PROBLEM BASED LEARNING (PBL)

WHY PBL? HOW IT WORKS AND WHAT IT ACHIEVES

Why PBL?

It is now widely recognised that the transmission model of learning (as practised in universities through the traditional didactic procedure of teaching by lectures) suffers from a number of drawbacks. Memorising knowledge and reproducing it on demand does not develop a student's reasoning skills or their ability to solve problems in new contexts. In order to do this, students need to be actively engaged in working with new concepts and techniques so that they can make sense of them and relate them to what they already know.

One way in which this can be achieved is through the use of a method known as Problem Based Learning, or PBL for short. With this technique real-world problems or case studies are used as the stimulus and focus for student activity. Instead of starting with the exposition of disciplinary knowledge (as in lectures, for example) a PBL course begins by confronting students with a problem. Working in small groups of typically eight to ten in number, students have to decide what knowledge they need in order to solve a particular problem and then set about acquiring that knowledge.

PBL is not new – it has been used fairly widely (and very successfully) in other vocational disciplines such as medicine and law for a number of years. In the case of engineering, however, the use of PBL is relatively rare and has been mostly confined to individual modules that are the responsibility of enthusiastic and far-sighted members of staff. One of the primary reasons for believing that PBL should be used more extensively in engineering degree programmes comes from the comments that employers make about the quality of engineering graduates. Here is a selection of the views expressed by industrialists in a survey carried out by the IEE:

- *"Graduates do not know how to apply knowledge."*
- *"The ability to relate to engineering principles is important – not learning by rote."*
- *"More basic practical skills [are required] … not just academic theory."*
- *"[We] want to see deeper understanding; practical application of academic science and technology."*

Although employers are generally happy with the specific engineering content of existing degree courses most of them are seeking graduates with what are variously described as transferable, core or key skills. They would like the acquisition of these skills to be embedded in degree courses, and this is precisely what can be achieved with PBL.

There is sometimes confusion over the use of the term ‘Problem Based Learning’. There are those who claim that they have been setting problems for students to solve in examples classes for years, and that this is the same as PBL. But the sort of problems that are used in this situation usually tend to be rather contrived and artificial and may not reflect what happens in the real world. McQuaid has observed[1]:

> *“… an ability to explain one’s judgements is an increasingly important competence for engineers and a structure for doing so should be part of the curriculum. The medical and legal professions realise this since they deal with problems with no ‘right’ answers and weight of evidence, balance of probability etc. figure strongly in their decisions. Engineering teaching is based far too much on problems with ‘right’ answers and assessment based on the student getting the ‘right’ answer. The poor student is brought rapidly down to earth after graduation when he or she finds that real problems are characterised by insufficient information so that judgements have to be exercised. Development of that judgement then takes an unnecessarily long time in career terms since it is not supported by any educational foundation.”*

It is important to realise that in a PBL course the problems are the main vehicle for student learning whereas in a traditional course they are designed to consolidate the knowledge that students acquire through attending lectures. Unfortunately an overwhelming body of research shows that students do not learn effectively from lectures, and testimony from the field corroborates this view.

Again, it is sometimes claimed that Problem Based Learning is the same thing as Project Based Learning, although the two should not be confused. <u>Projects</u> are designed to reinforce what has already been taught and demonstrate the relevance of knowledge already acquired. In Problem Based Learning, <u>Problems</u> are set before the knowledge has been acquired and cause the students to acquire the knowledge they need to complete the task.

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[1] McQuaid, J., “Output Standards and Professional Body Accreditation”, Report of the Engineering Professors’ Council Professional Bodies Working Group, EPC Engineering Graduate Output Standard, 2001.

How PBL Works.

Students tackle a new problem in each of the 24 non-examination weeks of the academic year. Each problem is self-contained and is designed to enable the students to achieve a specified set of learning objectives. The portfolio of problems that comprise a particular programme of study is carefully created so that students will accomplish all of the desired learning objectives for the programme in question.

The class is divided into groups of between 8 and 10 students and it is normal for the groups to stay together for a semester, after which remixing occurs. Students will typically spend about 15 hours on each problem, including the formal weekly PBL session which takes about 2 hours. Each formal session follows the same pattern.

1. One of the students is appointed to chair the proceedings and another acts as the scribe. These roles are changed for each problem. The students run the meeting. A Facilitator, who is a member of staff, is present.

2. The first part of the meeting debriefs the problem set the previous week. The second part is briefing for the new problem.

3. The briefing element starts with the students being given a written scenario. This could be something along the following lines:

   > “A radar engineer is designing an airborne radar system to detect small boats. The radar operates at X-band and uses an electronically scanned phased array antenna with an area of 1 sq m. The calculations show that a Swerling 1 target of radar cross section (RCS) 10 sq m should be detectable at a range of 100km, with a probability of detection of 95% and a false alarm rate of 1:10,000, in a sea state 4. However, in practice, it is found that the detection performance is not achieved. It is suspected that the problem is that the model assumed for the statistics of the radar clutter is incorrect. The calculations are repeated using a K-distribution model instead of a Rayleigh distribution. A Constant False Alarm Rate (CFAR) processor is designed, which gives the desired performance.”

4. The Chairman reads out the problem and the group identifies the significant words and phrases it contains which need to be understood. A whiteboard or a flipchart is provided to help the process. The group then turns to the issues raised in the problem. A degree of understanding will emerge, but additional goals will be identified. The group is setting its own learning objectives. The Facilitator is present to ensure the group remains focused, that there is broad agreement among the group and that, generally, the correct set of learning goals has been identified. The Facilitator will not necessarily be expert in the subject matter and, for this reason, is provided with a confidential document, prepared by the problem

writer at the time the problem was drawn up, showing all the issues the students are expected to identify. It is not the role of the Facilitator to lead. Those who fall into the trap are headed off by the students themselves. The Facilitators are trained to assist the students with well-directed questions, most of which will have been rehearsed during the facilitators' briefing session before the group meeting.

5. The students then leave the meeting. A set of learning resources is available to them. These have been written, or assessed, by the problem writer as part of the problem writing process. The students decide what resources they require, e.g. laboratory facilities, library back-up and computing access. Tutors are available to help with their identified learning needs.

6. In the first part of the group session the following week, the group presents the results of its findings followed by a critique. Normally, this is a single group activity but, on occasions, it will be an open forum with two or more groups. These multi-group sessions can become 'robust'.

It is not only the students who go through a learning experience. It is by no means uncommon for the academic staff (the Facilitators) to find that their knowledge also expands.

The PBL sessions are supplemented by 'special resource sessions' which may include lectures, practical sessions or field trips. Some subjects such as mathematics are likely to continue being taught by means of lectures, although these will have to be restructured, and the lecture timetabling reviewed, to provide the information in sections and at times when the students will appreciate its relevance.

What PBL Achieves

So far the information about the quality of those graduating from PBL courses, as compared with conventional courses, is limited. What is available suggests that:

- PBL graduates have deeper understanding of their subject and better long-term recall of the knowledge they acquire. Graduates from conventional courses may cover a wider range of topics, but their ability to recall this information is likely to be short term;

- Students are engaged in an active learning process – they discover knowledge in the context of problems that they are likely to encounter in the real world;

- PBL is an integrated, holistic approach to learning that helps students to appreciate how the different threads of a subject are related to one another;

- The development of key skills such as group working, problem solving, critical reasoning, effective communication etc. is inherent in the way that PBL works;

- PBL forms a solid foundation for lifelong learning.

Appendix 1 explains the difference between active and passive learning and between deep and surface learning. PBL is an active learning method that leads to deep learning.

It is proposed that a full-scale evaluation of problem-based learning should be carried out. This will provide valuable new evidence on the relative merits of those graduating from PBL and conventional courses.

Further Reading

This document (and other supporting documents) have been produced using a large amount of published and unpublished material, together with information gathered in discussions with those currently using, or considering, PBL. Hence, a list of specific references is not appropriate. However, the following material could be of interest and use. Copies of the individual documents are available through the IEE on request.

1. Not Just a Method But a Way of Learning. Charles E Engel, (London School of Hygiene and Tropical Medicine), in "The Challenge of Problem-Based Learning", Boud, D. and Feletti, G. (Eds), Kogan Page, London (1991).

2. From a Traditional to a Problem-based Curriculum - Estimating Staff Time and Resources, A J Sefton (Faculty of Medicine, University of Sydney, Australia), Education for Health, Vol. 10, No. 2, (1997).

3. Course Outline and Objectives for the Undergraduate Degree Programme, Faculty of Medicine, Dentistry and Nursing, University of Manchester, (1998 - 1999).

4. Problem-based Learning: helping your students gain the most from PBL - Instructors Guide, Donald R. Woods, (1996) (ISBN 0-9698725-0-X).

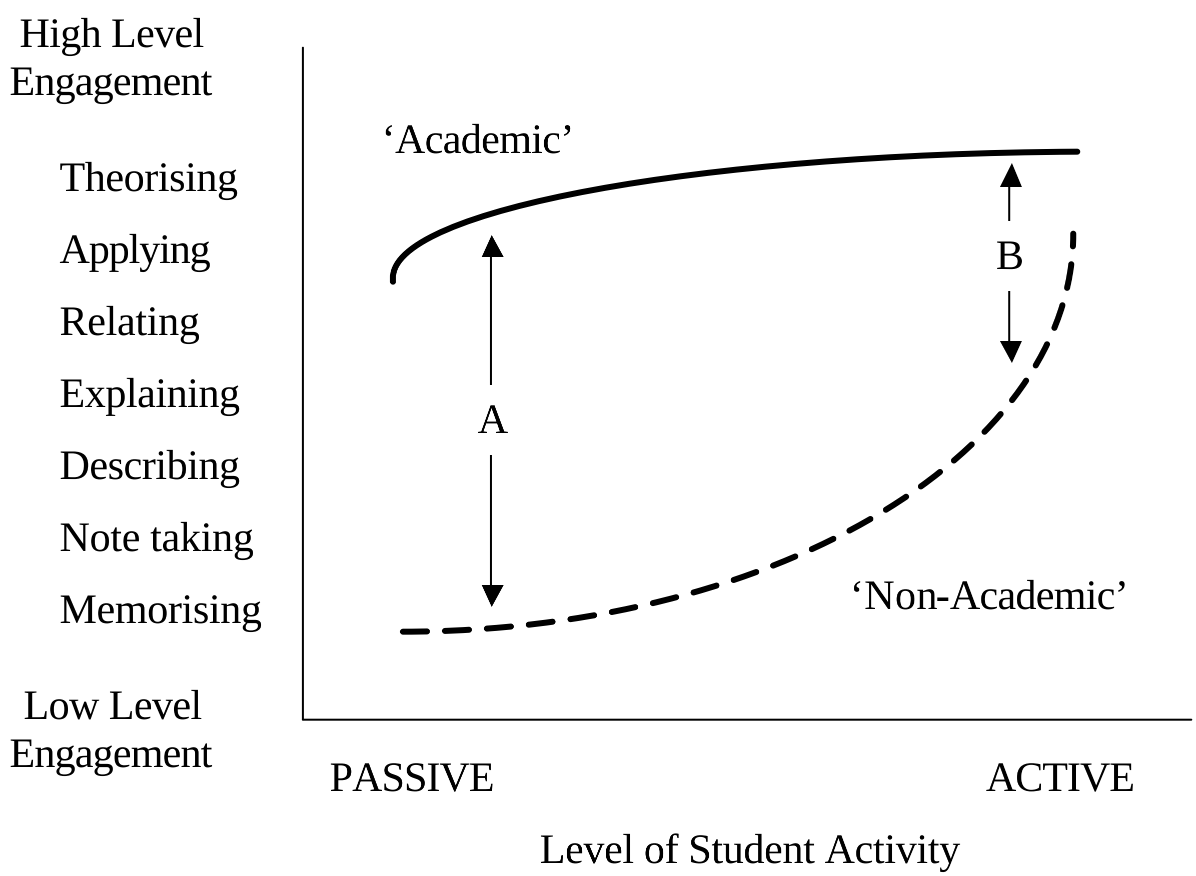
5. What the Student does: teaching for enhanced learning, John Biggs (University of New South Wales), Higher Education Research & Development, Vol.18, No.1 (1999).

Appendix 1

Active versus Passive Learning

The following extract is taken from an article by Biggs (1999) and explains the differences between ‘active’ and ‘passive’ learning and between ‘deep’ and ‘superficial’ learning.

“Let us take two students attending a lecture. Susan is academically committed; she is bright, interested in her studies, and wants to do well. She has clear academic and career plans, and what she learns is important to her. When she learns she goes about it in an "academic" way. She comes to the lecture with relevant background knowledge and a question she wants answered. In the lecture, she finds an answer to that question; it forms the keystone for a particular arch of knowledge she is constructing. She reflects on the personal significance of what she is learning. Students like Susan (continuous line in the figure) virtually teach themselves; they need little help from us. The way Susan learns fits Marton and Saljo's (1976) description of a *deep* approach to learning, but in making this connection it is important to emphasise that "deep" describes how Susan usually goes about her learning, it does *not* describe a personality characteristic of Susan.



Now take Robert. He is at university not out of a driving curiosity about a particular subject, or a burning ambition to excel in a particular profession, but to obtain a qualification for a job. He is not even studying in the area of his first choice. He is less committed than Susan, and has a less developed background of relevant knowledge; he comes to the lecture with no questions to ask. He wants only to put in sufficient effort to pass. Robert hears the lecturer say the same words as Susan heard, but he doesn't see a keystone, just another brick to be recorded in his lecture notes. He believes that if he can record enough of these bricks, and can remember them on cue, he'll keep out of trouble come exam time. Robert (dotted line in the Figure) appears to adopt a *surface* approach to learning (Marton & Saljo, 1976), but again it must be emphasised that this is not to describe Robert as a person, but to describe the way he currently learns. The teaching challenge is precisely to change his usual way of learning, not to see it as an impediment to teaching him.

Students like Robert probably are in higher proportions in today's classes than was the case 20 years ago. They will need help if they are to achieve the same levels of understanding that their more committed colleagues achieve spontaneously. To say that Robert is "unmotivated" may be true, but unhelpful. What that really means is that he is not responding to the methods that work for Susan. The challenge we face as teachers is to teach so that Robert learns more in the manner of Susan. The diagram, based on a number of studies and observations summarised in Biggs (1999), postulates a two-way interaction between the degree of learning-related activity that a teaching method is likely to stimulate, and the academic orientation of the students, as they jointly affect students levels of engagement in the task. "Academic" students will adopt a deep approach to learning in their major subjects, often despite their teaching, while non-academic students are likely to adopt a deep approach only under the most favourable teaching conditions.

Thus, at Point A, the "passive" end of the teaching method continuum, there is a large gap between Susan and Robert in terms of the their level of engagement, as in the lecture example described above. If we look at the ordinate of the Figure, the student's level of engagement, we see that Susan is relating, applying, possibly theorising, while Robert is taking notes and memorising. At point B, the "active" end of the teaching method continuum, the gap between Susan and Robert is lessened; both are now using the higher-level activities. Problem-based learning would be an example of an active method, because it *requires* Robert to question, to speculate, to generate solutions, to use the higher order cognitive activities that Susan uses spontaneously. The teaching has narrowed the gap between them, at least in terms of the kind of cognitive activity engaged."

References

Biggs, J., *"What the student does: teaching for enhanced learning",* Higher Education Research and Development, <u>18</u>, 57-75, (1999) Marton, F. and Saljo, R., *"On qualitative differences in learning: outcomes and processes",* British Journal of Educational Psychology, 46, 4-11, (1976)