The Project on the Effectiveness of Problem Based Learning (PEPBL): A field trial in Continuing Professional Education

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Abstract

Problem based learning (PBL) has been adopted around the world as a philosophy and method for teaching and learning in professional education in particular. Advocates of the approach have made many claims for its success. Despite the apparent widespread use of this approach and the plethora of published papers on PBL there are numerous basic questions about the method that remain controversial. At a fundamental level there is no universal agreement about what PBL actually is. Similarly there is little agreement about what the specific measurable outcomes of PBL are or how they should be measured. These conceptual, methodological and practical problems are being confronted currently in the Project on the Effectiveness of Problem Based Learning (PEPBL), funded by the ESRC’s Teaching and Learning Research Programme. This paper explains the rational behind the field trial and outlines the research design and methods being used in the study.

Introduction

Problem Based Learning has been introduced into education in many professional fields including medicine, nursing, dentistry, social work, management, engineering and architecture (Boud & Feletti 1997). In its modern guise PBL started to become a feature of educational programmes during the 1960's. Since then there has been a steady growth in the number of programmes and institutions that have adopted PBL around the world. This transformation has been encouraged by an almost evangelical PBL movement that has published of a wealth of anecdotal material extolling the virtues of PBL (Wilkie 2000). PBL has been endorsed by a wide variety of national and international organizations (Tomkins 2001). These include the Association American Medical Colleges (Muller 1984) the World Federation of Medical Education (Walton & Matthews 1989), The World Health Organization (WHO 1993), the World Bank (1993) and the English National Board for Nursing Midwifery and Health Visiting (ENB 1998). In recent years the advantages that are claimed for PBL have become part of the generally articulated outcomes for education at all levels (Evenson & Hmelo 2000)

The theoretical basis of PBL

The philosophical and theoretical underpinnings of PBL were not explicit in the early PBL literature (Rideout 2000). Barrows, a pioneer of PBL, explains that the he and the other developers of the original the McMaster PBL curriculum had no background in educational psychology or cognitive science. They just thought that learning in small groups through the use of clinical problems would make medical education more interesting and relevant for their students (Barrows 2000a). PBL can be interpreted as congruent with two distinct streams of theory about knowledge and learning Constructivism (Evenson & Hmelo 2000, Davies 2000) and Cognitive Psychology (Schmidt 1993).
PBL, pbl, p-bl

The wide dissemination of PBL has spawned so many mutations that the genus “problem based learning” now has an almost unclassifiable array of species (Barrows 2000a). Vernon and Blake (1993) in a review of the field, found that PBL was described in a variety of ways that could be summarised as a complex mixture of general teaching philosophy, learning objectives and goals and faculty attitudes and values. Maudsley (1999) argues that the label PBL is often borrowed for prestige or subversion, adorning many narrowly focused single subject courses within traditional curricula that do not use PBL at all. Myers Kelson & Distlehorst (2000) reviewed the curricula of 124 medical schools in the USA, 85 of which claimed to be using some form of PBL. However when the Criteria for ‘authentic PBL’ developed by Barrows (2000b) were applied it appeared that PBL was being used as a generic category which included almost any teaching approach.

PBL

Bereiter and Scardamalia (2000) distinguish between PBL (uppercase) and pbl (lowercase). Practitioners of PBL tend to adhere to the structures and procedures systematized by Barrows (1986). PBL can be operationalized as a carefully designed system of teaching and learning selected to support particular types of learning (Entwistle1992) through attention to factors that have been identified as affecting academic performance (see figure 1). Lowercase pbl refers to an indefinite range of educational approaches that give problems a central place in the learning activity.

Engel (1991) Barrows (1986) Savin-Baden (2000) all emphasize that the difference with PBL is at the level of curriculum. Walton and Matthews (1989) argue that PBL is to be understood as a general educational strategy rather than merely a teaching approach. They present three broad areas of differentiation between PBL and the 'traditional' subject centred approaches:

1. Curricula organization: Around problems rather than disciplines, integrated, emphasis on cognitive skills as well as knowledge.
2. Learning environment: use of small groups, tutorial instruction, active learning, student centred, independent study, use of relevant 'problems'.
3. Outcomes: Focus on skills development and motivation, abilities for life long learning.

The curriculum is operationalized into a number of scenarios or problems. The scenarios are designed to mirror situations that the students will encounter in ‘real life’. In addition to a short narrative (See box 1) a scenario pack typically includes additional information pertinent to ‘the case’ and a directory of further resources. The scenarios provide the triggers for the students together with their tutor to embark on the process of learning. The teaching and learning process used in PBL is described by various authors in terms of a number of steps. Schmidt (1983) described ‘seven steps’:

1) clarifying and agreeing on working definitions of unclear terms/concepts;
2) defining the problem(s), agreeing which phenomena require explanation;
3) analyzing components, implications, suggested explanations (through brainstorming) and developing working hypothesis
4) discussing, evaluating and arranging the possible explanations and working hypotheses
5) generating and prioritizing learning objectives
6) going away and researching these objectives between tutorials
7) reporting back to the next tutorial, synthesizing a comprehensive explanation of the phenomena and reapplying synthesized newly acquired information to the problem(s)

Typically the learning process is organized in three meeting cycles (Woods 1995). In the first meeting with a new scenario the students work through steps 1 to 5. The second two meetings are devoted to getting feedback on what the students have learnt from the research that they have undertaken between the meetings, synthesizing and applying this information to the scenario. At the end of each cycle the group reviews its performance and learning goals are identified for improvement.

The teacher’s role is one ‘facilitator of learning’ for one or more groups. Facilitation in this context can be defined as playing the role of the more knowledgeable member of the social community of which the student is also a member. Assistance for learning is provided through interactions characterized by such activities as directing, modelling, questioning,
and providing cognitive structuring and feedback until the learners are able to perform without assistance (Rideout & Carpio 2000). PBL programmes are informed by the maxim that assessment drives learning i.e. students will focus their learning efforts on the things that they are tested on (Brown et al 1997). As a consequence the content and process of assessment in PBL programmes is or should be congruent with the learning goals that the course is trying to promote or at the very least assessment should not detract from or artificially inflate the importance of some goals over others.

Evidence about the effectiveness of PBL

Norman and Schmidt (1992) argue that there is good empirical evidence to support at least two of the key aspects of PBL in the cognitive psychology literature. Firstly that learning is improved where there is activation of prior knowledge and secondly that elaboration of knowledge at the time of learning enhances retrieval. However with regard to some of the other key aspects of PBL notably self-regulation and group participation Evenson and Hmelo (2000) argue that the theory is a bit vague and that there is a lack of empirical evidence. Even if there were stronger evidence for the component parts of PBL, as Woodward (1997) points out this is not the same as empirical evidence to support the claim that PBL produces practitioners with consistently high levels of performance that are maintained throughout their professional career.

Various claims are made for the effectiveness of PBL at delivering additional benefits in terms of knowledge, understanding, critical thinking, communication, problem solving, teamwork and student satisfaction. There have been at least four reviews (which vary in the degree to which they maybe called systematic) of PBL. (Vernon & Blake 1993, Albanese & Mitchell 1993, Berksen 1993, Van den Bossche et al 2000). All four reviews are difficult to interpret due to their varying methodological limitations including: the use of a non-systematic approach to identifying studies for inclusion, different and highly flexible interpretations of PBL within and between the reviews, and the absence of any specified methodological inclusion criteria. This combination of factors meant that the reviews included studies that had a number of common methodological weaknesses. These include the use of single group post-test designs, the use of non-comparable sample groups, poorly specified and/or non-comparable interventions, the use of non-objective outcome measures/assessment tools that had no established validity and/or reliability.

The reviews included a very similar range of literature but came to different conclusions. Vernon and Blake (1993) concluded that “results generally support the superiority of the PBL approach over more traditional academic methods”. Albanese and Mitchell (1993) whilst acknowledging the weaknesses of the research literature concluded that PBL was more nurturing and enjoyable and that PBL graduates performed as well and sometimes better on clinical examinations and faculty evaluations. However, they also concluded that PBL graduates showed potentially important gaps in their cognitive knowledge base, did not demonstrate expert reasoning patterns, and that PBL was very costly. Van den Bossche and colleagues (2000) concluded that there was a robust positive effect from PBL on the skills of students but a negative (non-robust) effect on knowledge. Berksen (1993) was unequivocal in her conclusion that “the graduate of PBL is not distinguishable from his or her traditional counterpart”. She further argued that the experience of PBL can be stressful for the student and faculty and implementation may be unrealistically costly. Berksen (1993) and subsequently Woodward (1997) and Colliver (2000) have argued that many studies have erroneously claimed effects for PBL when it was more likely that the effects were due to selection and philosophy of care differences.

Davies (2000) argues that it seems safe to conclude that problem based learning may not be invariably better than other methods, or superior for all types of learning or learners. Wolf (1993) concluded that the reviews (published in 1993) demonstrated that there is a paucity of good-quality studies and evidence available regarding the hypothesis that PBL produces learning and/or learners different from or those derived from traditional approaches. Further he suggests that there is a tremendous need for well-designed, creative primary research studies that examine clinically important, clinically relevant behaviours and outcomes.

PEPBL

PEPBL is a three-year research and development project funded by the ESRC Teaching & Learning Research Programme.
There is not space to present all of the details of the study design and method here and therefore only the key points will be outlined. The project can be located under the broad heading of evaluation research. The aim is to find out whether Problem Based learning is effective and why. The educational programmes being used in the study are two nursing continuing education programmes, the Advanced Diplomas in Medical and Surgical Nursing. These programmes are accredited by the professional body and provided widely across the United Kingdom. Students enrolling for the programmes over a two-year period will be randomly allocated to groups that will follow either a PBL curriculum (as described above) or the traditional approach, which uses a mixture of teacher and student centred approaches.

Study design

An experimental research design is being used as this is most useful to demonstrate programme impact and causal inference (Boruch & Wortman 1979, Tate 1982). All possible threats to validity cannot be controlled in any one study and complex educational programs are implemented differently in various settings and are influenced by a host of political and social contexts. For these reasons, Besson and Michael (1982) argue that smaller studies aimed at eliminating bias (internal validity concerns) and random error (statistical validity concerns) are imperative with new or innovative educational programmes (such as PBL).

PBL is a complex intervention and thus is subject to the specific difficulties in defining, developing, documenting and reproducing all such interventions. The project uses a framework for the design and evaluation of complex interventions (Campbell et al 2000). The framework utilizes a sequential phased approach to the development of randomized trials of complex interventions. Using this framework PEPBL can be considered as a phase II exploratory trial. A phase II exploratory trial is concerned with defining the control intervention, estimating the size of the effect, identifying and piloting various outcomes and outcome measures. Thus a greater number of measures maybe used than would be the case in a Phase III definitive randomized controlled trial.

Selection of outcome measures and instrumentation

Cervero’s (1988) framework for the evaluation of continuing education for professionals (see box 2) has been used as a set of organizing principles for the consideration and selection of appropriate measures and assessment tools for the study. The category ‘Impact of the application of learning’ refers to the so-called second order effects. In the context of this study this refers to whether there are measurable improvements in patient outcomes as a result of nurses undertaking courses using PBL. Measurement of such effects is beyond the scope of this study and so has not been considered. The impact measures and instruments being used are summarised in tables one and two. The selection of impact measures was informed by a need to identify valid markers of the impact of PBL in its broadest sense and of the need for validity and reliability in the instrumentation.

Flanders Interaction Analysis is a system of classroom interaction analysis. The system in its original and modified forms have been used extensively in classroom observation studies (Wragg, 1999). It has also been used in the study of differences between expert and non-expert PBL tutors at University of Michigan Medical School (Davis et al 1992). Measures of students workload can be useful as curriculum evaluation tools (Swanson et al 1991). Students will be asked to report on the quantity and type of course related work undertaken a number of times during the study. Learner satisfaction will be assessed using the Course Experience Questionnaire (CEQ) (Ramsden 1992). A standardized assessment tool developed on the basis of empirical and theoretical work on the quality of teaching in higher education. The CEQ is used to evaluate student satisfaction on the Problem Based Learning Programmes in the Health Science Faculty at Griffith University in Brisbane (Margotson 1995).

Assessing Learner knowledge, skills and attitudes

This category focuses on measuring changes in the learner’s cognitive, affective or psychomotor competence. Given the purpose of the research project there is a need to select sensitive, valid and reliable tools to assess student performance. It is not possible within the scope of this project to develop new valid and reliable assessment tools and therefore efforts have focussed on identifying existing tools that could be used for this purpose.

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Issues in the selection of appropriate measurement tools

An important aspect of PBL philosophy is the recognition of the fact that assessment has a major impact on learning. Although all advocates of PBL share this premise its consequences are interpreted differently. Some writers suggest that both the response format and the content of the test must be appropriate to PBL (Marks-Maran & Gail Thomas 2000). Others argue that response format is of less consequence than content and test-design (Norman 1991). There is no consensus on the either the outcomes or methods of measurement to be used to assess the affects of PBL. The selection and use of measurement tools for the study involves a trade off between reliability, validity, educational impact, acceptability and cost (Van Der Vleuten 1996).

The majority of studies reported in systematic reviews of PBL use as outcome measures state licensing exams (or the equivalent) (Vernon & Blake 1993, Albanese & Mitchell 1993). It likely that these exams do not measure the skills that PBL claims to promote. Norman argues that many of the assessment methods that have been developed specifically for PBL (See Modified Essay Questions and the Triple Jump Exercise below) have not been tested for content validity (Norman 1989).

Proposed measures of cognitive knowledge and skills

For methodological and practical reasons only a limited number of measurements can be used in this study these are summarized in table 2. The main method of assessing achievement under will be the course assessments. With their emphasis on self selection of topic, self-directed information searching and presentation of data in a clear focussed manner, written assignments are viewed as a relevant evaluation method within the PBL approach (Rideout 2000). They are widely used in PBL courses elsewhere (Marks-Maran & Gail Thomas 2000). However, problems with reliability of these methods, particularly when the sample of items is small, are well known (Van Der Vleuten 1996). It can be argued that the cause of these validity and reliability problems is the tutors marking rather than anything inherent in the method itself (Swanson et al 1991). The provision of simple protocols to structure and score oral examinations can significantly improve the reliability as compared to free judgement (Verma et al 1997). The course team have developed protocols for the structuring and scoring of each assessment using the SOLO taxonomy (Biggs 1999). For the purpose of the research mark each student’s assessments (n=3) will be marked blindly by a separate external assessor (n=3). The addition of more than one new examiner per case has been shown to increase reliability by more than 30% (Swanson 1987).

PBL places great emphasis on group or teamwork, as the process of learning and because of this, improved group work skills are an outcome of PBL (Savin-Baden 2000). The claim that PBL improves group work skills and that this improvement produces measurable increases in leaning and thinking and later on in patient care appears to be an assumption that requires further testing by research (Thomas 1997). Each group will be videoed whilst completing a range of problem solving exercises. Validated scales are available measuring different aspects of group performance including (Patton et al 1989)

- Process of the group (Bales Interaction Process analysis)
- Functioning of individuals in the group (Task/person, Team Orientation & Behaviour inventory)
- Group cohesiveness (Seashore index of group cohesiveness)
- Problem solving (The Brillhart problem solving process scale)

The claim that PBL creates self directed learners will be assessed by comparing changes in student learning styles over the duration of the programme. ASSIST (Approaches and Study Skill inventory for Students) (Tait & Entwistle 1996) was developed from the approaches to studying inventory ASI (Entwistle & Ramsden 1983). Both ASSIST and the ASI have been used in large numbers of studies including studies of problem based learning (Coles 1985).

Conclusion

The case for evidence based approaches to education has been convincingly argued (Taylor Fitzgibbon 1999, Van der Vleuten et al 2000). Despite the volume of literature on PBL there is a lack of robust evidence that demonstrates the superiority of the approach over any other approach to teaching and learning. That PBL is a complex intervention which takes place within complex social environments increases rather than decreases
the need for high quality experimental research designs. PEPBL hopes to contribute towards the evidence base for education using just such an approach.

References


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**Figure 1:** General model of college teaching and learning (McKeachie et al 1986)

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**Box 1:** Example of PBL scenario from Advanced Diploma in medical nursing at Middlesex University

Fred Smith is a 62-year-old retired building contractor is admitted to your ward via the Accident & Emergency Department. A CAT scan confirms the diagnosis of a stroke. Three days after admission he has a dense left hemiplegia and remains drowsy and agitated. Mr. Smith has a Grade 2 pressure ulcer on his sacral area. The student nurse reports this to you. You note that there is no record of this in the nursing notes. It has not proved possible so far to insert a nasogastric tube. Mr. Smith’s family are distressed about his condition and on the late shift tell you they are worried because Fred is not being fed food which will upset his Diabetes.
Box 2: Organizing principles for consideration and selection of measures

Framework for the evaluation of continuing professional education (Cervero 1988)
- Programme design and implementation
- Learner participation
- Learner satisfaction
- Learner knowledge, skills and attitudes
- Appitiation of learning after the programme
- Impact of application of learning (second order effects – e.g. improvements in the health of patients)

Table 1: Summary of impact measures & instruments (excluding knowledge skills and attitudes)

<table>
<thead>
<tr>
<th>Category</th>
<th>Measurement tool</th>
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<tbody>
<tr>
<td>Programme design and implementation</td>
<td>• Non-participant observation</td>
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<td></td>
<td>• Tutor reflective accounts</td>
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<tr>
<td></td>
<td>• Flanders Interaction Analysis (Flanders 1970)</td>
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<tr>
<td>Learner participation</td>
<td>• Attendance</td>
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<td></td>
<td>• Self-reported study workload</td>
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<td></td>
<td>• Flanders Interaction Analysis</td>
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<tr>
<td>Learner/ teacher satisfaction</td>
<td>• Course Evaluation Questionnaire (Ramsden 1982)</td>
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<td></td>
<td>• Teachers Reflections</td>
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<td></td>
<td>• Nominal Group Technique</td>
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<td>Application of learning after the programme</td>
<td>• Behavioural event interview using the Executive Skills Profile</td>
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</tbody>
</table>
**Box 3: Claims made for PBL (Engels 1991)**
PBL is more effective at producing practitioners who are better at:
- Adapting to and participating in Change
- Dealing with problems and making reasoned decisions in unfamiliar situations
- Reasoning critically and creatively
- Adopting a more universal or holistic approach
- Practising empathy/Appreciating the other persons point of view
- Collaborating productively in groups or teams
- Identifying own strengths and weaknesses and taking appropriate remedial action

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**Table 2: data collection – student knowledge, skills and attitude**

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<thead>
<tr>
<th>PBL Objective</th>
<th>Assessment tool</th>
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<tr>
<td>Adaptation</td>
<td>Assignments x3</td>
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<td></td>
<td>Learning Styles (ASSIST)</td>
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<td></td>
<td>Practice Assessment</td>
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<tr>
<td>Problem solving</td>
<td>Assignments</td>
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<td>Group work video</td>
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<td></td>
<td>Practice assessment</td>
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<tr>
<td>Reasoning</td>
<td>Assignments</td>
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<td></td>
<td>Group work video</td>
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<td></td>
<td>Practice assessment</td>
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<td>Universal holistic approach</td>
<td>Group work video</td>
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<td></td>
<td>Assessment of Practice</td>
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<td>Empathetic</td>
<td>Group work video</td>
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<td></td>
<td>Practice assessment</td>
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<tr>
<td>Self-directed learner</td>
<td>Learning styles (ASSIST)</td>
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<td></td>
<td>Study workload</td>
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<tr>
<td>Teamwork</td>
<td>Group work video</td>
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<td>Practice assessment</td>
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