge is a necessary, yet not sufficient, condition for understanding and remembering new information. Prior knowledge also needs to be activated by cues in the context of which the information is being studied.	Elaboration on prior knowledge through small-group discussion, both before or after new knowledge has been acquired: active processing of new information.
Knowledge is structured. The way in which it is structured in memory makes it more or less accessible for use.	Restructuring of knowledge in order to fit the problem presented. Construction of an appropriate semantic network.
Storing information into memory and retrieving it can be greatly improved when, during learning, elaboration on the material takes place.	Learning in context. The problem serves as a scaffold for storing cues that may support retrieval of relevant knowledge when needed for similar problems.
The ability to activate knowledge in the long-term memory, and to make it available for use depends on contextual cues.	Since students will tend to see the problems presented as relevant and since they engage in an open-ended discussion, epistemic curiosity can be expected to emerge.
To be motivated to learn, prolongs the amount of study time (or processing time, to put it in cognitive psychology terms) and, hence, improves achievement.	

Figure 1:
The positive relationships between PBL and the principles of cognitive learning.

PBL: The Process

The 'medical school' model with which PBL is commonly associated demands a highly structured learning process wherein small groups of students tackle a medical problem (without first being given background information or theory) during tutorials facilitated by a tutor. The facilitating role of the tutor is a key feature of this process and clearly needs considerable practice and expertise. The 'medical school' PBL process developed by the School of Medicine, South Illinois University was demonstrated at a PBL conference held at Brunel University in September 1997 where Professor Barrows facilitated 2 problem-based tutorials with a group of students about to enter medical school. The process is included here (as an appendix) to provide a starting point and a source of ideas for tutors who are considering introducing PBL into their curriculum. However, it is not being presented as a readily transferable structure. Indeed, it can be argued that the medical school setting is not typical of the current undergraduate higher education environment and the process may need to be considerably modified according to local factors. For instance, Allen et al. (1996) suggest that students in the medical school setting have particular characteristics ie they are "intellectually mature and highly motivated, and have the opportunity to work in small groups with an assigned faculty tutor."

HILP's Hybrid Model

HILP has developed its so-called 'hybrid' model of PBL in the light of the reservations expressed in the last paragraph about the transferability of the 'medical school' model whilst still seeking to retain what are seen to be the essential features of PBL.

The more specific reasons for these modifications are related not only to the broader context of present-day higher education but also to the current curricular practices and staff dispositions at the University of Hertfordshire. These were, in part, clarified by the interviews with participating staff from the eleven disciplines of the HILP consortium that took place soon after the start of the project.

Factors identified that were thought to militate against any curriculum-wide adoption of a pure form of PBL included:

- high student: staff ratios and resulting loss of small group tutorials and seminars;
- time constraints on students (e.g. concern that students might spend time doing the wrong thing);
- time constraints on staff (e.g. insufficient time to develop case study materials);
- the changing nature of the role of the tutor;
- loss of academic content;
- mixed ability classes;
- concerns about ability of students to manage their own learning;
- an insufficient level of research skills, particularly of first and second year students;
- attitudes of professional accrediting bodies.

Whilst some of these perceptions might be queried and questions raised as to whether they are arguments against PBL, they did give an indication of the issues that needed to be addressed if an acceptable element of problem-based learning was to be introduced as one means of integrating skills development in the curriculum.

In examining these arguments, the HILP team came to the conclusion that the 'medical school' model of PBL would not be acceptable. There were insufficient resources for the small group tutorial approach and staff were hesitant about students engaging in self-directed study without any initial background information or theory.

These difficulties, however, relate more to the particular structure of PBL that has been adopted elsewhere than to the underlying philosophy. Therefore HILP sought to develop a hybrid model which modified the structure of the 'medical school' model but which was still consistent with its philosophy. In particular, the attempt was made to develop an alternative structure that was still based on the notion (as outlined above) that the learning process:

- can be driven by a problem;
- starts from an understanding of how students learn (including learning styles and motivational factors);
- should help students to take responsibility for deciding what they need to know;
- is a collaborative enterprise between students (sometimes working in groups) and staff acting as facilitators;
- gives students the opportunity to acquire a variety of skills ranging from the practical to the intellectual and from the personal to the interpersonal;
- should generate the desire and ability to think deeply and holistically and thus have the potential for extending learning beyond the presented situation (the problem) into new ones.

These ideas are consistent with the University's Learning and Teaching Strategy (University of Hertfordshire, 1999) and with its General Educational Aims (University of Hertfordshire, 2000).

HILP's alternative form of PBL, the hybrid model, has the following key features:

- problems drive the enquiry and learning process;
- students undertake a transdisciplinary problem-based case study;
- framework lectures are given at the beginning;
- tutors facilitate students' group workshops by rotating around the groups
- graduate skills to be developed are identified, made explicit[4] and skills workshops provided;
- an assignment is designed to integrate graduate skills development with academic content;
- student reflection on skills development is achieved by completion of a Graduate Skills Self-Evaluation Sheet;
- paper-based, computer-based and audiovisual resources are developed and provided for student use.

Given the intention to develop a flexible approach that can be adapted to a wide variety of disciplinary contexts, all of these features will not necessarily be present in all the applications.

One application that includes all these features is the Broadland Case Study, a transdisciplinary case study developed collaboratively with staff from Environmental Sciences, Law, Music and Business Studies during the early stages of the project then implemented during the middle stage with students from the respective disciplines.

The Broadland Case Study

As an example of the HILP hybrid PBL model in practice, the Broadland Case Study was developed in collaboration with officers from the Broads Authority in East Anglia and offered a real-life, real-time case study that has been used by four disciplinary areas (Environmental Sciences, Music, Law and Business Studies) integrating academic content with a range of graduate skills. Thus this project was aiming not only to provide a valuable educational exercise for students at the University of Hertfordshire but also to feed back to the Broads Authority ideas that might have a practical impact on the future economic and recreational development of an environmentally sensitive part of the Broadland. By working closely with staff from the Broads Authority, the HILP team have gained access to valuable resources, including scenarios for problem-based learning and the kind of rich background information which can only be derived from a 'real-world' case study.

The focus of the case study is the Upper Waveney Valley Project which has the overall aim of ensuring that the valley is developed sustainably so as to conserve and enhance the positive environmental, social and economic characteristics of the area. The project encompasses sufficient diversity to serve the subject-specific needs of a range of different disciplines, thus furthering HILP's intention of developing transdisciplinary case studies. It is in this context that students have been able to work on problems which are related to a live project and which require the application of skills identified in the Graduate Skills Menu. As an added bonus, they will have an opportunity to contribute to the success of the project.

Staff from several university departments have visited the Waveney Valley to see for themselves the problems and opportunities faced by the Broads Authority. In return, staff from the Broads Authority have visited the university to brief the University of Hertfordshire staff on the project and to help work out the details of potential teaching and learning activities. Also they have acted as expert guides and advisers when students have visited the area.

The development of this case study helped to inform our thinking about how to achieve an explicit/embedded approach to skills development within the curriculum, focusing on identification of skills, opportunities for practising them and resources needed to aid development. Through the evaluation process feedback was acquired about how students and staff felt about the way skills were explicitly addressed within the case study and whether students could articulate the conditions necessary for skills to develop.

The members of staff and students interviewed were comfortable with the attention given to skills and students, in particular, felt that such explicitness was not out of place - and even expected.

Reasons given by students for improvement in ability included:

- exposure to a new skill;
- opportunity to practise an existing skill;
- peer support and influence through teamwork.

The problem-based process and assessment structure adopted appears to have provided these opportunities but further work needs to be done to establish this more firmly. It would also be interesting to investigate the role of feedback (from peers and/or tutors) given that this was hardly mentioned as a reason for improvement

Conclusion

It is important to note that the HILP team's experience of the process of adopting the hybrid form of PBL was itself a problem-based learning event. For the curriculum developers the problem was to design a curriculum that would facilitate the integration of skills with academic content: and (as occurs frequently in PBL) within the main problem to address a number of sub-problems such as:

- incorporating PBL into an established curriculum;
- identifying a module/course that would accommodate PBL;
- identifying tutors who would collaborate on design and delivery;
- structuring the learning experience (presentation of problem, framework lectures, skills workshops, surgeries, assessment, teaching facilities); and
- designing and articulating an appropriate problem for students.

The Broadland Case Study can therefore be viewed as a problem-based learning exercise for both students and the staff, allowing students to develop the skills that are intrinsic to the PBL experience and staff to enhance their skills as reflective practitioners.

This paper has been modified, with kind permission, from Chapter 5 of "Integrating Skills Development with Academic Content in Higher Education: a guide to the work of the Hertfordshire Integrated Learning Project" produced in 2000 at the University of Hertfordshire.

End Notes

[1] HILP was funded through HEFCE's Fund for the Development of Teaching and Learning (phase 1) - see http://www.herts.ac.uk/envstrat/HILP/

[2] Although problem-based learning is the most commonly used term for the type of learning that is being discussed in this paper, it should be made clear that the emphasis in terms of learning is primarily on the process of problem identification and problem working rather than on the solution to the problem per se. Other terms, such as inquiry based learning (THES, 2000) are also in use and maybe indicate more accurately the central purpose of the learning. Also in PBL the use of the word problem can be interpreted in a wide sense to include issues and areas of interest that are not necessarily focused on a particular difficulty but where some choice between alternative courses of action or interpretation is involved.

[3] The Graduate Skills Menu was designed by the HILP project team as a tool for staff and students - it can be viewed at the project's web-site, http://www.herts.ac.uk/envstrat/HILP/gradskill/menu.htm

[4] For instance, students are provided with descriptors for the skills on which they are asked to focus, given opportunities to discuss the nature and relevance of the skills and to evaluate development through pre and post case study self-assessment and reflection. The intended outcomes are raised awareness, articulation and advancement of skills.

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Problem Based Learning: A Personal View

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In many ways the idea of Problem Based Learning asks a fundamental question in Higher Education. How do colleagues teach and how do students learn? Many students will come from a traditional 'A' Level background, but an increasing number are restarting education after a short or considerable break. The transition from school (or equivalent) to university is traumatic enough without taking away the traditional structure of lectures, tutorials, seminars and practicals / workshops that they perceive (and quite honestly their parents, school teachers perceive) to be the established norm for knowledge transference and the presentation and assimilation of factual content. Supplementary to this 'content base' we are also required to equip a modern student with a plethora of skills (core, transferable or otherwise) so that when content has been forgotten these skills can later resuscitate it, and the graduate may thus go on to further successful education or the world of work.

The missing link in this structure is that the vast majority of students have no idea how they learn anything successfully. They do it intrinsically with varying levels of success. How many, however, are personally aware of the learning process? There is undoubtedly some truth in the old adage that the more mud (knowledge) you throw at a wall the more it sticks, however, would it be a great advantage if that mud could be thrown in such a way that each throw reinforced the next before it actually hit the wall!

Problem Based Learning, therefore, is not only 'a means of managing the knowledge explosion' (Savin Baden this volume) but also a vehicle to introduce learning theory to new undergraduates and also to provide a different learning environment to those students who have not experienced PBL exercises before.

The problem-solving approach to learning is very well established in most areas of Higher and associated levels of education. What is rare, is an exercise that encourages (forces?) the student to work through a learning process (whether they know it or not) to produce an answer that is acceptable within the confines of the problem given. It follows that not all problems are solvable and there may be levels of correctness. In my experience the problems where the 'correct' answer is somewhat nebulous may increase the credibility of the tutor with the student as you have discussed several 'correct' answers and, on the bounds of probability, chosen one.

Once given the problem (or having formulated it themselves see Chappell - this volume) students will realise that although they may, as individuals, know something that pertains to the problem they do not know enough to solve it. Essential to the PBL method is that students' prior knowledge, is in itself, insufficient for them to understand it in depth. They must now decide what information they need to learn, or skills they need to gain, to manage the problem effectively and provide a solution.

The process advocated helps students to learn how to learn and offers the opportunity to develop independence in inquiry/research. The processes that the individual or group go through to achieve their problem solution have been detailed elsewhere in this volume (Honeybone et al).

It, therefore, follows that the PBL approach giving each student the responsibility for their own learning is essentially a student-centred approach. It also encourages students to work together in small groups and develop the interpersonal skills that will be so important in the management/solving of problems in post-degree times.

In the degree schemes with which I am associated, I initiate PBL at Level I (First Year) to provide a vehicle for learning strategies and at Level II (Forensic Geology) and Level III (Environmental Geology) as discrete intra-module exercises that advocate PBL principles. There is no point in waiting for institutional change as the University 'supertanker' takes a lot of slowing down let alone turning it around. My recent experience shows me that PBL does work and students who may initially resent the change in approach go on to produce some very creditable work and appreciate the faith shown in them to solve the problem posed.

To progress through the following problem in Environmental Geology generally requires several stages:

1. Clarification of terms and concepts (keywords);
2. 'Brainstorming' the nature of the problem (group or individual);
3. Assembly into problem areas (prioritisation);
4. Definition of problems/issues;
5. Formulation of learning questions;
6. Acquisition of knowledge by self-directed learning, (hours? Days?); with the setting of group/personal goals and deadlines;
7. Reporting back and solution.

In my experience the advantages and limitations are as follows:

Advantages

1. Students genuinely enjoy PBL as they learn in context in an integrated way. They generally perceive the relevance of their learning.
2. They understand why they have to learn something and can see how to apply that learning.
3. They retain the information they learn and effectively learn, how to learn.
4. They do not learn unnecessary details but concentrate on key concepts and principles.
5. Transferable skills are developed that will/should remain with them for the rest of their lives.
6. They learn how and where to find information and how to process it systematically.
7. They learn how to analyse and solve problems.
8. They learn how to work in or lead a team.

Limitations

1. Students are unprepared for this style after 'A' Levels, (crammer courses??)
2. Not all students like group work.
3. Some enjoy discussing and some do not.
4. PBL is more time consuming. Is it not more cost effective for a single member of staff to lecture to 200 students than staff to sit silently, (?) listening to the discussion of a small group?
5. Small groups need small rooms and sufficient space for private study.
6. Considerable demand for books and computers.
7. Faculty resistance (Bah Humbug!) "If I do not give them the facts, how will I be sure they get them?"
8. As students (parents) now pay £1,075 plus in tuition fees they expect to be tutored more and see observable gains. Some (especially overseas students who pay substantially more) take a dim view of being asked to tutor themselves/each other.

In summary, therefore, PBL postulates that:

1. Learning through problem solving may be much more effective than the traditional didactic methods of learning in creating in the student's mind a body of knowledge that is useable in the future.
2. In life/industry, problem-solving skills are more important than factual memory recall alone.

Over the next few pages, PBL exercise material is provided in the form of notes for both students and tutors:

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Name And Locate That 'Town' (La Muskalah)
A Problem Based Learning (PBL) Exercise In Environmental Geology

Material for Students

Introduction

Using your Problem Based Learning techniques assimilate the knowledge (information) presented and postulate the most likely geographical location and name of an historical town which was destroyed by 'natural forces' but is well known in established literature.

Keywords for discussion

Depressed faulted area?
global feature?
enclosed sea?
evaporation ponds?
phosphates?
palynological?

1 Geography

The town lay in a long depressed faulted area that is part of a large global feature that in places may be several kilometres below sea level.

Within the central depression is an enclosed sea (75 km x 15km) that has two portions, a Northern lake (circa 400m deep) and a Southern lake (< 10m deep) that shows extensive evaporation ponds for chemical production especially phosphates. These two lakes are separated by a peninsular that reduces the lake to 5km wide. Water levels in the lake at the present time are relatively high but were somewhat lower (30-40 metres) during the town's existence. Even though there was probably a high evaporation rate, palynological evidence suggests the area was relatively well forested and well watered. The area is seismically active, with the eastern boundary fault being most active over the last five thousand years.

Pull-apart basin
graben
earth movements
late Cretaceous
sinistral strike slip
Pleistocene to Recent
normal fault

2 Geology

(i) Structure. A pull-apart basin that is part of a faulted graben with a low-lying central section. Relative earth movements (earthquakes?) began in the late-Cretaceous with sinistral strike - slip faults trending NNE/SSW. Some tensional (normal) faults occur at high angles to the border faults. Within the central portion some 3-5 km of Pleistocene to Recent, sediments have accumulated in a region with a complex seismological history.

Palaeozoic?
Tertiary?
Quaternary?
volcanic plugs/flows?
escarpment?
post-graben formations?
B.P.?
strata?
rock salt?
intercalates?
detrital gravels?
Early-lower?
Late-upper?
wadiis?
flash floods?
alluvial fans?
aeolian?
fault control?
fluvial sediments?
facies associations?
water escape structures?
convolute bedding?
micritic?
radiometrically?
lacustrine?

(ii) Stratigraphy. The strata that was deposited before the subsidence of the main graben are exposed along the graben sides and consist of Palaeozoic to lower Cretaceous sandstones to the east and Cretaceous to Tertiary dolomite, limestones and marls to the west. Quaternary volcanic plugs and flows are seen along the eastern escarpment fault. Post graben formations are Pleistocene to Recent and may be seen in Data Card 1A and shows stratigraphical and climatological information over the last 100,000 years BP (Data Card 1B).

The earliest post-graben strata is in excess of 3000m of rock salt. Against the boundary faults the salt intercalates with detrital gravels and marls until the late Pleistocene. Recent (Lisan type) wadiis supply clay, silt, sand and gravels by flash floods and the alluvial fans produced are often fault controlled. Aeolian medium to fine sands often blanket the underlying fluvial sediments. Within this pile of sediments water - escape structures and convolute bedding is noted. Syn-sedimentary faults with displacements of several metres may be seen.

Beneath these facies associations is a uniformally textured micritic silt some 40m thick that underlies most of the area and is dated radiometrically as 15,000-20,000 years ago. Similar deposits lie higher in the column with similar high void ratios and high moisture contents. The area also has a history of sub-aerial and sub-lacustrine hydrocarbon seeps and has been known in the published literature as the 'Lacus Asphaltitis'. Even in this area today large floating blocks of several tonnes may be found on the surface of the lake. It also has a history of fluctuating lacustrine levels so that land may be alternatively wet or dry. Historical, geological and hydrological studies would indicate that some 2000 BC conditions were dry.

Exercise

Interpret this written information into a three dimensional diagram to show the structural stratigraphical and sedimentological data presented.

Question

Is this horizon (Data Card 1B) dated radiometrically as 15,000-20,000 years ago misnamed? If so, why?

Exercise

(a) Explain the hydrocarbon seeps.
(b) Why do water levels behave so erratically?

Richter?
Mercalli?
Earthquake magnitude?
Earthquake intensity?
Epicentre?
Thixotrophy
Liquid limit

(iii) Engineering Notes. Regional seismicity studies (see Data Card 2) show that the average earthquake in the region would be of the order of magnitude of 6.2 (Richter Scale) with a range of 5.8 to 7.5. An earthquake with a magnitude of approximately 6.5 would result in a horizontal ground acceleration of 0.2g to 0.8g for 15 km from the epicentre. The Mercalli Scale is also often used (see Data Card 4) and earthquake intensities are specified. A crude estimation of intensity of about IX equates to a ground acceleration of about 0.7g. The Eastern boundary fault is the most seismically active with a magnitude maximum of 7.5 and a range of 6-7 every 100-800 years or so. A magnitude of 4.2 was recorded in August 1993.

Unfortunately, certain types of earth materials are vulnerable to a severe loss of strength when subjected to seismic forces. It is known that shallow and saturated fluvial, deltaic and aeolian deposits of Recent origin have the greatest susceptibility (thixotropy) to liquefaction and hence ground failure and that accelerations due to seismic shock of 0.6g to 0.8g may cause the intact strengths of sediments to be exceeded especially if there is any interspersed sand laminae. This vulnerability is controlled in clay soils by:

Material finer than 0.005mm	< 15%
Liquid limit	< 35%
Water content	0.9 x liquid limit %

(After Wang 1979 reported in Harris and Beardow 1995)

Some geotechnical properties of the Sedom Clay are given in Data Card 3.

Question

Do the values seen in the following Data Card 3 conform to Wang's criteria?

The Problem

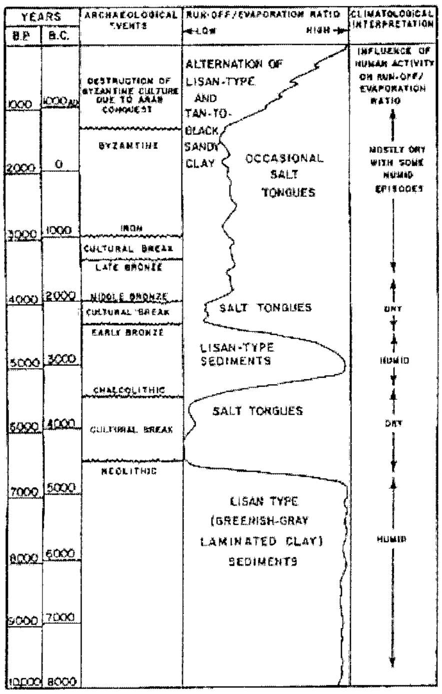
Using all the available information (given or otherwise) locate and if possible name the town. Remember you are a geological detective, all statements must be justified by evidence.

1. Argue the location of the town based on:
   (i) Freshwater resources.
   (ii) Food (fish, bread).
   (iii) Hydrocarbons.(iv) Salt.
2. Explain the mechanisms for destruction based on:
   (i) Physical destruction.
   (ii) Fire.
   (iii) Water.

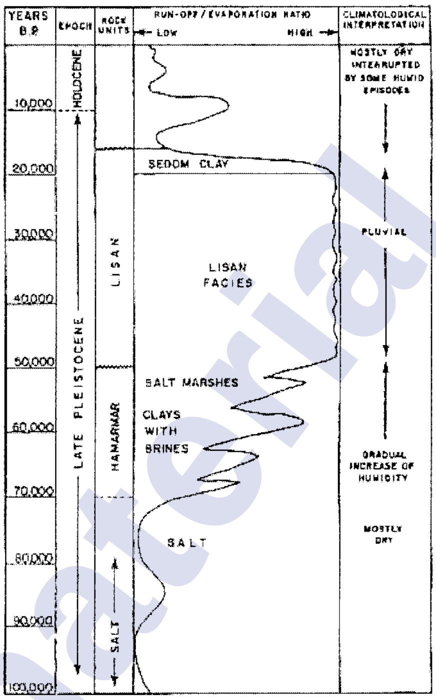
N.B. Make sure you understand the meaning and associations of the key words listed. If you don't know find out.

DATA CARDS 1A AND 1 B

A



B



Dead Sea Stratigraphy.

Adapted for this exercise after Neev & Emery, 1967 (reported in Harris & Beardow, 1995):
(a) 10, 000 years BP to present.
(b) 100, 000 years BP to present

DATA CARD 2

Year	Intensity	Magnitude	Remarks (anecdotal)
1822AD	?	?	22,000 deaths
1956 AD	?	5.8	
c.1150BC	IX-X	?	Temple destroyed
749AD	>X	?	Destruction of the Roman City
1903AD	?	5.7	
1911AD	?	6.0	
c.1450BC	>X	?	City walls tumbled
1927AD	>X	?	Widespread destruction, city rocked
31BC	>X	?	Total destruction of city
c.1900BC	>IX	>6.0 (est)	Total destruction of city
c.1500BC	>VII	?	Mountain shaken
1955AD	?	6.3	
1922AD	X	5.9	
365AD	>IX	7.0 (est)	
c.800BC	>X	?	Widespread terror
c.500BC	XI-XII	?	Mountains split
1170AD	>X	?	Towns and castles destroyed
1922AD	?	6.5	

Notes
1. Intensity in Modified Mercalli Scale units (approximate only)
2. Magnitude in Richter Scale units
3. Dates of events are best estimates only

Adapted for the exercise from Harris and Beardow, 1995.

DATA CARD 3

Geotechnical Properties of the Sedom Clay

(after Adler and Harris, 1983: Reported in Harris and Beardow, 1995)

Soil Property	Number of Tests	Range	Average Value
Graduation			
• Sand	9	1 - 37%	14%
• Silt	9	28 - 55%	42%
• Clay	9	22 - 71%	56%
• Silt and Clay	9	63 - 99%	86%
Moisture Content	29	19.2 - 43.6%	32%
Density			
• Bulk	30	1759 - 2116 kg/m3	1931 kg/m3
• Dry	30	1242 - 1775 kg/m3	1475
• Specific gravity	18	2.76 - 2.89	2.80
Atterberg Limits			
• Liquid	18	18 - 43	32
• Plastic	18	15 - 25	20
• Plasticity index	18	3 - 21	12
Undrained shear strength			
• Undisturbed (vane)	8	28 - 104 kPa	69 kPa
• Remoulded (vane)	8	12 - 54 kPa	26 kPa
• Sensitivity	8	1.9 - 4	2.6
Drained shear strength			
• Internal friction angle (total stress)	3	7 - 13º	10.5º
• Internal friction angle (effective stress)	6	26 - 37º	32.5º
• Cohesion (total stress)	3	37 - 63 kPa	49 kPa
• Cohesion (effective stress)	6	0 - 23 kPa	10 kPa
• Pore pressure parameter (A)	9	+0.06 - +0.84	0.35
• Brittleness index	9	0 - 29%	9%
Consolidation			
• Void ratio	29	0.555 - 1.250	0.9
• Compression index (Cc)	14	0.10 - 0.60	0.23
• Recompression index (Cr)	18	0.002 - 0.06	0.02
• Over-consolidation pressure	8	41 - 238 kPa	130 kPa
• Over-consolidation ratio	8	1 - 4	2
Soluble Salts	13	1.8 - 9.4%	2
Mineralogy Very fine grained calcite comprises > 90% of all samples. Additional minor phases include gypsum, detrital quartz and limestone fragments, salt and traces of clay minerals. Additional carbonate phases may also be present in minor quantities.			

DATA CARD 4(a)
Modified Mercalli intensity scale

I Not felt except by a very few under especially favourable circumstances	VII Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures.
II Felt only by a few persons at rest, especially on upper floors of buildings.	VIII Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; great in poorly built structures. (Fall of chimneys, factory stacks, columns, monuments, and other vertically oriented features).
III Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognise as an earthquake	IX Damage considerable in specially designed structures. Buildings shifted off foundations. Ground cracked conspicuously.
IV During the day felt indoors by many, outdoors by few. Sensation like heavy truck striking building.	X Some well-built wooden structures destroyed. Most masonry and frame structures destroyed with foundations. Ground badly cracked.
V Felt by nearly everyone, many awakened. Disturbances of trees, poles, and other tall objects sometimes noticed.	XI Few, if any (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground.
VI Felt by all; many frightened and run out doors. Some heavy furniture moved; few instances of fallen plaster or damaged chimneys. Damage slight.	XII Damage total. Waves seen on ground surfaces. Objects thrown upward into air.

DATA CARD 4(b)
Earthquake magnitudes and expected world incidence

Richter Magnitudes	Earthquake Effects	Estimated Number per Year
<2.5	Generally not felt, but recorded.	900,000
2.5 - 5.4	Often felt, but only minor damage detected.	30,000
5.5 - 6.0	Slight damage to structures	500
6.1 - 6.9	Can be destructive in populous regions	100
7.0 - 7.9	Major earthquakes. Inflict serious damage.	20
≥ 8.0	Great earthquakes. Produce total destruction to communities near epicentre.	One every 5-10 years

Material for Tutors

Fresh water

Channelled through wadii deposits from contiguous highlands, more saline away from escarpments. Drainage system may 'flash' after rain storms. Surface or underground storage in artificial or natural reservoirs.

Food

Fish (too saline?) from nearby enclosed sea.
Bread from grain fields (irrigated/natural).

Hydrcarbons

Seeps from organic rich source rocks (shales) intercalated into sequence by stratification of water body causing the preferential accumulation of organic matter. Maturation at shallow burial owing to high regional heat flows. Perhaps 'leaky faults' give hydrocarbon pathways and seepage was more prolific than in the past, as with lower lake levels hydrostatic pressure would be reduced. Bitumen, water-proofing, boats and as cement in stone built houses, medicinal use, fuel.

Salt

An important source of ancient wealth and chemical deposits. NaCl, salaried staff, other salts?

Destruction

(i) Physical — Earthquake shock. Ground liquification (Thixotrophy).

(ii) Fire — Volcanic action, natural seep fires, spilled fuel.

(iii) Water — Tsunami/rebound tsunamis generated perhaps by transverse faults.
Displacement landslips into lake and Thixotrophic low angle landslips from the land to the lake.

Please remember the aim of the exercise is not to necessarily produce a definitive name and location for the town but to take the students through the learning process that may help them to do so.

If they get it then great, but if not, then

Sodom!

The master reference for this exercise is:

Harris, G.M. and Beardow, A.P. (1995) *The Destruction of Sodom and Gomorrah:* A Geotechnical Perspective. *Q.J. Eng. Geol.*, 28: 349-362.

In addition a BBC2 production featuring G.M. Harris and Professor Lynne Frostick (University of Hull) was featured on the 14th August 2001 and may be of use as a post exercise feedback.

Planet

Got a Question or Query?

The LTSN Subject Centre for Geography, Earth and Environmental Sciences (GEES) is developing a register of interest database. This enables us to efficiently and effectively put individuals who approach the Centre with a learning and teaching question, in-touch with relevant experts in our disciplines. So, if you would like to know more about computer-based assessment, integrating C&IT in fieldwork, subject benchmarking, running overseas field trips etc., or if you have any other question or query, then please contact Judith Gill at the Subject Centre on: 01752 233530 or email: info@gees.ac.uk. We guarantee a response time of no more than 48 hours.

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

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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:

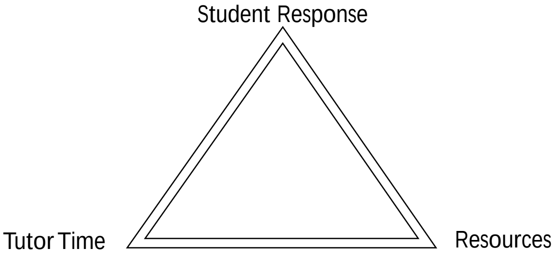

Figure 1: The "Warning Triangle"

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.

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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.

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

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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)

There are several 'How to....' books that provide useful advice on overcoming difficulties in teaching such as the 'imitation subject' (Ramsden, 1992) described above. However, much of this advice serves to resolve the symptom and not the cause of the problem, namely that conventional teaching is lecturer-focused and learning is not given its due consideration. This and other issues like it in Geography, e.g. training versus education and the role of fieldwork in teaching and learning etc. can be tackled using problem-based learning. The aim here is to: (1) describe the growing disillusion with the current convention of lecturer-focused teaching in Geography; (2) outline the use of reflective practice in identifying pertinent difficulties that inspired the investigation and development of a PBL framework to tackle some of these difficulties; (3) outline an implementation of the PBL framework in an undergraduate modular curriculum and its institutional constraints and limitations.

A growing disillusion?

The nature of higher education has changed considerably, not least because of the drive towards mass consumption. Average university class sizes in Geography have increased enormously and this has probably caused a redefinition of the relationship between lecturer and student (Mathews and Livingstone, 1996). There is said to be a growing emphasis on student-centred teaching strategies, active learning and learning as a deep rather than a surface process (Ramsden, 1992). However, Savin-Baden (1999) warned against self-directed learning, if it signalled less dialogue and collaboration amongst students. The development of more student-centred approaches may well coincide with recent understanding that student learning is more to do with what the student does and less to do with the lecturer (Shuell, 1986). The approach may hold the key to retaining fieldwork as an essential part of undergraduate Geography education (Kent et al., 1997) and to maintaining an intimacy in teaching and learning (Livingstone, 1996) under increasing pressures. With these changes in teaching strategies has come a reinterpretation of the role of the lecturer from "...authority figure, through interpreter and demonstrator to adviser and colleague" (Gold et al., 1991, p.3). Many institutions have responded more slowly to the current pressures on higher education than their lecturers. The teaching infrastructure (e.g. modular courses and lecture halls) in many Geography Departments or Schools reflect the mode of delivery by an 'authority figure' typical of 30 years ago. Assessment in some institutions has changed over the same period at an even slower rate than the infrastructure, perhaps because that convention is strongly entrenched (Holroyd, 2000). A student undertaking a degree in Geography in Departments with these characteristics is faced with a myriad of overt and latent messages from the lecturers, the institution and the context of learning. Students exposed to these situations are likely to be confused about how to organise and develop their learning because of the lack of curriculum (constructive) 'alignment' (Biggs, 1999). This confusion is likely to make students become increasingly strategic (Kneale, 1997) in their decision-making and tend toward a surface rather than a deep approach to learning.

Reflective practice to support change

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 (between February - May 2001). It was designed by the Educational Development Unit at the University as part of a Postgraduate Certificate in Teaching and Learning. Peer observation and feedback, unlike previous quality assurance assessment (QAA) frameworks, were used to promote reflection by each individual on their practice (Schön, 1983); a 'critical friend' (Biggs, 1999) was used to support the lecturer whilst challenging their own conventions on practice; learning journals (Moon, 1999) provided the intellectual space to reaffirm intuitions and increase personal awareness. This reflective process provided the support and confidence to tackle entrenched conventions on teaching and learning in the Division. Amongst the most important realisations of the process for teaching and learning in Geography at Salford were that:

- Difficulties with teaching and learning were caused by the convention (and infrastructure) of lectures and the belief that an authority figure was required to control the delivery of knowledge, and that knowledge must be acquired before it can be used.
- Students have individual requirements for their learning which depend on context (Marton and Sälsjö, 1984) which need to be accounted for in order to develop their self-motivated independence towards learning.
- Lecturers have considerable knowledge and experience that may be used to facilitate learning rather than deliver teaching.
- The alignment of the whole curriculum (learning outcomes, explicit criterion-referenced assessment etc.) is important for consistency in the context of learning and essential in maintaining deep approaches to learning (Ramsden, 1992; Biggs, 1999).

These realisations are not new, most are well-established in the literature and some of these difficulties with teaching and learning are probably prevalent in other institutions. The importance of the realisations is that they became pertinent because of the reflective practice and inspired the investigation and development of a framework to tackle some of the difficulties. The framework is problem-based learning (PBL) which is one of the best examples of student-centred learning which lends itself to constructive alignment of the curriculum.

Problem-Based Learning
Learning to learn, not learning to imitate

In problem-based learning (PBL) a problem or a series of problems form the curriculum and during the initial definition of the problem and (attempted) solution of the problem(s) is where the learning takes place. PBL challenges the conception that learning requires a pre-determined and finite body of knowledge, a series of meanings to be understood and a number of techniques to be acquired (Savin-Baden, 2000). In short, PBL is implemented in many diverse curricula in many other disciplines (Boud and Feletti, 1997) to "...help students to make sense for themselves. It is an approach to learning through which many students have been enabled to understand their own situations and frameworks so that they are able to perceive how they learn, and how they see themselves as future professionals." (Savin-Baden, 2000).

PBL is challenging and demands of the learners a sound understanding of knowledge that has been researched and explored and an ability to evaluate and critique information. It is commonly seen as a method to integrate learning across subjects and disciplines and fosters high levels of self direction and considerable practice in team working (Boud, 1985). These multi-layered studies seem to assist the student in making cognitive connections between one topic and another, facilitating later retrieval (Reynolds, 1997). It offers considerable potential as a framework for teaching and learning within the inter-disciplinary nature of Geography and for developing problem-solving skills suitable for real world situations where problems do not fall naturally into academic disciplines. PBL avoids an over-reliance on training associated with skill development and the dominance of solely knowledge-based education; an issue discussed by Geographers (cf. Marantz and Warren, 1998) and people in other disciplines (e.g. Callery, 2000). It is also an example of teaching aligned for assessment, teaching and learning activities (TLA) and learning outcomes (Biggs, 1999) which should ensure that knowledge is being acquired and key skills are being achieved to satisfy external quality assurance (Dearing, 1997: 21).

A 'growing web' of belief?

The definition of problem-based learning is important to its implementation as an educational practice and how the role of problems in learning are used to design curricula. Barrows (1986) provided a classification of PBL which is contextualised for medical education. Margetson (1998, 2000) suggested that there are two fundamentally different forms of problem-based learning (used in Medical Education) which have implications for curriculum design. One type stems from the conception that a problem is a 'convenient peg' on which acquired foundational knowledge is hung, ready to be taken off the peg later and applied in practice. Margetson (2000) suggests that this leads to "...atomistic curriculum design with learning thought of as the adding together of isolated and independent fragments". It is highly suited to the bureaucratic expediency of modularisation which promotes individualism within staff and students; it is much easier for experts to give lectures on their speciality, leaving integration and application as the students' problem to solve (Savin-Baden, 2000). The second type reflects a 'growing web' in which problems constitute knowledge, understanding and practice. This approach leads is believed to lead to holistic curriculum design with learning as an integration of knowledge, understanding and practice in increasingly larger and coherent wholes (Margetson, 2000). Savin-Baden (2000) offered a classification that is based on the way in which learners are enabled or disabled in constructing knowledge for themselves.

The following section describes a framework for the implementation of PBL that is based on my experience and reflective practice and realisations in Geography at Salford. The form of PBL, in terms of knowledge construction, probably falls within Savin-Baden's (2000) model of 'transdisciplinary learning'. The framework below attempts to create a learning environment which is student-centred (e.g. no lectures, lecture halls etc.) and in which students' define the problem/issue, design an approach to its solution and attempt the solution. It is 'reiterative' PBL (Barrows, 1986) in the sense that any of the stages may be repeated at any time in order to overcome difficulties or redefine/re-evaluate the problem; it is a 'growing web' of knowledge, skills, problem-solving and learning. Students' initial definitions of the problem/issue are constrained by the topic of the module it is currently part of. This and other difficulties in the development of the PBL framework are outlined in the conclusion.

A Framework For Problem-Based Learning In Geography

Model / concept-based learning

The PBL framework described here is the same for all levels in undergraduate courses and consequently could be readily modified to other institutions. Although structured around modules, each framework is implemented as if part of a single curriculum accounting for progression between levels. The level 1 framework is implemented for student preparation of problem-based learning; to develop the skills (e.g. team work, dialogue and critical thinking etc.) necessary to work within that context. Level 2 is implemented for exploration and to support, using the facilitator and team work the transition from 'teach me' to 'help me learn' and is designed to challenge conceptions of learning and issues in Geography. Implementation at level 3 is an attempt to promote independence and an increased emphasis is placed on team work and peer support.

Figure 1 shows the generic framework or template used for all levels. The product or outcome is the development of a model. The model or concept is expected (using learning outcomes) to be of increasing complexity at each level of study. The process of reaching the outcome is the most important aspect of the learning. In order to achieve the outcome students have to undertake all aspects of the framework (reconception, redefinition, reinvestigation and reflection) and by doing so are locked into a positive cycle of learning. These aspects are based on Kolb's (1984) theory of experiential learning and are used as a framework in other disciplines (e.g. Stice, 1987; Healey and Jenkins, 2000). Explicit assessment criteria are provided at level 1, negotiated between the facilitator and teams at level 2 and designed solely by teams at level 3. Grading of assessed work is organised in a similar manner to develop students' confidence in their own judgement and to ensure students become responsible for their learning. The students know exactly what is expected of them and how to reach their target and the reward they will receive upon reaching it. Thus, the framework is 'constructively aligned' (Biggs, 1999).

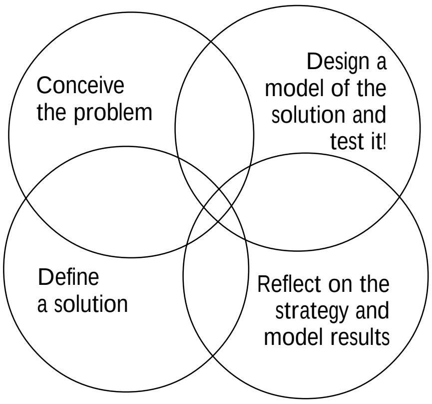

Figure 1. The reiterative process of model development that utilises Kolb's (1984) stages of experiential learning (reconception, redefinition, reinvestigation and reflection).

An example of student-centred fieldwork

An example of an implementation of this framework is provided here by the level 3 module on Dryland Geomorphology (Figure 2). The aim of the module is to use a critical appreciation of empirical approaches to (fieldwork) research and develop an understanding of the role of modelling in dryland geomorphological research. The intended learning outcomes of knowledge and understanding are:

- To utilise prior experiences of aeolian geomorphology (level 1), dryland environments (level 2) and other modules and deepen an holistic perspective to research and fieldwork;
- To develop a critical awareness of the limitations of empirical approaches to fieldwork and research in spatial and temporal process domains;
- To develop and implement a conceptual and/or practical model to better tackle fieldwork/research in dryland geomorphology.

Figure 2. Students on a level 3 Dryland Geomorphology module.

The module requires students to develop a portfolio of materials derived from classroom activities in which there appears a concept map, a statement of the problem, rationale and material from individual-led seminars. These materials are all formatively assessed by peers and moderated by staff. An additional student-defined piece of work included in and based on the portfolio materials is summatively assessed by peers and moderated by staff. A reflective commentary on the process of model development is also expected (assessed by staff) and is based on a learning journal (not assessed) that is kept during the module. The syllabus has also been designed with only few assessments because there is evidence that students become more strategic and tend toward surface learning as stress is introduced (Ramsden, 1992; Biggs, 1999). An indicative outline of the syllabus is given overleaf:

- Introduction to the module (aims and objectives, learning outcomes, assessment criteria);
- Student investigation, enquiry and refocus (of individual roles);
- Student feedback/requirements and staff re-direction negotiation;
- Focus teams - concept mapping, planning and research;
- Student feedback/requirements and/or staff contribution; team/ individual seminars;
- Focus teams - difficulties and solutions (learning journal and reflective commentary);
- Focus teams - fieldwork preparation;
- Fieldwork - testing model assumptions and/or conduct experiments to test the model;
- Focus teams - consolidation; inter-team discussions; conceptual misunderstandings;
- Focus teams - reflection and portfolio preparation.

The syllabus is based loosely on a weekly schedule which provides guidance for students but which may be be conducted (with the exception of fieldwork in a semi-arid region) in any order or even ignored depending on the student team's approach and learning styles. It is supported by a member of staff and postgraduate assistants who (at this level) are trained to facilitate teams of students working towards collective goals. Whilst the syllabus may appear to be conventional it should be noted that there is no definition of subjects or topics and these are constrained only by the module title. These are developed by the students in response to a prompt or 'trigger'. These initial triggers might be a thought-provoking image that encapsulates a variety of issues that can be tackled from several perspectives, or a scientific paper that challenges the received wisdom. The essential ingredient of a PBL approach is that the students define their own problem and develop their solution etc. and reiterate until either they are satisfied with the solution or the facilitator provides a helpful 'nudge'.

This example combines theoretical, practical and field work and tackles some of the difficulties for conducting fieldwork described in the literature (Kent et al., 1997). It shows how students may prepare more adequately for fieldwork to avoid squandering precious time (Haigh and Gold, 1993) and improve its effectiveness (Bradbeer, 1996). Fieldwork provides the arena for the integration of theoretical and practical concepts (e.g. Lonergan and Anderson, 1988) but it is also required to have an explicit and well-defined function. In the example, fieldwork is used to validate model assumptions and/or obtain data for specific model testing. The significance of fieldwork is not limited to these attributes because students are likely to return from fieldwork with a better understanding of reality and undergo reflection as a catalyst for reconception and definition of the model. This is only likely to be achieved if investigation is student-centred with the lecturers role being that of a facilitator rather than supplying facts for students. The PBL outlined above is consistent with these fieldwork requirements (Kent et al., 1997) and should encourage responsible, independent motivation to promote deep learning of the student's own choosing or style.

Conclusion

The problems are challenging the convention!

The lecturer as 'authority figure' seeks to control, under the guise of the convention, the performance during the 'show' and learning may be upstaged. The transition from lecturer to facilitator requires a separate philosophy, one in which the benefits to students of the loss of power and control are appreciated: "...the facilitator is one who assists in the student's learning, even to the extent of providing or creating the environment in which that learning may occur, but (s)he is never one who dictates the outcome of the experience." (Jarvis, 1995, p.113 in Savin-Baden, 1999). There are fundamental problems with the conventional approach to teaching and learning and the evidence appears damning: "...the widespread use of surface approaches to learning and the related fact that students may successfully complete their courses while never gaining an understanding of fundamental ideas which the teachers of those courses themselves desire their students to gain...." (Ramsden, 1992; p. 182). It is no longer acceptable to excuse lectures as efficient methods for the mass transfer of information. The most important issue is student learning and not conventional teaching. Learning might be conceived better as a growing web dependent on student experience and learning style. Learning is a difficult process and disjunction (Savin-Baden, 1999) in its various forms requires careful professional handling and the creation of an environment of trust in which students and staff may make mistakes.

The successful implementation of PBL requires a curriculum change and considerable support for staff and students. There are many papers in the literature describing the difficulties and pitfalls of the transition undertaken by faculties/schools in different disciplines (e.g. Boud and Feletti, 1997). Most transitions are deemed to be worthwhile by those who have gone through them (Toohey, 1999). It is likely that the (increased?) disharmony amongst staff and students caused by the concurrent operation within a curriculum of the conventional lecturer-focussed teaching and a student-centred problem-based learning approach is worse than that of the upheaval during transition. A fundamental change in the philosophy of teaching and learning appears to be making slow progress, but the problems are challenging the convention.

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Acknowledgements

I would like to thank those staff of the Geography Division, Salford University who contributed to the teaching observations and reflective practice for their incisive and thought-provoking discussions of many of the issues described, in particular A. Thomas for his enthusiastic support. I am grateful to the team of the EDU, Salford University, especially B. Lisewski for encouraging the reflective practice and for supporting the challenge to existing conventions in teaching and learning. Thanks are extended to A. Warren and I. Livingstone for their comments on a draft of the manuscript.

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Using Geographic Information Systems and the Internet to Support Problem-based Learning

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Abstract

This article describes an activity that integrates geographic information systems (GIS) and Internet technology to support problem-based learning (PBL) in geography and closely related disciplines. First, the article discusses the theoretical context of PBL and reviews notable PBL projects involving GIS and the Internet. Next, the article outlines step-by-step procedures for implementing the activity. In conclusion, the article recommends strategies for creating conducive, technology-rich environments for PBL in undergraduate geography courses, modules, and classrooms.

Introduction

Problem-based learning (PBL) has a long tradition in geography education, particularly in the form of inquiry. Hill (1990) developed a learning model based on Slater's (1982) ideas of teaching geography as inquiry in the social studies curriculum (Figure 1). This model uses questions as tools for planning lessons that teach new analytical and geographical skills and that address relevant social and environmental issues.

The Hill-Slater model has been applied to a variety of curriculum development projects, notably Geographic Inquiry into Global Issues (Hill 1995), and has served as a curricular resource for geography teacher education institutes in the United States. Lorsbach and Basolo, Jr., (1999) express particular enthusiasm for using inquiry as a method for teaching geographical issues, and according to some studies (e.g., Klein 1995), inquiry can enhance content knowledge, geographic skills, and cross-cultural perspectives of environmental and social issues affecting individuals, communities, and nations.

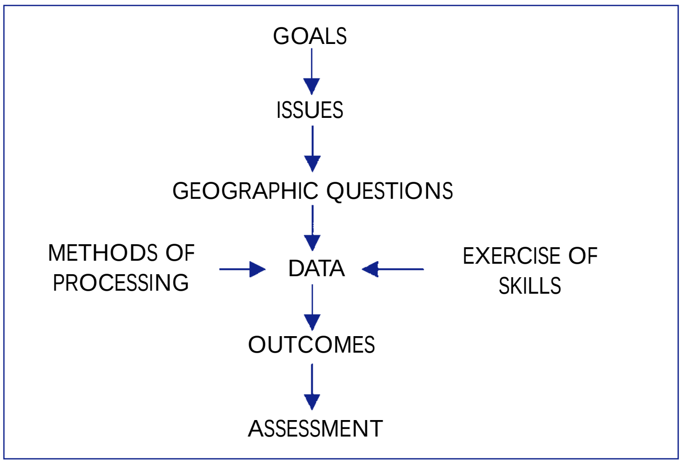

Figure 1: Slater-Hill model for issues-based geographic inquiry (Hill 1990).

As the theoretical referent for inquiry and PBL, constructivism has also emerged as a guiding theory for teaching with GIS and the Internet. Keiper (1998), for example, reports on the use of GIS to design constructivist learning projects for elementary school students. Using a simplified user-interface, the students in Keiper's case study examined and manipulated data layers to decide where to locate a new playground facility in their local neighbourhood.

One of the pioneers in on-line GIS instruction is Dr. Kenneth Foote. Foote's Geographer's Craft project, which he developed at the University of Texas at Austin, is a two-semester course that introduces students to GIS and other tools used by geographers for applied research (Foote 1997). In this course, students combine resources on the World Wide Web with GIS, GPS, remote sensing, and computer cartography techniques to solve geographical problems.

As spatial data providers increase the amount of GIS data available to the public through the Internet, so too do opportunities for integrating GIS and the Internet in geography instruction. Although PBL with the Internet is not practised extensively in geography, variations of the method seem to have caught favour among many GIS instructors in the United States. Solem (2000, 2001) analysed the content of undergraduate geography lessons on the Web and the methods adopted by geography faculty members and found that inquiry-based approaches to on-line instruction tend to be practised more frequently in geographic information science (GISci) courses. He attributes this finding to GISci faculty members' comparatively higher levels of experience with computers, educational technology, and on-line data sources.

The next section of this paper outlines an activity that applies the Hill-Slater inquiry model to support PBL with GIS and the Internet. This activity was first assigned as a term project in an introductory GIS course1 at Southwest Texas State University in the spring of 2001. This course typically enrols 48 students who meet twice weekly for a 50-minute lecture followed by a 2-hour lab (two sections) taught by a graduate student assistant.

The procedures described below can be used by instructors to guide students through the process of using GIS to plan, carry out, and evaluate a collaborative inquiry project. Specific educational objectives include:

1. Demonstrate understanding of spatial analysis and fundamental GIS knowledge and skills;
2. Work collaboratively on using GIS to solve a local geographical problem; and
3. Understand the scholarly and practical importance of Internet technology for GIS.

Activity procedures

I assign this activity approximately half-way through the semester, after covering fundamental GIS topics such as spatial data structures, data input methods, map projections, co-ordinate systems, and so forth. By that time in the course, students have gained hands-on practice with GIS in lab and are beginning to learn basic spatial analysis techniques (buffering, overlaying, spatial queries, classification, etc.), and therefore are ready to begin conceiving a practical GIS application when the activity is presented to them.

I. *Form project teams.* In the real world, much GIS work is collaborative work. Even a modest GIS project requires a lot of planning and effort, and multiple partners can bring several talents to bear on learning tasks and increase the likelihood that work will be completed in a timely, efficient manner.

Have students form a team with two or three partner(s). Point out that project grades will ultimately be a reflection of both individual and group performance (see Assessment procedures below). On occasion, individual students resist group work or fail to co-operate fully with their team members. Therefore, aim for a total of 3-4 students per group so that any given team will not be hindered by the failure of one individual to participate.

II. *Choose a topic.* Geographers study relationships among people, places, and environments and address many important issues in their work. Once students form their groups, it is time for them to choose a topic for their project. Students should be given wide latitude in choosing a topic, yet their project should in some way address an authentic issue that is geographically relevant and of significance to people living in their state, province, or local community.

III. *Pose research questions.* Having decided upon their topic and formulated a problem statement, students should work together to brainstorm geographic questions for their research. Remind students that thinking and working geographically involves examining location, place, human-environment interaction, movement, and region — five themes that are fundamental to the geographer's perspective of the world.

IV. *Acquire GIS data.* Geographers need data to test hypotheses, build theory, and answer research questions. After students settle on their research questions, they must turn to the process of collecting data for their project. Because finding data can be a very time-consuming task, I suggest that instructors provide students with links to a variety of on-line data providers where they can download free spatial data sets.2 Note, however, that on-line data files can be very large and often must be decompressed using software like WinZip or Stuffit Expander.

V. *Create a database and data dictionary.* Even modest GIS projects can involve a dizzying amount of data that can confuse novice users. Students must be taught to construct and carefully manage a database so that their spatial, attribute, and/or image data are properly referenced, accurate, and capable of being processed in a GIS. Many students find it helpful to develop a data dictionary to help them better understand and manage their data.

V. *Analyse data with GIS.* This is the step where students can apply the various spatial analysis techniques that they presumably learned in lab exercises and tutorials. Encourage students to use diverse data displays (e.g., maps, tables, and charts) to help them interpret their data. Each method of analysis should be linked to a specific research question so students not only can describe what they are doing with their data, but also can explain why their methods are necessary for resolving the problem.

VI. *Communicate results.* PBL often culminates in an authentic assessment of student knowledge and skills. After students complete their GIS analysis, evaluate their learning with two performance-based assessments: a technical report published on the Web and an oral class presentation.

VI (a) *Project Web Site.* At a minimum, the on-line project report should contain the following items:

1. Title page (title should be phrased as a geographic question)
2. Names of team members
3. Abstract (100-150 word summary of project objectives, procedures, and results)
4. Table of Contents
5. List of Tables and Figures
4. Introduction (problem statement, research questions, and overview of report's contents)
5. Background (500-word review of related GIS studies and applications)
6. Methodology (data collection, analysis, and management)
7. Results (findings and outcomes)
8. Conclusions and Recommendations (interpretation of the results and recommended solution(s) to the problem)
9. Limitations (missing data that might affect interpretation of results)
10. References

VI (b) *Oral Presentation.* Once groups complete their Web site, have them prepare a 10-minute classroom presentation in which they discuss the general problem under study and explain how they used GIS to address the problem. At a minimum, the oral presentation should:

- Introduce the topic and purpose of the project;
- Develop the project's background by summarising the relevant literature, with some details;
- Explain how and why data were collected and managed;
- Present the results of the GIS analysis;
- State the conclusions and recommendations; and
- Allow 1-2 minutes for questions from the audience.

VII. *Assessment*. Assign grades based on your evaluation of students' knowledge and understanding of GIS, their ability to work collaboratively in a team, and the extent to which their project addresses a relevant issue from a geographic perspective. Both group and individual effort can factor into the assessment, as follows:

VII (a) *Personal Evaluation*. Have each team member submit a 1-page typed statement describing his or her individual contribution to each component of the project — GIS lab work, project Web site, and the oral presentation.

VII (b) *Team Member Evaluation*. In addition, each team member can complete the following scales for each of their partners. A brief written evaluation may be included with each scale.

I would rate [team member's name] contribution to the GIS lab work as a(n):

A	B	C	D	F

I would rate [team member's name] contribution to the project Web site as a(n):

A	B	C	D	F

I would rate [team member's name] contribution to the oral presentation as a(n):

A	B	C	D	F

Conclusions and Recommendations

The activity outlined in this paper is a challenging task for both students and instructors. PBL involves a complement of intellectual, social, and practical skills, many of which are new or underdeveloped among undergraduate students. Moreover, the activity requires a considerable amount of planning, facilitation, and mentoring by the instructor. The following strategies were found to be crucial factors in successfully preparing students for undertaking the task of GIS-based collaborative inquiry:

1. *Build a co-operative and constructivist learning environment*. Many students are unaccustomed to PBL and working on tasks with classmates as equal partners. Because the GIS activity requires students to work collaboratively, exercise critical thinking, and apply new geographic concepts, students should be given ample opportunity to exercise and refine these skills. With this in mind, I weave co-operative learning activities into every 50-minute lecture period to reinforce fundamental GIS and geographic concepts. These activities are designed to complement the key components of the Hill-Slater inquiry model and include role-plays, simulations, library research, computer and Internet exercises, and small-group discussions.

2. *Familiarise students with working and communicating on-line*. One of the main learning objectives of the GIS activity is to improve communication and research skills with the Internet. Although many students are familiar with e-mail and the World Wide Web, relatively few know how to communicate effectively with hypermedia, and fewer still understand how to search for and retrieve spatial data the Web. Early in the semester, I assign a series of activities to train students in the basics of Web page construction, exploring on-line databases, and importing digital data into ArcView GIS, so that they are proficient in these technical skills by the time the GIS activity is assigned.

3. *Schedule office consultations*. About one-month before the project due-date, I dedicate a week of lecture time for groups to consult individually with me on their projects. The purpose of these consultations is to ensure that groups make timely progress toward completion of the project, and also to define further my constructivist role as a facilitator and collaborator of learning. I stipulate that all group members be present for the meeting and prepared to discuss their proposed topic, research questions, methodology, and work plan.

4. *Provide students with adequate laboratory time*. This GIS activity requires several hours of additional lab work beyond regularly scheduled lab periods, and therefore access to labs was a very important consideration. Accordingly, I schedule open lab periods during the final two weeks of the course and arrange for labs to be kept open after-hours.

It is questionable whether this activity could be successfully implemented in a larger course or in a course lacking staff assistance. Although some readers might doubt the feasibility of teaching this activity in an introductory course, the overall quality of student work affirmed my belief that with foresight, technical support, and purposive instruction, students can achieve the tasks set forth in the activity with creativity, skill, and enthusiasm.

The author invites readers to contact him with comments, questions, and suggestions for improving this activity.

Notes

1. Course materials, lesson plans, links to student GIS projects, and other learning resources are available on-line at: http://courseinfo.mediasrv.swt.edu/courses/GEO2426/.

2. In the United States, many local, state, and federal government agencies offer free spatial data ready to be imported into a GIS. The provision of free or inexpensive spatial data over the Internet may not be extensively practised in other countries, in which case instructors will need to supply local data or explore alternative sources and data entry procedures.

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The World Bank Scenario - A Problem-Based Learning Activity in Human Geography and Environmental Science

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Abstract

Problem-Based Learning (PBL) is a powerful and exciting form of small-group, self-directed, and self-assessed learning that can be used in virtually any discipline. This case study details the use of the World Bank as the scenario for a PBL lesson that has been developed for use in Human Geography and Environmental Science and could be adapted for use in many other sub-disciplines. The lesson requires multiple class periods and work outside of the classroom for acquisition of critical knowledge and development of team participation skills to address a real world issue.

Introduction to Context

The World Bank provides the perfect scenario for a Problem-Based Learning Activity that has been adapted for use in both Human Geography and Biology Environmental Science courses. As required by PBL, rather than traditional problem solving, the lesson requires acquisition of critical knowledge, problem solving proficiency, self-directed learning strategies, and team participation skills.

The problem initially posed to the student is to choose a country that would be best suited for funding by the World Bank. In Human Geography this PBL is part of a lesson on the topic of politics as integrated with economic spatial activities and in the Environmental Science course the PBL is integrated with studies of economic development and sustainability.

In each course the students are preliminarily challenged with the problem of choosing the most appropriate country to receive a World Bank loan. The students must learn about the World Bank and its operations and generate a list of questions that should be asked of the country. Once the list of questions is generated, the students use the CIA Fact book and other student-identified resources to learn about countries and ultimately choose one country that best fits the list of questions generated.

Once a country is chosen by the individual student, classroom groups are formed representing the Project Research Division of the World Bank and each student has an opportunity to put forth his/her rationale for country choice. Each student defends his/her choice of questions and argues the strength and potential success of his/her chosen country. The team must work together, however, to ultimately narrow the individual choices down to one country. That country, along with supporting documents that defend and support the group choice, is presented to the other groups in the class and to the instructor in the form of a written report.

The problem drives the learning in both class settings and the student must learn new knowledge before they can address the problem. The role of the facilitator/instructor is to set the preliminary agenda for learning sessions and to ensure student information is accurate. What differs in the Geography as against the Environmental Science problem is the spatially-oriented criteria for selection of the most promising country. This lesson could be modified and adapted for use in any geography, environmental science, or related course at both the secondary and university-level.

Goals and Objectives

1) To identify the role of the World Bank in economic development;
2) To understand the spatial relationship between economics, politics, and the natural environment;
3) To assess criteria related to economic viability, infrastructure, and their relationship to sustainability in developing nations;
4) To identify thought processes and criteria used in distribution of World Bank monies.

Student Learning Processes

1) Identification of relevant resources and information;
2) Development of criteria based on new information;
3) Justification of loan question criteria;
4) Group consensus and group building;
5) Critical thinking;
6) Decision making process.

Lesson Sample

The World Bank is an internationally run financial organisation that attempts to stimulate the economic progress of less-developed countries. The intent is to use wealth from the developed countries to provide monetary assistance to developing but impoverished countries. The capital, in theory, allows countries to develop the infrastructure necessary for more rapid economic development (railroads, roads, port facilities, funds for agriculture, industrial development and so on). The Bank charges minimal interest and requires that: (1) the money must be used for economic improvement, (2) the money is loaned only for specific projects, (3) the beliefs, politics, alliances, and/or degree of internal liberty of a country should not be factors in the lending decision, and (4) the country should be relatively stable.

Scenario

It is the first week of work for a newly formed group of aides to the Project Research Division. You are to provide insight on the decision making process of lending money to a developing state.

Figure 1. Working through the PBL exercise

Assignment

Part One. Your first task as a member of the team is to individually generate a set of questions that you believe may be important for the World Bank to consider in evaluating the stability of a newly independent country prior to lending money. Using the terms associated with the reading and lecture for this section, list the questions that you believe should be considered, keeping in mind that your questions should reflect issues related to economic development, stability, and long-term improvement of the countries' sustainable infrastructure. You should generate a list of ten questions that you believe are the most important from a spatial perspective. In parenthesis after each question, justify why this question is valid and important in loan consideration.

Part Two. To further apply critical appraisal, go to the CIA Fact book online and locate a developing country that you believe would be a good risk for the World Bank based on the questions for part one that you deemed important. To what country would you recommend a loan? Why? What specific attributes does the country possess that may make it worthy of consideration? This part should be a written statement, explanation, and summary of the country you deem the best risk for the World Bank. This preliminary written report along with your questions must be provided to your fellow team members prior to your first group meeting.

Part Three. The group must develop a list of ten questions from the individual lists you have made for lending criteria. Again justify each question and describe any resources used in making your list (textbook, internet, journals etc.). The group must decide to which country a loan will be given. A consensus (at least 2/3 majority) must be achieved and a justification for the loan should be written. To accomplish these tasks you must each take on an additional role new role: (1) chair- runs the group, sets the agenda, and co-ordinates communication outside class, (2) recorder- takes minutes of the meeting, (3) archivist- tracks down and provides reference materials and keeps records of such, (4) writer- responsible for drafting final report, (5) editor- responsible for editing final draft, and (6) group co-ordinator- provides assistance in all areas.

You are to hand in both your individual and group work in written form. In addition each group will present findings and recommendations to the rest of the class. One half of your grade will be based on your individual efforts and one half on your group work. In addition, groups will convene for a final meeting after listening to oral presentations to reflect and assess learning from this PBL. A brief written assessment summary must be submitted to the instructor/facilitator.

Thoughts and Reflections

The problem used in this scenario requires some initial discussion of the concepts of economic development, sustainability, and economic spatial activities. Typically one class period is devoted to providing background information to the students and to describing the process to be undertaken. Individual criteria-question development and country choice is completed outside of class. A second class period is devoted to forming groups and the discussion of individual findings. Groups are encouraged to meet outside of formal class meeting times so that by the third class period final discussions result and conclusions can be generated so that final reports may be presented.

The role of the instructor as the facilitator is to provide the background information necessary related to the broader scope of the problem, to answer questions, and guide the students toward appropriate resources. In most PBL type learning activities, allowing students to pursue inappropriate avenues is allowed to a certain extent. Making mistakes, and realizing these errors often reinforces the correct information. Additionally, personal biases often are exposed in group discussions, therefore the facilitator must encourage students to stay on track with the task. Typically, group sizes are kept small (no more than 6 students) in order to facilitate discussion and the group process. A tutor/teacher for each group was not possible for the authors because of lack of personnel resources.

The student response to this activity has been positive. Some students who are less familiar with PBL initially think they are being given social time. This is easily dispelled when the student realises the task being asked of them is not as simple as it first seems and does have real-life implications. Although most PBL poses the problem before learning begins, we have found our modification, presented here, tends to motivate the students just as well.

Facilitation of the process is encouraged by a fairly critical first review of the initial questions posed by students. It is crucial to make the students justify their questions and thought processes. This is enhanced in the student group setting through peer pressure and a desire on the students' part to not seem ignorant in front of their peers. Student response to the PBL scenario has been invigorating in that the students see the real world ramifications of the problem and very often go beyond what is initially asked of them. They take ownership of the problem very quickly. It is also apparent that increased student interest level instils a greater retention of formal didactic pedagogy that typically follows the PBL activity.

Unfortunately, the activity can be time consuming and can take on a life of its own as students raise questions that lead to more questions. It is important for the facilitator to keep the students focused and on track. Assessment of the PBL is, of course, subjective. Criteria for assessment include addressing how well the students approached the goals and objectives. Students participating in PBL did not score any higher on standard tests but their self-reported interest level and confidence definitely improved.

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Fieldwork and Problem-based Learning

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Abstract

For the last two years a second year overseas residential field course run by the School of Geography in the University of Manchester has been restructured into a Problem-based Learning format. This paper reports on the reasons for change, describes the structures and learning outcomes underpinning the PBL-based field experience and also addresses problems of implementing such a course. It is concluded that the potential of a student-centred and group-based approach to fieldwork can be realised if PBL is adopted as an organising framework for the whole learning experience.

Setting the scene

The School of Geography in the University of Manchester runs compulsory residential overseas field classes for all single and joint honours Geography students. Courses are not tied to other second year course units, but are increasingly designed to complement research methods classes, offering a range of field experiences relevant to, and supportive of, undergraduate dissertation research. Students choose the field location from a range of five or six options; the content of courses varies according to the research interests of staff and the local context. The learning outcomes and style of different field courses vary, but common assessment across the whole field experience was introduced in 2001. This paper focuses upon the Normandy course, and upon our implementation of Problem-based Learning in the field.

The Normandy field course was set up eight years ago, and has focused in the main upon themes related to heritage interpretation, commemoration and the links between form and process in landscape studies. The field course is based in a largely rural, intensively farmed region between Bayeux and Caen. The chateau hotel at which we stay provides some room for student presentations, but offers only limited facilities for laboratory analysis of field data. The course has changed year-on year, in an organic process that has seen us move progressively towards a greater emphasis on reflective and critical skills, learning rather than teaching, and group work. 'Project days' have always been an element of the course, and until 1999 involved field research by groups of up to ten students, supported by active staff direction in the field and afterwards. Outcomes of this work were assessed by completion of field diaries and an individual student project 'write up'. Prior to the course a series of briefing lectures had been held, largely staff-led, but with some student presentation.

Meanwhile across disciplinary divides enthusiastic curricular reform was taking place to implement PBL and the literature stressed obvious benefits reported elsewhere in this special issue (see Boud and Feletti, 1997). In our own University PBL has been implemented in fields as diverse as the medical school and across the humanities (Barnett, O'Connell and Higham, 2000).

Field work in geography has generally evolved away from the 'Cooks Tour' model towards an implicitly more student centred and problem solving approach (Higgett, 1996). Problem-based approaches to fieldwork have been implemented, (Bradbeer, 1996; Kneale, 1996), but despite widespread acceptance of the need for student centred deep learning experiences in the field (e.g. Kent et al, 1997; Livingstone, et al. 1998), there appear to be relatively few approaches to field work that involve an active definition of the nature of a field problem and the explicit incorporation of a PBL framework.

Implementing PBL

PBL seemed to us to offer a useful framework for our Normandy field course but to implement it in the field we needed to take on board a number of key philosophical changes:

- The field experience had to became part of a learning process that started once a student been accepted to go on the Normandy course, and was organised around a number of problems soluble only through active engagement with the local environment. The field trip shifted into a field course.
- This experience had to be as much as possible under the control of groups of students rather than dictated by teaching staff. Students had to became responsible for the operation and planning of their own learning.
- Individual student responsibilities had to be very clearly defined.
- Staff roles had to shift from lecturing and leading, to facilitating, organising structures and monitoring performance.
- There had to be a much greater emphasis upon processes of learning, rather than outcomes.

To realise these goals we adopted the 'Seven Jump Maastricht' model of PBL and adapted it in a pragmatic way to meet the particular needs in Manchester and Normandy. 16 timetabled contact hours were available prior to the field course, eight of which had in the past been used to brief students, largely in a lecture format. The focus of these sessions was completely changed.

- Students were allocated to learning groups in the very first session, which concentrated upon the philosophies of PBL, and on group discussion of tactics involved in the resolution of research problems. The rules of the game were made clear and students discussed their own responsibilities. Basic introductions were made to the nature of the area and to the transport facilities available to students during field research (mountain bikes, coach and staff-driven car).
- Each of the next four weeks focused upon setting up a research problem and devising group strategies for field investigation. Staff set up the problem with a brief lecture, and defined relevant resources in a handout. Each group of students nominated a Chair and Scribe to lead on different problems and identified responsibilities. During the subsequent week each group had to research possible solutions to the field problem. In the first half of each following timetabled session, groups reported back to the field course as a whole, and sought advice from staff on strategies, including discussion with technical staff about the feasibility of using appropriate field kit. Students self-evaluated their progress on a weekly basis.
- After four weeks of preparation the next two weeks focused on in depth oral presentations. Each group was required to lead on one of the research problems. Students led a discussion on the feasibility of strategies and issues raised in the presentations. Other groups used this to inform their own field strategies.
- A final week was used to ensure written field strategies had been completed, and to clarify the implications of PBL for field learning.

In the field in Normandy groups rotated between research problems and implemented their own strategy. Individuals completed a daily reflective diary, in which they commented upon the research process and outcomes. Staff offered feedback on these diaries on a daily basis. Evenings were used for each group of students to present results to staff.

After the field course groups of two or three students completed a research problem write up, in which their field results were discussed in relation to the wider research context and in relation to their chosen strategy. Individuals also completed more synoptic field diaries, drawing together themes from different problems.

Field course assessment reflected the Problem-based Learning emphasis upon process, with elements based on learning before, during and after the field course. Preparation sessions were monitored through evaluation of individual diaries and group field strategies. In the field individual reflective diaries and evening presentations contributed to a further mark. The final 60% of the unit assessment derived from group write ups.

Benefits from the changed system

- In the past attendance at briefing sessions (timetabled at 9am) had been at best sporadic. Ownership of problems and peer pressure significantly improved the motivation of students to attend.
- Students knew much more about the field context than was ever the case in the past. All of the field research problems required students to plan the logistics of their own field work, transport, timings, appropriate field equipment, risk assessments, and individual responsibilities for different parts of the work. Maps and guidebooks were heavily used. Students were more aware of how to use field equipment, having already liaised with technical staff in the preparation sessions.
- By the time of the field course students had read much more widely and knew much more about the research problem, than had been the case in previous years. This allowed them to benefit much more from the field experience itself.
- Students were able to concentrate upon their own interests and to take the lead on problems most relevant to their dissertation topics.
- Group work allowed skills to be shared, and new skills learnt from peers with different backgrounds.
- Staff time was freed up for more effective teaching.

Problems and potential

'Letting go' has been seen as a problem with PBL. My research problem on military cemetery landscapes and how they might be interpreted in relation to nationality had worked well for the past five years. I knew what worked. Student groups in the new system had to learn for themselves for the first time, and if they failed to take hints or advice, had to learn from their mistakes. Their discussion sessions were less structured than those I had facilitated in the past. I had to be prepared to let them make their own mistakes, and recognise that different kinds of insight would flow from the much freer student centred model.

Hard science has been seen as challenging for PBL. Many staff might see more technical or theoretically difficult areas as less appropriate for student-led learning. However, linking resource provision to appropriate staff advice worked this year in water chemistry and biological monitoring research problems. More abstract concepts are in our experience harder to learn and apply: staff need to offer more feedback on field strategies in order to encourage 'critical' responses to problems.

Group dynamics are always going to be a problem with PBL. Students increasingly have to juggle academic and work commitments and finding times when all of a group can meet to plan preparation can be difficult. Equal participation in the field and group work is always also going to be problematic. This year in Normandy we had one group that was significantly weaker than all of the others - more students in this group were less motivated and one was clearly not prepared to put in any effort at all. In the past he might have got away with this and simply completed summative assessments. The changed focus onto problem-oriented group work, however, created much more pressure for him to pull his weight in the field and drew attention to the difficulty. Groups have to be given the opportunity to blow the whistle on those who do not wish to learn.

Provision of resources needs to be more carefully co-ordinated than in conventional fieldwork. Student groups may not always tell staff what they really need in the field - we had to anticipate greater demand than had been planned for in some field strategies. It was very helpful to have a technician available on this year's Normandy field course to deal with technical problems arising from student decisions about use of equipment.

Local knowledge is essential for successful problem definition. It would be difficult to set up a new field area using a Problem-based approach, without background knowledge derived from a reconnaissance. New staff will face greater difficulties than on more conventional courses.

Conclusion

Problem-based fieldwork in Normandy offers significant advantages. Student evaluations suggest that they see much more explicitly the links between their field experience and skills needed for their own research or dissertations. Students are much more engaged; more are prepared to take on responsibility and control their own learning. We need to devote more time to preparation sessions and to refine staff consultancy roles. A more explicit recommendation to students about their use of time in the field would help them use our skills in future years. An anecdotal ending however, perhaps best illustrates the value of PBL. During the 2001 field course a significant gastro-enteritic viral infection disabled two thirds of the field party (staff and students) for at least two days. A more conventional model of fieldwork would have been impossible to deliver. In contrast in 2001 fit students simply got on with their own research problems on behalf of their groups, and a disastrous field experience was mitigated.

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