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The author acknowledges feedback on drafts of this commentary by John Mergendoller, John Larmer, and Jonathan Martin, as well as Johannes Strobel, Andrew Walker and Peg Ertmer.

Summarizing Findings and Looking Ahead to a New Generation of PBL Research

Jason Ravitz

Abstract

The articles in this issue effectively summarize three decades of Problem Based Learning (PBL) research. The meta-analysis (Walker & Leary) and meta-synthesis (Strobel & van Barneveld) articles review outcomes of studies conducted from 1976 to 2007 that compared a PBL curriculum to a traditional curriculum. The third article offers a critique of assessments used in these studies. This commentary highlights the conclusions of the articles and their unique contributions to our understanding of PBL and the breadth of its impact. Issues to be addressed in future research are discussed.

Overview

Walker and Leary's meta-analysis is the most recent attempt to quantify the effect of PBL across a range disciplines, including an increasing number of studies outside of medical education. It also tries to account for specific features of PBL and the types of problems that were used. Strobel and van Barneveld provide a qualitative summary of previously conducted meta-analyses, resulting in an extensive list of outcomes that largely favor PBL over other teaching methods. All three articles emphasize the importance of assessing depth of learning, not just basic content knowledge on standardized tests. Belland, French, and Ertmer, in particular, highlight the difficulty of measuring different kinds of PBL outcomes and raise concerns about the quality of measures that have been used.

What do the studies say about PBL effectiveness?

The available evidence is promising. Compared to alternative teaching methods, PBL holds its own on standardized tests of concept knowledge and excels on other kinds of outcomes. Walker and Leary's meta-analysis combined 201 outcomes reported across 82 different studies. They focused on the average effect size of differences in studies comparing students who received a PBL-based curriculum to those who did not. Although

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some of the studies they reviewed reported that students in a traditional, non-PBL-based curriculum did better on standardized tests of basic concepts, others did not. Walker and Leary conclude that even on standardized tests of basic concepts "PBL is able to hold its own in comparison to lecture-based approaches" (p. 27). Moreover, both Walker and Leary and Strobel and van Barneveld determined that when studies use assessments measuring application of knowledge and principles, the results clearly favor PBL.

The kind of assessment that is used has a strong influence on PBL outcomes. PBL impacts are most favorable when a wide range of outcomes are measured. In some of the meta-analyses that Strobel and van Barneveld reviewed, PBL was less effective for short term learning, but they suggest that it was more valuable in promoting other kinds of long term and application-based outcomes. For example, they cite the results of Dochy, Segers, Van den Bossche, and Gijbels, who concluded that "the better an instrument was able to evaluate students' skills, the larger the ascertained effects of PBL" (p. 51).

PBL is effective for outcomes beyond standardized tests. For example, Strobel and van Barneveld conclude that "a PBL approach tended to produce better outcomes for clinical knowledge and skills" (p. 53). They cite Vernon and Blake (1993), who found that clinical performance ratings for medical students "significantly favored PBL students" (cited in Strobel & van Barneveld, p. 50). In addition, although PBL students felt disadvantaged in preparation for standardized tests, they more often were accepted to their first choice of residencies, and felt better prepared to use "self-directed learning skills, problem-solving, information gathering, and self-evaluation techniques" (Albanese & Mitchell, cited in Strobel & van Barneveld, p. 49).

PBL shows considerable promise outside of medical education. While PBL generally "broke even" in studies of science, engineering, and medicine, the most favorable results for PBL appeared in studies of teacher education, social science, business, allied health, and other disciplines. Walker and Leary found that it is in these non-medical disciplines where new problem types are most likely to be explored, e.g., "strategic performance" and "design" problems that so far have had better outcomes than comparison treatments.

The future of PBL research

This section highlights issues to be addressed by future PBL researchers concerning how PBL is designed and implemented, and how outcomes are assessed.

Studies must specify how PBL is used in different disciplines and contexts. Barrows' (2002) definition of PBL from medical education continues to be a widely accepted definition, used by all three sets of authors in this issue. While this definition has served the field well and continues to be a touch-stone, it is important to look for variations, particularly in new disciplines and contexts. In addition, depending on the purpose of their investigation, researchers of PBL may want to include attention to curricula that calls itself project-

based, inquiry-based, design-based, challenge-based, etc. Although there are differences among these variations the similarities are more significant, allowing them to be viewed as "close cousins" with many similar characteristics (Barron and Darling-Hammond, 2008; Savery, 2006).

We need studies that inform practice and studies that inform policy. There is a tension between these research approaches. Looking at PBL from a great distance, as in a meta-analysis of outcomes, it becomes difficult to focus on critical details concerning variations in interventions, comparison treatments, and outcomes. Strobel and van Barneveld consider the case to be closed concerning the overall effectiveness of PBL. They call for studies that look more closely at which specific PBL practices are effective, and ways to improve PBL processes by finding "optimal scaffolding, coaching, and modeling strategies for successful facilitation of PBL" (p. 55).

Specific mechanisms that contribute to its PBL's effectiveness should be identified. Walker and Leary reported that studies often lacked basic information about the type of problems (e.g., as identified by Jonassen, 2000) and methods used. Although they found promising results for "strategic performance" and "design" problems, relevant information about other types of problems and PBL practices were not available to examine. "There may well be a relationship between PBL method and problem type that we simply do not yet have enough data to reveal" (p. 29). Walker and Leary were able to identify favorable results for "closed-loop" PBL in which learners were "asked to revisit the problem to determine any improvements they could make to their reasoning process" (p. 18). It is useful to consider other sources of variation. One might contrast a "delayed teaching" approach that creates a need for and interest in information before it is presented, to a "pre-teaching" approach in which teachers provide information prior to a problem beginning, or to an approach where students rely on themselves and each other to find information using available technologies.

Studies should avoid emphasizing a false dichotomy between PBL and traditional instruction. Although it is doubtful that either traditional instruction or PBL exists in "pure" forms, studies almost always have focused on comparing "the effectiveness of PBL versus traditional learning approaches" (Strobel & van Barneveld, p. 47). An exception is Newman (1993, cited in Strobel & van Barneveld, p. 52) who reported mixed results for PBL compared to different comparison treatments. In fact, it has long been acknowledged that PBL itself can take different forms that are worth exploring (Walker and Leary, p. 13), including variations in how much learning is directed by teachers or students within a single problem or across an entire course or curriculum.

The role of content lectures or whole-class discussions within PBL should be considered. Definitions of PBL frequently indicate that teachers in PBL act as facilitators and may "forgo lecturing" about content and focus instead on facilitation strategies and scaffolds for learning (e.g., Hmelo-Silver & Barrows, 2006). Although lectures may play a role, one

of the original intentions for PBL was to promote self-directed learning among medical students who ultimately expected to obtain and process information without direct instruction (Barrows & Tamblyn, 1980, cited in Belland, French, & Ertmer, p. 63). In other educational settings, students more often may need to be presented with key concepts at critical junctures during problem solving. In these cases, PBL is used to stimulate interest in lectures, to make them relevant and meaningful, not to forgo them entirely (e.g., see Maxwell, Bellisimo, & Mergendoller, 2001). There is a hypothesis that knowledge and skills learning is enhanced by being grounded in an application-level problem, offering better teachable moments and opportunities to learn. When viewed in this way, the distinction between traditional and PBL instruction may really be one of emphasis, leaving room for multiple approaches to be used and studied.

Issues related to outcome measures

PBL student learning outcomes should be defined or measured in agreed upon ways. The use of standardized tests assessing different levels of learning has been critical in understanding the effectiveness of PBL in medical education. In other disciplines it will be important to identify key outcomes to assess, including whether there are appropriate standardized tests of learning in each discipline. These can provide comparisons on which PBL should at least "break even." Other outcomes should address long-term application of skills, gains in knowledge or performance over time, and performance on more complex performance-oriented transfer tasks (Bransford & Schwartz, 1999). The challenge, as noted by Belland, French and Ertmer, is to find or create high quality assessments that are aligned and valid with respect to the specific content, context, and learning objectives of each PBL study. Belland, French and Ertmer emphasize that the results of PBL studies are far too often based on unreliable or invalid measures. In particular, they cite concerns with insufficiently specified or measured outcomes concerning deep content learning, problem-solving ability, and self-directed learning. Attention to the importance of these kinds of outcomes has led to large-scale assesment efforts of college and workplace readiness (Association of Colleges and Universities, 2002, Silva, 2008). While Belland et al. are correct to offer guidance for constructing specific measures that are appropriate for each study, the availability of large scale assessments of critical thinking for college and high school students could be very beneficial for PBL research.

Many medical school studies have focused on the clinical knowledge of medical school residents as a long term learning outcome. It is not clear if there is an equivalent of "clinical knowledge" for K-12 or college students. Is it success in college, workplace success, or a satisfying post-school life? Indicators of high school success typically include student outcomes such as improved attendance and graduation rates, getting into college and staying in, obtaining good jobs, and so on. Some additional candidates for outcomes that may be

related to use of PBL include youth development outcomes such as autonomy and hopefulness (e.g., Newell & Van Ryzin, 2007) as well as development of 21st century skills (Barron & Darling-Hammond, 2008; Partnership for 21st Century Skills, 2007). Measures of these outcomes might be positively related to use of PBL and considered valuable indicators of effectiveness. In addition, PBL may lead to a variety of process outcomes (as discussed in Walker & Leary). In schools or classrooms that are using PBL we might look for changes in the nature of classroom interactions as well as increased student connectedness, engagement, motivation, or prolearning attitudes (e.g., Klem & Connell, 2004; National Resource Council, 2003). PBL may also promote student engagement in authentic intellectual work, which can lead to better academic outcomes (Fredricks, Blumenfeld, Friedel, & Paris, 2004; Mitchell, Murphy, Hafter & Shkolnik, 2004; Newmann & Associates, 1996).

Considering research designs

It is important to consider the context for PBL use, including control measures and variations in PBL implementation. The effectiveness of PBL may depend on a variety of factors that influence implementation and outcomes. These include the type of school environment and conditions. For example, in a K-12 context it is important to know if PBL is used by individual teachers or as part of a larger school wide reform that is compatible with PBL either by design is or through a change process (e.g., Blumenfeld, et al, 2000; Pearlman, 2002). Without paying attention to the contextual factors and the quality of implementation it is hard to attribute results (or lack of results) to the design of PBL (O'Donnell, 2008). It is also important to identify the intensity and duration of PBL practices. In medical school, a three year curriculum and testing cycle might be common. In contrast, K-12 teachers may devote only weeks or months to PBL, combining it with a variety of other instructional methods.

Studies should identify the kinds of students participating so it is clear to whom the results might generalize. Despite favorable findings concerning use with diverse students in an intensive intervention (Marx et al., 2004), there are concerns about the ability of PBL to be broadly useful. When students lack basic math and language skills these may influence how PBL can be used and its outcomes**.** It is not clear whether meta-analyses have accounted for student differences, whether the studies included randomly selected students, or controlled for entry performance by looking at learning gains. It would be useful to consider student characteristics, and whether a study demonstrates an effect across a variety of students, teachers, or schools.

Other sources of variation may include teacher effects and professional development. It is clear that use of both PBL and "traditional" teaching varies in effectiveness. Shulman (1990) argues that it is generally the teacher, not the curriculum, that matters most (in O'Donnell, 2008, p. 44). Within a particular study, some teachers who use a traditional

curriculum out-perform PBL teachers, and vice versa (e.g., Mergendoller, Maxwell and Bellisimo, 2006). Studies need to take into account the extent of teacher experience and content knowledge, as well as how extensively teachers have been prepared to do PBL. Meta-analyses could control for these and similar variables when they are available, while continuing to use studies that did not include these measures in the rest of their work.

Conclusion

The articles in this issue summarize PBL research to date. They point to promising results in medical education and to a new generation of PBL studies taking place outside the field of medicine. Some directions for future research have been suggested here including continuing efforts to specify PBL treatments, outcomes, and conditions. Future researchers can benefit by considering the issues discussed in this commentary and in each of the articles that follow.

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