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When is PBL More Effective? A Meta-synthesis of Meta-analyses Comparing PBL to Conventional Classrooms

Johannes Strobel and Angela van Barneveld

Abstract

Problem-based learning (PBL) has been utilized for over 40 years in a variety of different disciplines. Although extensively researched, there is heated debate about the effectiveness of PBL. Several meta-analyses have been conducted that provide a synthesis of the effects of PBL in comparison to traditional forms of instruction. This study used a qualitative meta-synthesis approach to compare and contrast the assumptions and findings of the meta-analytical research on the effectiveness of PBL. Findings indicated that PBL was superior when it comes to long-term retention, skill development and satisfaction of students and teachers, while traditional approaches were more effective for short-term retention as measured by standardized board exams. Implications are discussed.
Keywords: Effectiveness, meta-synthesis, PBL

When is PBL More Effective? A Meta-synthesis of Meta-analyses Comparing PBL to Conventional Classrooms

Problem-based learning (PBL) has been utilized as a design methodology for teaching in domains like medicine, engineering, science, and economics for over 40 years. Although a large number of research studies have been conducted to investigate the effectiveness of PBL instruction compared to other forms of instruction, there is no consensus on the value of PBL, but rather a heated debate on its effectiveness. A recent widely debated article in *Educational Psychologist* by Kirschner, Clark, and Sweller (2006) argued particularly vehemently of the failure of PBL due to the claimed failure of minimal guidance. While it is beyond the scope of this particular paper to debate all of the implications of Kirschner et al.'s paper (2006), this article addresses the specific claim that PBL is unsuccessful and ineffective for learning.

Several meta-analyses, conducted over the past 15 years, have specifically investigated and quantified the effectiveness of PBL compared to traditional instruction (Albanese

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& Mitchell, 1993; Vernon & Blake, 1993; Kalaian, Mullan, & Kasim, 1999; Dochy, Segers, Van den Bossche, & Gijbels, 2003; Newman, 2003; Gijbels, Dochy, Van den Bossche, & Segers, 2005). Although defining PBL similarly, these studies were not consistent in their findings, particularly because of differences in defining effectiveness of learning, and how effectiveness was measured.

Purpose

The purpose of this study was to synthesize the different meta-analyses, compare and contrast different conceptualizations of learning and how it was measured, and identify common and generalizable findings across the meta-analyses with regard to the effectiveness of PBL.

Our research questions were:

1. How do differences in (a) the definition of learning and (b) the measurement of learning contribute to the inconclusiveness of the different meta-analyses with regard to the effectiveness of PBL?

2. Taking the differences into consideration, what generalizable value statements about the effectiveness of PBL can be made and are supported by the majority of meta-analyses?

What is Problem-based Learning?

PBL in its current form originated as a response to low enrollments and general dissatisfaction with medical education (Barrows, 1996). Since its origin, PBL has been used in a variety of disciplines and educational levels (see Savery [2006] for a history; see Savery & Duffy [1996] for an introduction; see Hung, Jonassen & Liu [2007] for a summary of the research).

As Barrows (1996) noted, PBL has taken on a myriad of definitions, pushed in part by institutions wanting to refine their particular approach. Maudlsey (1999) cautioned us not to assume that those making use of the term, *problem-based learning* were all referring to the same concept, especially since the use of problems as a teaching strategy does not necessarily constitute a PBL-oriented instructional methodology.

One of Barrows' most recent definitions (2002) identified the following key components of PBL:

- Ill-structured problems are presented as unresolved so that students will generate not only multiple thoughts about the cause of the problem, but multiple thoughts on how to solve it.
- A student-centered approach in which students determine what they need to learn. It is up to the learners to derive the key issues of the problems they face, define their knowledge gaps, and pursue and acquire the missing knowledge.

- Teachers act as facilitators and tutors, asking students the kinds of meta-cognitive questions they want students to ask themselves. In subsequent sessions, guidance is faded.
- Authenticity forms the basis of problem selection, embodied by alignment to professional or 'real world' practice.

For our study, we were guided by the definition of problem-based learning put forth by Barrows, as described above, and by Savery (2006) who indicated that it is "an instructional (and curricular) learner-centered approach that empowers learners to conduct research, integrate theory and practice, and apply knowledge and skills to develop a viable solution to a defined problem" (p. 9).

In contrast to PBL, we considered traditional learning approaches to be large-class, instructor-driven, lecture-based deliveries within a curriculum, which compartmentalized the content (e.g., in medicine, the instruction would be broken down into pharmacology, anatomy etc.) (Barrows, 2002).

Methodology

To answer our research questions about how the differences in the definitions and measurements of learning contribute to the inconclusiveness about the effectiveness of PBL, we conducted a meta-synthesis (Bair, 1999) of existing meta-analyses. The goal was to determine which generalizable value statements about the effectiveness of PBL were supported by the majority of meta-analyses.

A meta-synthesis is a qualitative methodology that uses both qualitative and quantitative studies as data or unit of analysis. It is primarily "concerned with understanding and describing key points and themes contained within a research literature on a given topic" (Bair, 1999, p. 4). Since we gave emphasis to the interpretation of data and to the understanding of the differences in the conceptualizations of what constitutes effectiveness in PBL, we opted not to do a meta-meta-analysis, which would have meant quantitatively synthesizing all effect sizes into a single one (see Spitzer, 1991, for an introduction to meta-meta-analysis). Rather, we chose a meta-synthesis approach because it allowed us to represent and account for differences in the conceptualizations and measurements of PBL effectiveness due to the qualitative orientation of the approach.

According to Walsh and Downe (2005), the steps of meta-synthesis include (a) search for articles, (b) make decision on inclusion, (c) appraise studies, (d) analyze studies including "translation" of different conceptualizations and comparisons, and finally (e) synthesize findings. While meta-syntheses are traditionally used to synthesize qualitative research findings exclusively, Bair (1999) expanded the use to include the qualitative comparison of quantitative, qualitative, and mixed-method studies.

Sample and process of selection

Our unit of analysis was a meta-analysis or systematic review. A meta-analysis is a process of quantitatively synthesizing research results by using various statistical methods to retrieve, select, and combine effect sizes and results from previously separate but related studies (see Bernard, Abrami, Lou, & Borokhovski, 2004, for a methodological discussion). Meta-analysis uses effect size as a metric for judging the magnitude of the standardized difference between a treatment and control condition in a large set of studies and may also be used to judge the magnitude of the relationship (r^2 or R^2) between measured variables in a large set of studies (see Leandro, 2005, for more details).

Four research databases, ERIC, PubMEd, PsychInfo, and Web of Science were searched using the terms *problem-based learning* (in a variety of different forms), *PBL*, and *meta-analysis*. The date parameter was set to include studies since 1992 (the first recorded meta-analysis for PBL that met the date parameter appeared in 1993). Twenty-five records that met these three broad search parameters were selected for an initial review. Abstracts were reviewed to ensure that articles met the additional criteria for inclusion, which were (1) a meta-analysis or a systematic literature review (general term for studies that provide overviews of primary studies that used explicit and reproducible methods [Greenhalgh, 1997]) that assessed multiple studies and either calculated or reported effect sizes, (2) contained comparisons of the effectiveness of PBL versus traditional learning approaches, or (3) focused on individual outcome measures rather than program evaluation. This first review of the 25 selected records resulted in eight studies that met the inclusion criteria—four meta-analyses and four systematic reviews. Then, the reference sections of those eight studies were reviewed in search of meta-analytical studies that may have been missed in the database searches. This resulted in finding two additional meta-analyses. Out of these ten studies, we excluded Norman and Schmidt (2000), because it was a response to an existing meta-analysis without providing new data or newly analyzing existing data, and Smits, Verbeek, and De Buisonje (2002), because the study did not compare traditional instruction to PBL-oriented training. The total number of studies included in this paper was eight meta-analyses and systematic reviews.

The research base on the effectiveness of PBL is particularly rich and strong in the field of medicine. Similarly well developed is assessment in the field of medicine, which allows comparisons of different instructional interventions on situated and standardized test environments. Not surprisingly, the meta-analyses dealing with PBL draw heavily from primary studies conducted in medicine, but contain studies from other domains (e.g., economy, computer science) to warrant a rather generalizable statement on the effectiveness of PBL.

Analysis

We looked for the reported quantitative findings and the narrative description of results in the meta-analytic studies and synthesized, qualitatively, the findings that assessed effectiveness of PBL versus traditional approaches.

Instead of predefining codes of effectiveness, we used an open-coding approach (Denzin & Lincoln, 2005) whereby the selected codes were derived from the research studies. We focused on the narrative reports of the findings to evoke the codes. In alignment with our research questions, we sought categories that coded the conceptual definitions of learning linked to the measurement strategies and outcome patterns used to determine effectiveness of the teaching and learning approach. We focused on the interpretation of narrative and qualitative reporting to support our meta-synthesis approach. Two additional coding categories emerged. One addressed overall satisfaction with the learning experience, and the other included patient management, a mix of knowledge and skills beyond basic science knowledge and in-situ clinical performance. We created a correlation matrix that captured the measures of effectiveness and modifying variables reported in each study and the specific orientation of effect sizes (positive or negative) of each variable. After all the measures were identified, we grouped them into categories based on similarity of measurement intent. To assist with the categorization, we made use of Dochy et al.'s (2003) definitions that knowledge tests measured "the knowledge from facts and the meaning of concepts and principles" (p. 537) and skill tests measured "to what extent students can apply their knowledge" (p. 537).

We excluded data from our coding strategy if only one study reported results, and if results focused on program evaluation rather than individual learning outcomes. Finally, we looked for overall patterns in measures that tended to favor PBL, indicated by a positive effect size, and those that tended to favor traditional approaches to learning/teaching, indicated by a negative effect size.

Details on meta-analysis and systematic reports

With regard to definitions of PBL, the reported meta-analyses consistently employed a definition of PBL in congruence with Barrows (1996) and Savery (2006), which guided the conceptual framework of this paper as well.

Summarized here is an overview of each of the eight meta-analyses selected for this paper, describing the research questions, the selection criteria that the researchers employed, and the findings. All of the meta-analyses included additional research questions, which were not pertinent to our particular investigation, for example, the cost of PBL compared to traditional classrooms. We summarized only the research revolving around the effectiveness of PBL as a learning strategy compared to the traditional classroom approach.

Albanese and Mitchell (1993) focused on the English-language international literature from 1972 to 1992 to gain insight into the effectiveness of PBL within the domain of medical education. They reviewed ten studies that provided data on outcome measures of basic science knowledge, measured by the National Board of Medicine Exam (NBME 1), and seven studies that reported outcome measures of clinical knowledge and performance (NBME 2). NBME 1 assesses understanding and application of important concepts of the sciences basic to the practice of medicine, with special emphasis on principles and mechanisms underlying health, disease, and modes of therapy. NBME 2 assesses application of medical knowledge, skills, and understanding of clinical science essential for the provision of patient care under supervision and includes emphasis on health promotion and disease prevention.

Research questions by Albanese and Mitchell (1993) included: Do PBL students develop the cognitive scaffolding necessary to easily assimilate new basic sciences information? To what extent are PBL students exposed to an adequate range of content? Does faculty dislike PBL because of the concentrated time commitment required? Results of assessments of basic science knowledge indicated an overall negative effect size (ES), meaning that students engaged in the traditional classroom learning approach tended to perform better on the standardized tests (NBME 1). The authors augmented the results with two additional points. The first was that standardized examinations "have been criticized for providing only a measure of the examinee's ability to recognize the correct answer from a limited list of potentially correct answers and of being heavily oriented toward recall" (p. 56). The second point was that, although the ES favored the traditional approach and the expectation was that PBL students would not perform as well in the area of basic science knowledge assessments, this assumption was "not always true" (p. 57). However, the authors took this tendency as evidence of support for inadequate cognitive scaffolding development on the part of PBL students, as well as support for the idea that PBL students may not have adequate exposure to a range of content. Interestingly, though, the results also indicated that PBL graduates did perceive that they were disadvantaged relative to their traditional learning counterparts. However, they viewed themselves as better prepared in self-directed learning skills, problem-solving, information gathering, and self-evaluation techniques. Results also indicated that the rates at which PBL graduates were selected for their first choice residency positions were higher than for traditional program graduates.

Vernon and Blake (1993) focused on 22 studies within the period from 1970 to 1992. Their study selection parameters included all identifiable research on health-related educational programs that contained significant PBL emphasis. That is, the studies used quantitative methods, provided data that compared PBL with more traditional educational methods, and measured outcomes that were of an evaluative nature. They excluded studies that were only descriptive or provided no comparison of the two learning approaches, PBL and traditional. The purpose of their research was to summarize all available data that compared PBL with more traditional education methods, to analyze variations via meta-analytic techniques, and to review perceived strengths and weaknesses of research in this field. The results indicated that, in terms of academic achievement (knowledge tests), the results for standardized NBME 1 assessment outcomes showed significant trends favoring students engaged in the traditional learning approach. For clinical knowledge and performance outcomes (NBME 2), results slightly favored the PBL students, while assessment outcomes of clinical performance (observation-based supervisor ratings) significantly favored the PBL students.

Berkson (1993) did a narrative review of 10 pre-1992 studies, seeking evidence of the effectiveness of the PBL curriculum in medical education. Her research questions included: Does PBL teach problem solving better than traditional schools? Does PBL impart knowledge better than traditional schools? Does PBL enhance motivation to learn medical science better than traditional schools? Does PBL promote self-directed learning (SDL) skills better than traditional schools? Berkson's review indicated that there was no evidence to suggest that a PBL approach taught problem solving better than the traditional approach. Results did not demonstrate an advantage of one approach over the other for imparting knowledge. However, results indicated that students and faculty favored PBL. In addition, academic achievement and knowledge assessment favored the traditional approach, while clinical assessments favored PBL. With regard to academic process, PBL students placed more emphasis on meaning (understanding) rather than reproduction (memory), which was the opposite pattern from students engaged in traditional learning methods. Berkson concluded that it was unlikely students will suffer detrimental consequences from participation in PBL programs.

Kalaian, Mullan, and Kasim (1999) focused on medical education studies from 1970 to 1997—22 studies on NBME 1 outcome measures, and 9 studies on NBME 2 outcome measures. The purpose of the research was to examine outcomes from primary research comparing impact of PBL and traditional curricula on NBME 1 and NBME 2. The set of primary studies reviewed included studies examined by previous reviews, augmented through online searches for studies within the 1970 to 1997 time parameter, and manual searches of medical education journals published in 1997. The exclusion criteria eliminated studies that did not provide data needed to compute ES for PBL and traditional learning approaches, as well as studies that examined only specific subtests of the NBME, rather than the overall NBME. The researchers found negative ES for NBME 1, and positive ES for NBME 2, which was consistent with previous findings that traditional learning approaches tended to produce better results for basic science knowledge, while PBL tended to produce better results for clinical knowledge and skills.

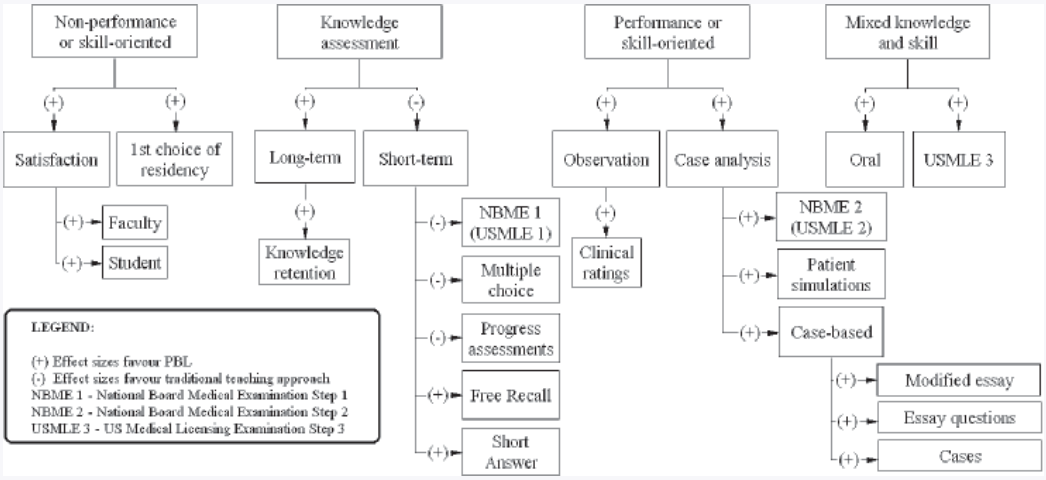
Colliver (2000) reviewed the medical education literature, starting with three reviews published in 1993 (Albanese & Mitchell; Vernon & Blake; Berkson) and included studies published from 1992 to 1998 comparing PBL to the traditional curriculum. The purpose was to focus on the credibility of claims about ties between PBL intervention and educational outcomes, particularly achievement (knowledge and skills), and on effect sizes of the intervention on said outcomes. As a study selection strategy, Colliver's search was limited to those articles that involved a comparison of curriculum tracks or schools. Where effect sizes were not provided, Colliver calculated them himself. Results indicated that there was no convincing evidence that PBL improved the knowledge base and clinical performance, at least not to the extent that may be expected for a PBL curricular intervention. Colliver acknowledged that PBL may provide a more challenging, motivating and enjoyable approach to medical education, as noted in the earlier research findings on student and faculty satisfaction and motivation, but claimed that its educational effectiveness, compared to traditional methods, remained to be seen.

Dochy, Segers, Van den Bossche, and Gijbels (2003) reviewed 43 studies, where 33 of them measured knowledge effects and 25 of them measured application of knowledge effects. Their study selection criteria stipulated that the work had to be empirical. Although nonempirical literature and literature reviews were selected as sources of relevant research, this literature was not included in the analysis. The characteristics of the learning environment had to fit the core model of PBL. The dependent variables used in the study had to comprise an operationalization of the knowledge or skills (i.e., knowledge application) of the students. The subjects of study had to be students in tertiary education. Also, the study had to be conducted in a real-life classroom or programmatic setting rather than under more controlled laboratory conditions. Research questions were: What are the effects of PBL on knowledge and skills? What are the moderators on the effects of PBL? Results indicated that assessment methods that focus more on recognition (e.g., NBME 1), showed significant negative effects for almost all knowledge and favored the traditional learning approach. Assessment methods that focused more on application of knowledge (e.g., NBME II) showed larger effects for PBL versus traditional learning environments. Researchers stated that the better an instrument was able to evaluate students' skills, the larger the ascertained effects of PBL.

Newman (2003) selected studies cited in the following papers which provided evidence of the effectiveness of PBL: Albanese and Mitchell (1993); Vernon and Blake (1993); Berkson (1993); Smits, Verbeek, and De Buisonje (2002a); and Van Den Bossche, Gijbels, and Dochy (2000). The final count was12 studies with extractable data in the medical education domain. The minimum criteria for study selection consisted of only including participants in postschool education programs. Study designs had to be controlled trials; studies that used only qualitative approaches were excluded. The minimum methodological inclusion criteria across all study designs were the objective measurement of student performance and behavior or other outcomes. The minimum inclusion criteria for interventions consisted of a cumulative integrated curriculum, learning via simulation formats that allowed free enquiry (i.e., not problem solving learning), small groups with either faculty or peer tutoring, and an explicit framework implemented in tutorials. Research questions included: Does PBL result in increased participant performance when compared to other non-PBL teaching and learning strategies? Does an authentic PBL curriculum deliver a greater improvement in performance than “hybrid” curricula? Results indicated that knowledge related outcomes favored the traditional learning environment. Also consistent with previous findings, study approaches and student satisfaction tended to favor PBL. However, improvements in applied practice returned mixed results, whereas previous studies reported better outcomes in a PBL environment.

Gijbels, Dochy, Van den Bossche, and Segers (2005) reviewed 40 studies that were published between 1976 and 2000. Study selection parameters stipulated that each study had to be empirical. Second, the characteristics of the problem-based learning environment had to fit the previously described core model of PBL (Barrows, 1996). Third, each study had to include some course or curriculum comparison between a PBL environment and a more traditional educational setting. Fourth, the study subjects had to be students in higher education. Finally, each study had to be conducted in a real-life classroom or programmatic setting rather than under more controlled laboratory conditions. The research question was: What are the effects of PBL when the assessment of its main goals focuses, respectively, on (1) understanding concepts, (2) understanding principles that link concepts, and (3) linking of concepts and principles to conditions and procedures for application? Results indicated that PBL students performed better at knowledge levels that emphasized principles (understanding the link between concepts) and application knowledge structures. The effect size of PBL interventions was larger when the assessment strategy focused on the understanding of principles that link concepts. Most studies reported positive outcomes of the traditional classroom approach on conceptual knowl-

Figure 1. *Map of learning outcomes.*



edge assessment, but when weighted average ES was taken in to account, PBL students performed at least as well as students in a traditional environment. This demonstrated the potential influence of the assessment strategy and tool on outcome measures. The authors stated that the better the capacity of an instrument to evaluate the application of knowledge by the student, the greater the ascertained effect of PBL.

In summary, the first general tendency of noted in the research was that traditional learning approaches tended to produce better outcomes on assessment of basic science knowledge but, according to Albanese and Mitchell (1993), not always. A second trend noted was that a PBL approach tended to produce better outcomes for clinical knowledge and skills. Interestingly, more recent research studies revealed that the assessment strategy and tool influence outcome measures.

Results and Discussion

We grouped and collapsed the data and established four high-level categories based on the assessment of learning outcomes. These four categories included:

- Non-performance, non-skill-oriented, non-knowledge-based assessment
- Knowledge assessment
- Performance or skill-based assessment
- Mixed knowledge and skill-based assessment

A map of effectiveness measures is shown in Figure 1. A detailed correlation matrix can be found in the appendix.

Trends in effect sizes were reported as overall tendencies based on the data, where the (+) symbol indicates that effect sizes favored PBL, while the (-) symbol indicates that effect sizes favored the traditional teaching and learning approach.

In the category coded as *Non-performance, non-skill, and non-knowledge-based,* which included student and faculty satisfaction measures, as well as successful assignment of first choice of residency, all the reported effect sizes favored PBL.

For the *Knowledge assessment* category, measures of short-term knowledge acquisition and retention returned mixed results, but tended to favor traditional learning approaches. With assessments delivered immediately post-course (Albanese & Mitchell, 1993; Dochy et al., 2003), outcomes of knowledge measures such as NBME 1 (assesses understanding and application of important concepts of the sciences basic to the practice of medicine), multiple choice questions, progress assessments using 250 True/False questions favored the traditional learning approach (Newman, 2003, who only discusses NBME 1). However, outcomes of knowledge measures that focused more on recall over recognition, such as free recall, where students were asked to write down everything they remembered on a topic, and short answer, which allowed for elaboration of answers, favored PBL (reported by all other systematic reviews which discussed both NBME 1 and 2).

Knowledge assessment that focused on long-term knowledge retention, described by Albanese and Mitchell (1993) as a comparison of immediate post-course results and results of the same test applied after a period of between 12 weeks to 2 years, returned effect sizes that consistently favored PBL. Dochy et al. (2003) looked only at whether a retention period existed and compared knowledge outcomes on the basis of retention period or no retention period. Long-term knowledge retention favored PBL.

The *Performance or skill-based assessment* category included observations with clinical ratings (formative assessment by supervisor during and at the end of performance) and case analysis measures. Clinical ratings favored PBL. The case analysis sub-category, which included measures from the NBME 2 (assesses application of medical knowledge, skills, and understanding of clinical science), patient simulations, and elaborated assessments such as essay questions and case studies, also favored PBL.

The final category, *Mixed knowledge and skill*, captured results that required both knowledge and skill for performance—oral examinations and the USMLE 3 (assesses application of medical knowledge and understanding of biomedical and clinical science essential for the unsupervised practice of medicine, with emphasis on patient management). The outcomes in this category favored PBL.

Specifically, to answer our first research question of how differences in (a) the definition of learning, and (b) the measurement of learning contribute to the inconclusiveness of the different meta-analyses with regard to the effectiveness of PBL, the discrepancy in reported results on the effectiveness of PBL for knowledge retention seemed to stem particularly from the differences in seeing learning as long-term (PBL favorable) and short-term retention of knowledge (traditional teaching methods favorable). Additionally, conceptualizations and consequently measurements of learning, which focused on the performance and were skill-oriented, indicate that PBL students outperformed traditionally taught students. The focus on short-term learning gains as a measurement of PBL seem a particular mismatch considering that learning within an authentic context is a key criterion of the definition of PBL (Barrows, 2002).

Overall, students and staff indicated greater satisfaction with the PBL approach to learning. Standardized tests that measured knowledge of basic science focusing on short-term acquisition and retention (primarily the medical board exams in their different versions) favored the traditional approach across all studies. However, when the method used to assess basic science knowledge required a level of elaboration beyond multiple-choice or true/false questions, results significantly favored the PBL approach. Standardized tests and other assessment methods that evaluated skill-oriented application of knowledge, mixed knowledge and long-term retention of knowledge, skills, and clinical performance significantly favored PBL.

As to our second research question, several value statements can be made about the effectiveness of PBL that were supported by the majority of the meta-analyses reviewed:

PBL instruction was effective when it came to long-term retention and performance improvement. PBL students were overall slightly underperforming when it came to short-term retention. Ultimately, the goal of instruction should be performance improvement and long-term retention. Therefore, preference should be given to instructional strategies that focus on students' performance in authentic situations and their long-term knowledge retention, and not on their performance on tests aimed at short-term retention of knowledge.

Conclusion

Instruction is often designed based on the assumption that learning is "a similar process in all individuals and for all tasks and thus many people feel a common instructional approach should suffice" (Clark 2000, p. 31). PBL is not the only successful strategy to achieve effective learning of ill-structured and complex domains. The results of these qualitatively synthesizing meta-analyses of PBL for preparation for the workplace indicate, however, that PBL is significantly more effective than traditional instruction to train competent and skilled practitioners and to promote long-term retention of knowledge and skills acquired during the learning experience or training session.

Future directions

The vast majority of research on the effectiveness of PBL has been conducted in the training of professionals in the field of medicine. Similarly solid research base is needed in other disciplines and contexts such as K-12 education, history, or engineering, to (a) expand the use of PBL in the learning environment and (b) to more clearly define the boundaries of its use.

Since the evidence suggests that PBL works in particular contexts, especially for workplace learning with a focus on skills and long-term retention, the focus should shift from researching effectiveness of PBL versus traditional learning, and should refocus on studying the differences in effectiveness of support structures to find optimal scaffolding, coaching, and modeling strategies for successful facilitation of PBL.

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Appendix

Correlation Matrix

1 = Albanese & Mitchell (1993)
2 = Vernon & Blake (1993)
3 = Berkson (1993)
4 = Kalaian, Mullan, & Kasim (1999)
5 = Colliver (2000)
6 = Dochy, Segers, Van den Bossche, & Gijbels (2003)
7 = Newman (2003)
8 = Gijbels, Dochy, Van den Bossche, & Segers (2005)

		STUDIES		1	2	3	4	5	6	7	8	Overall ES Trends	Favours
NON-PERFORMANCE, NON-SKILL, and NON-KNOWLEDGE-BASED	Satisfaction	Student		+	+			+				+	PBL
		Faculty		+	+							+	
	Residency	1st choice		+		+						+	
KNOWLEDGE ASSESSMENT	Short-term	NBME 1		-	-	-	-	-	-	-	-	-	Trad'l Learning
		MCQ			-				-	-	-	-	
		ShortAns							+		+	+	
		Progress							-		-	-	
		Free Recall							+		- /+	+	
	Long-term	Retention		+					+		- /+	+	
PERFORMANCE or SKILL-BASED ASSESSMENT	Case Analysis	NBME 2		+	+	+	+		+		+	+	PBL
		Sims							+		+	+	
		Case-based	Cases						+	+	+	+	
			MEQ			+			+	+	+	+	
			Essay						+		+	+	
	Observation	Rating		+	+			'+	+		+	+	
MIXED KNOWLEDGE and SKILL	Oral								+		- /+	+	PBL
	USMLE 3							-	+		+	+	