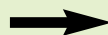


The effectiveness of Problem Based Learning 1: a pilot systematic review and meta-analysis

'Problem Based Learning', a cluster of applied approaches to teaching, is increasingly popular in professional education both in the UK and internationally. However, there are still many important questions about its definition and about the forms of Problem Based Learning which may be best for particular students in different contexts. This Research Briefing reports on a pilot systematic review and meta-analysis, undertaken to evaluate evidence of the effectiveness of Problem Based Learning as defined by the research studies which were cited in five previous reviews.

It indicates the challenges of conducting research of this sort and the difficulty of achieving 'safe' knowledge of teaching effectiveness.

The term 'Problem Based Learning' is used in relation to a wide range of practices. Descriptions of the Problem Based Learning, and of the control group interventions to which it was compared, were generally inadequate to identify the key features of the approach used.



There is a need for consistent reporting of the key features of the Problem Based Learning approach used in any particular study.

The results of the outcomes reported were mixed. Some effects favoured Problem Based Learning, whilst others favoured the control group with which Problem Based learning was being compared.



Previous reviews do not provide sufficient evidence to support the widespread adoption of Problem Based Learning without further research. Where Problem Based Learning is introduced, it should be accompanied by rigorous evaluation.

The research

Background

Problem Based Learning is a major development in educational practice that has a large impact across subjects and disciplines worldwide. It is not always clear what exactly has been done in the name of Problem Based Learning. There is also a growing number of references in the literature to adapted or "Hybrid" Problem Based Learning courses and to courses described as 'Enquiry' or 'Inquiry' Based learning. Problem Based Learning has arguably been one of the most scrutinised innovations in professional education. However, despite the volume of literature on Problem Based Learning it is not at all clear that we have safe knowledge about the effects of Problem Based Learning in different learning contexts and in different modes of operation.

Whilst the principle of research reviews is well established in education, the appropriate process and purpose for them is not. Systematic reviews can be a valid and reliable means of avoiding the bias that comes from the fact that single studies are specific to a time, sample and contexts and may be of questionable methodological quality. They attempt to discover the consistencies and account for the variability in similar appearing studies. There is a consensus emerging about the need for systematic reviews covering selected topics in education. Such reviews will identify the existing evidence, provide at least some answers to the review questions and provide directions for future primary research.

Objectives of the pilot review

- To establish the level and quality of existing 'safe' knowledge about the effectiveness of Problem Based Learning based on previously published reviews
- To confirm the need for a full systematic review of the effectiveness of Problem Based Learning
- To establish the value of the method

- of systematic review used
- To identify and clarify any problems with the review protocol, process and instruments

Review questions

The initial review questions were... When compared to other approaches does Problem Based Learning result in increased participant performance 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 person's point of view;
- collaborating productively in groups or teams;
- identifying own strengths and weaknesses and undertaking appropriate remediation (self-directed learning)?

Methods

Review Design

The review followed the approach used by The Cochrane Collaboration, an international effort to identify evidence of effectiveness in the field of health care. The design of the review protocol, data extraction tools and overall review process is based on the guidance for reviewers produced by The Cochrane Effective Practice and Organisation of Care Review Group and the NHS Centre for Reviews and Dissemination. This approach has been developed from the emerging 'science' of systematic reviewing in order to minimise bias and errors. The review protocol was registered with the Campbell Collaboration. Copies of the review protocol and instrumentation are included in the full project report.

Inclusion criteria

- The review included participants in post-school education programmes.
- Study designs included were Randomised Controlled Trials (RCT), Controlled Clinical Trials (CCT), Interrupted Time Series (ITS), and

- Controlled Before & After studies (CBA). Qualitative data collected within such studies e.g. researchers' observations of events, were incorporated in reporting. Studies that use solely qualitative approaches were not included in the review.
- The minimum methodological inclusion criteria across all study designs were the objective measurement of student performance/behaviour or other outcome(s) and relevant and interpretable data presented or obtainable.

Minimum inclusion criteria for interventions (i.e. what is Problem Based Learning) were set out in the review protocol. However, reporting was insufficient to establish whether these criteria were met in virtually all the primary studies considered.

Review Process

The review coordinator examined the reviews and identified the relevant citations. For each citation either an abstract or full text copy was obtained. Two members of the review team then screened the citations to eliminate those that obviously did not meet the minimum inclusion criteria. The included papers were then distributed amongst the reviewers for quality appraisal and data extraction. Each paper was reviewed independently by two reviewers. Where there were differences of opinion between reviewers the review coordinator also reviewed the paper. At all stages, the process used and outcomes are explicit. A full list of included and excluded studies is provided in the full report. The completed quality assessment and data extraction tools were returned to the review co-ordinator who lead the process of producing a report of the review synthesising and analysing the results where appropriate.

Results

91 citations were identified from the five reviews. Of these 15 were judged to meet the inclusion criteria. Of the 15 only 12 reported extractable data. The discussion below refers only to these 12 studies. The studies all reported on Problem Based Learning used in higher education programmes for health

professional education at both pre and post registration levels. The majority of students were in medicine and the majority of these studies reported on pre-registration medication education. The majority of reported effects were for what appeared to be tests of 'knowledge' using multiple choice formats. There were also a small number of effects reported on 'impact on practice' and on 'approaches to learning'. Very little information was given in the papers from which data was extracted about the design, preparation or delivery processes of either the Problem Based Learning intervention or the control to which Problem Based Learning was being compared. Four of the studies used a randomised experimental design, two a quasi-randomised experimental design and the remainder were controlled before and after studies. Only one study reported standard deviated effect sizes. Effect sizes were calculated for all the other extracted effects with the exception of three studies where insufficient data were provided in the study report.

The studies that reported 'effects on practice' all used different outcomes and measurement instruments. In only one of the studies that reported 'effects on practice' was sufficient data provided to calculate effect sizes. This makes it difficult to synthesise the study results. One study reported 'attitudes to practice' and found effect sizes that favoured Problem Based Learning. Another measured 'nursing process skills' and of the seven effects reported five favoured the control group. The third study reported 'consultation skills' and on all the effects reported the results favoured the control group. However, in this particular study, which used a quasi – experimental design, the nature of the Control group intervention and the outcome measures used would appear to have put the control group at a distinct advantage.

Two studies reported effects on 'approaches to learning'. The two studies used different instruments and reported five effects. In both studies, the results favoured Problem Based Learning on all the scales. The Problem Based Learning groups had fewer of the undesirable and more of the desirable 'approaches to learning' after the intervention. However, the overall

Major implications

The review found comparatively few studies cited in the five sample review papers whose design and methodology were good enough to eliminate bias and provide precise estimates of effect. Studies that achieved this were concentrated largely in medical education in North America and Europe and focussed mainly on measuring 'accumulation of knowledge' using multiple choice assessments.

However, an outcome of 'accumulation of knowledge' and in particular its assessment through multiple choice instruments is not regarded by many advocates of Problem Based Learning as congruent with the approach itself or as a valid indicator of success. The second issue is how generalisable these results are to other disciplines and to other cultural contexts.

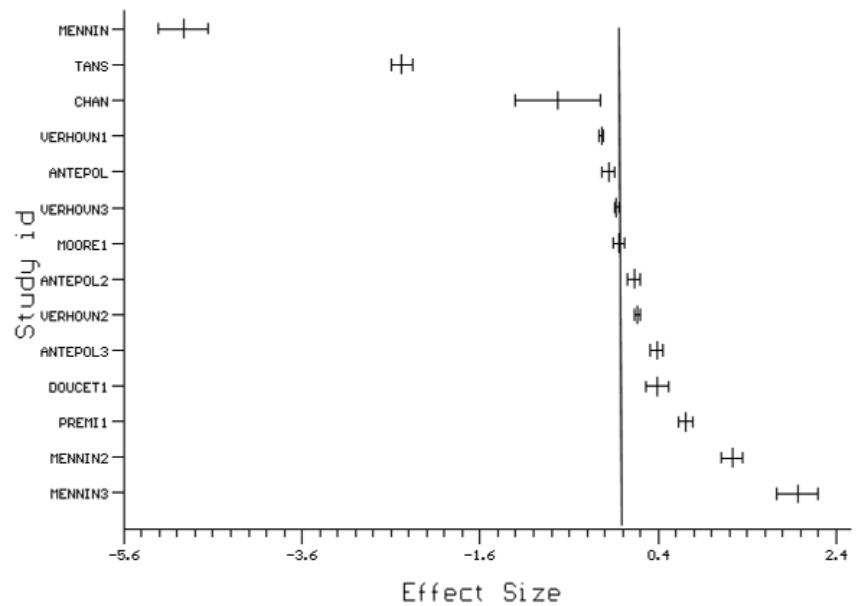


Figure 1: Effect size for reported study outcomes focussing on 'knowledge'

picture was of deterioration in the approaches to learning of both the Problem Based Learning and control groups, which Problem Based Learning appears to have mitigated.

Figure 1 illustrates the effect sizes for reported outcomes that could usefully be grouped under a heading 'knowledge'. Effect sizes ranged from $d = -4.9$ to 2.0 . There were sufficient effects reported to justify an attempted meta analysis. The meta analysis of the outcome 'knowledge' included 14 effects reported in 8 different studies. Concerning the review questions, the results of the meta analysis are largely inconclusive. The mean effect size was $d = -0.3$ but the 95% confidence interval did not exclude an effect size of $d = 0$. Sensitivity analysis suggested that study design, randomisation, level of education and assessment format are all potential moderating variables but the results were not conclusive. Importantly

the 95% confidence intervals do not exclude potentially 'large effect sizes of $d = + 1.0$ or $- 1.0$ '. An effect size of $d = 1.0$ would mean that 84% of students in the control group were below the level of the average person in the Problem Based Learning group. An effect of this size would appear to have important practical significance.

Only one study reported effects on 'satisfaction with the learning environment' that met the review inclusion criteria. The study in an undergraduate medical education programme required students to rate their experience on a series of scales. On all except two of the nine effects reported, the effect size favoured the Problem Based Learning group. The largest effect size in favour of Problem Based Learning was the students rating of innovation ($d = 1.6$). The largest effect size in favour of the Control group was students' rating of clarity ($d = -1.0$).

Further information

Further information about the project can be downloaded from the project website (address below). A detailed summary of the two empirical studies can be downloaded from the ESRC Regard website (www.regard.ac.uk). A full report of the Pilot Systematic Review and Meta-analysis was published by the Learning & Teaching Subject Network Centre for Medicine, Dentistry and Veterinary Medicine and can be downloaded from its website www.ltsn-01.ac.uk. A full report on the evaluation of Problem Based Learning in Continuing Nursing Education is available from the project website.

Systematic Review team

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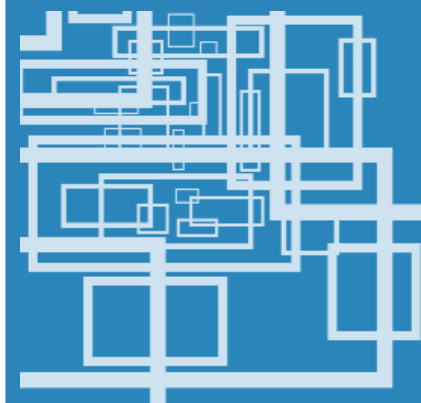
The warrant

The research question in this study was specifically concerned with establishing whether the use of activities termed Problem Based Learning results in different 'outcomes' to the use of other teaching and learning approaches. The review used a systematic and transparent process that has been demonstrated to provide a more valid and reliable appraisal of existing research evidence that allows for the development and accumulation of 'knowledge' specifically by:

- Defining transparent inclusion criteria that limit consideration to studies that used research designs which have been empirically established as optimal for providing evidence about effectiveness
- Using these criteria to make decisions about the inclusion of studies, the results of studies and the interpretation of these results
- Two reviewers independently appraised the quality of these studies and carried out data extraction
- The use of existing frameworks for the reporting of Problem Based Learning as a basis for providing descriptive summaries of the included studies
- The use of an explicit framework for the analysis of the results from the individual studies using both systematic narrative synthesis and exploratory meta-analysis

The limitations of the study design and its conduct and their consequences have been reported and explored. The relationship between the results and conclusions is therefore explicit and the limited conclusions drawn do not go beyond that justified by the results of the study.

Teaching and Learning Research Programme



TLRP is the largest education research programme in the UK, and benefits from research teams and funding contributions from England, Northern Ireland, Scotland and Wales. Projects began in 2000 and will continue with dissemination and impact work extending through 2008/9.

Learning: TLRP's overarching aim is to improve outcomes for learners of all ages in teaching and learning contexts within the UK.

Outcomes: TLRP studies a broad range of learning outcomes. These include both the acquisition of skill, understanding, knowledge and qualifications and the development of attitudes, values and identities relevant to a learning society.

Lifecourse: TLRP supports research projects and related activities at many ages and stages in education, training and lifelong learning.

Enrichment: TLRP commits to user engagement at all stages of research. The Programme promotes research across disciplines, methodologies and sectors, and supports various forms of national and international co-operation and comparison.

Expertise: TLRP works to enhance capacity for all forms of research on teaching and learning, and for research-informed policy and practice.

Improvement: TLRP develops the knowledge base on teaching and learning and collaborates with users to transform this into effective policy and practice in the UK.

TLRP is managed by the Economic and Social Research Council research mission is to advance knowledge and to promote its use to enhance the quality of life, develop policy and practice and strengthen economic competitiveness. ESRC is guided by principles of quality, relevance and independence.

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