

Distance PBL: Problem-Based Learning

In an Online Environment

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Introduction

Problem-based learning is a form of guided inquiry that is a key curricular component in many graduate and professional programs. Closely related to the case method, problem-based learning (PBL) offers small groups of students the opportunity to solve real-world problems through self directed learning, group interaction, the application of information resources, and the guidance of a tutor or facilitator.

Over the last decade, several schools and continuing education programs using PBL have experimented with some form of distance-based PBL. Some of these distance programs were primarily synchronous, others were asynchronous, and a few incorporated a distance component together with traditional, face-to-face PBL small groups. This paper examines research from the last ten years to determine whether distance-based PBL is as satisfactory and effective as traditional PBL. Questions addressed include:

1. Are students in distance-based PBL courses as satisfied with the learning experience as their counterparts in face-to-face PBL courses?
2. Do learners in distance-based PBL courses demonstrate the same acquisition and retention of knowledge as their face-to-face counterparts?
3. Does research suggest guidelines to follow when structuring either synchronous or asynchronous PBL?

This review is limited by methodological problems in the research literature. First, there were no large, randomized controlled trials comparing distance-based PBL with face-to-face PBL. Studies were usually small, program-based, prospective or retrospective analyses. Second, no studies were identified that directly compared synchronous PBL to asynchronous PBL. Because of the small sample sizes and program-based analyses, generalizations made from this set of studies should be tested in larger, controlled research trials before assuming applicability to all situations and populations.

Problem-Based Learning

Problem-based learning is a form of self directed learning using small group discussion, the integration of knowledge resources, and facilitator guidance to enable students to solve actual problems in a specific discipline. The PBL method was first used at Canada's McMaster University Medical School in 1969, but became widely known after the method was outlined in a 1980 book entitled *Problem-based learning: An approach to medical education* (Barrows & Tamblyn). Problem-based learning continues to have its deepest roots in medical education, and although Barrows was a U.S. physician, PBL methods gained stronger footholds in Canada and in the U.K. Other graduate and professional programs, particularly those in nursing and in the allied health sciences, utilize aspects of PBL. In some universities, PBL is gaining in importance in the undergraduate curriculum.

Problem-based learning has three goals. Within PBL, the student will:

1. Acquire a common body of knowledge in the discipline
2. Apply the acquired knowledge to real problems or scenarios
3. Develop effective self learning techniques and habits

Traditional PBL is usually organized around a “tutorial,” a small group session where students receive a problem and begin developing a plan of action by which to approach the problem. John Bligh (1995) outlines seven steps used in PBL tutorials:

1. Clarify terms and concepts
2. Define the problem or problems
3. Analyze the problem through brainstorming
4. List possible explanations
5. Formulate learning objectives and set priorities
6. Search for information outside of the group
7. Report back, synthesize, and test the information

The role of the teacher in PBL shifts from a traditional teacher who conveys information and knowledge through didactic lectures. Rather, the teacher becomes a “facilitator” or “tutor,” guiding students to ask pertinent questions, use appropriate resources, and hone critical thinking skills. A 1999 review synthesized existing literature on various tutor roles in PBL, and developed guidelines for effectiveness. The review found that most students new to either PBL or the content area benefit from more directive tutors with expert-level content knowledge. As students gain experience, they thrive in (and may demand) a less structured environment with “more leeway in deciding what and how they will learn” (Neville, p.400). Less directive tutors ask pointed questions, but do not share their knowledge over-enthusiastically. They encourage students to listen, they tolerate silence, allow learners to determine objectives and priorities, and encourage cooperation (p.395). Finally, an effective tutor provides corrective feedback during problem solving. Allowing learners to move forward with incorrect or incomplete understanding may limit the learner’s ability to transfer new knowledge to related problems. The tutor must therefore step in and guide the discussion back to the right track (p.396).

Effectiveness of PBL

A just-published review looked at empirical research on minimally guided instruction – a category to which PBL belongs – and found “the past half-century...has provided overwhelming and unambiguous evidence that minimal guidance during instruction is significantly less effective and efficient than guidance specifically designed to support the cognitive processing necessary for learning” (Kirschner, Sweller, & Clark, 2006, p.76). This cognitive and pedagogical research evidence points to the following reasons for the “failure” of PBL:

- PBL does not consider the interplay between working memory and long-term memory. It places a huge burden on the former, and does not support transfer to the latter (p.77).
- PBL confuses the way that an expert *practices* in his domain to the way one *learns* in that domain (p.78).
- PBL does not provide strong learning support for less able students, leading to a possible loss of learning for those students (p.81).
- PBL may hinder the development of forward reasoning, “which is a hallmark of expertise.” Experts use a schema of knowledge to recognize patterns and therefore identify a problem’s structure. Learning problem solving methods does not necessarily encourage schema acquisition or the ability to discard irrelevant information (p.83).

Because the effectiveness of PBL as an instructional strategy has been seriously called into question, this paper does not review distance-based PBL compared to more directed methods of distance education. Rather, it examines distance-based PBL in relation to face-to-face PBL in terms of student satisfaction, learning effectiveness, and communication methods.

Distance-Based PBL

Answering questions related to distance-based PBL is difficult, because published research in the field varies greatly in both quality and emphasis. Many published articles present single case studies, and do not compare data collected on the distance PBL with that from a control group. A few identified studies compared distance-based PBL groups to control groups, but these studies measured different variables, making it difficult to form conclusions.

Student Satisfaction

The first question to answer was whether learners in distance-based PBL groups were as satisfied with the learning experience as their counterparts in traditional PBL courses and workshops. Little research was found focusing on student satisfaction levels, though a few studies mentioned satisfaction as part of an overall evaluation of a program or project.

A study done at Iowa State University found a high level of student frustration regarding synchronous meetings in a problem-based unit offered in a biotechnology course (Cheaney & Ingebritsen, 2005). This is likely attributable to the University’s decision to limit interaction to text-based chat, since low bandwidth technologies made the course more accessible to a greater range of students. Text-only synchronous chat can be time-consuming and burdensome if participants aren’t fast typists or completely comfortable with the technology. The students also didn’t like having to find times at which everyone could attend the synchronous chat; this removed some of the flexibility inherent in distance education.

A 2003 study by Dennis directly compared distance-based PBL groups to face-to-face control groups. However, learner satisfaction was not a measured variable. The evaluation found that the distance groups spent a much greater time both on task and off topic than the face-to-face groups. When synchronous chat logs were analyzed, investigators found a high percentage, ranging from 24.5% to 37.8%, of irrelevant and off-topic exchanges (Dennis, p.206). This longer time on and off task indicates that distance groups were less efficient. It can be surmised, but not proven, that students were less satisfied with this outcome than their colleagues in traditional PBL groups.

A group of Dutch researchers evaluated student satisfaction with a distance-based component of an undergraduate medical curriculum. This study examined the use of a virtual learning environment (VLE) as a *supplement* to, rather than a replacement for, face-to-face PBL. Investigators collected data on the student's perceived value of the online component during each of three phases of PBL (preliminary phase, self study phase, and reporting phase). On a scale of one to ten, mean student response for value during the preliminary phase was 6.12, value during the self study phase was 7.05, and during the reporting phase 5.97 (de Leng, Dolmans, Muijtjens, & van der Vleuten, 2006, p.572). Study authors felt that "general assessment of the value of the VLE for the learning process...was disappointing" (p.574).

A small 2000 study of 15 family physicians evaluated participant satisfaction with a continuing medical education (CME) workshop offered via an asynchronous Internet bulletin board. The content was found satisfactory in terms of relevance to clinical practice, but the bulletin board itself was rated fairly low. On a scale of one to five, "The bulletin board was useful" had a mean rating of 3.5; "I received enough instruction in the use of the bulletin board" a mean of 3.6; and "I felt comfortable participating in the bulletin board" a mean of 3.6 (Sargeant et al., p.S51).

Chen, Shang, and Harris compared the case method (not strictly problem-based learning) used in a face-to-face environment to the same method in an online asynchronous environment (2006). The Chinese learning management system Xoops, similar to Blackboard or WebCT, was used in a Management Information Systems course. Students complained about the difficulty of reading other students' comments in the default discussion board hierarchy (p.85). Although this study did not measure motivation, authors theorized that "time delay and motivation issues in the [online] environment can lower the tension of interpersonal interaction, thereby reducing the effectiveness of higher level knowledge that can be realized by case-based teaching in the F2F environment" (p.74).

Knowledge Outcomes

More studies directly evaluated learning outcomes than student satisfaction, making this an easier question to address.

In their biotechnology course, Cheaney and Ingebritsen compared examination results from the distance-based PBL students with results from students who completed a

distance unit on the same content “using a lecture-based instructor-centered approach” (2005, Evaluation section, para. 2). Students in the PBL group scored one-half a letter grade lower on the exam covering this content than their counterparts. The study authors point out that higher-order learning – which is the focus of PBL – was great among the PBL group. They theorize that distance PBL may not facilitate lower-level learning including the recall and comprehension of factual information.

The 2003 Dennis study compared WebCT-based PBL groups to face-to-face PBL groups. The author found “no statistical difference between the means of the students based on the conditions of learning” (p.201). Students were enrolled in a Masters of Physical Therapy program at the Medical College of Georgia, and the learning outcomes were based on the final course grades. As stated earlier, the distance process was *less efficient* since WebCT groups spent more time on task. But there was no difference in *effectiveness* between the two delivery methods.

Chen, Shang, and Harris evaluated the case method in an online environment compared to the same content taught in a face-to-face environment (2006). Students were graded both on participation in the online case discussion, and on a written report that came out of the online discussion. Grades on the written case reports correlated with performance in the course based on the final grade, but grades on the online case discussion itself *did not correlate* with final learning outcomes. This indicated that “the online case discussion may not be an effective approach...[it] may not greatly help to improve an individual’s ability to solve case-related problems” (p.83). The investigators concluded that the online environment promotes motivation and participation rates (p.84) and for that reason a hybrid approach, blending online and face-to-face interaction, may be warranted for case-based learning.

Stromso, Grottum, and Lycke looked at student perceptions of their own self-learning strategies both before and after a distance problem-based learning unit (2004). This PBL unit was conducted during a clinical placement rotation in which medical students who had previously studied together on campus were scattered to multiple clinical sites. The researchers developed a questionnaire to determine 1) the influence of distance-based *discussion* on study strategies, and 2) the influence of the distance *tutor* on self study. At the end of the 12-week rotation, some interesting results were tabulated. Students indicated that they relied more on experts, and less on discussion with colleagues, at the conclusion of the PBL unit. This “significant decrease in the participants’ attitudes toward co-operation with fellow students...might be explained by the absence of fellow students on clinical placements” (p.396). Students used the Web more, and textbooks less, although textbooks remained the most popular knowledge resource (p.395). And finally, students expected “significantly less tutor guiding” (p.394) after the conclusion of the unit.

Chan, Leclair, and Kaczorowski (1999) conducted a continuing medical education (CME) workshop for two groups of family practice physicians via the Internet. They compared the results from an online, small-group PBL workshop with results from a group given access to Internet educational materials but no group interaction and

discussion. Learning outcomes were measured using multiple-choice pretests and posttests. There was no significant difference between the test scores of the two groups; interestingly, there was no significant difference between pretest and posttest scores, indicating a lack of effect of either Internet intervention (p.57).

One study did find a difference between the learning outcomes of students enrolled in a Web-blended problem-based learning course with those in a traditional PBL course (Taradi, Taradi, Radic, and Pokrajac, 2005). From 1996 to 2001, second year medical students at the University of Zagreb took an elective in acid-base physiology as a face-to-face PBL course. In 2002-2003, the course was offered in a hybrid Web/face-to-face format. Students in the hybrid course achieved significantly higher scores on the final evaluation than those in the traditional course (p.37). However, the experimental group was only half the size of the control group, and participants in the blended course were self selecting. It is also difficult to determine whether the increase in scores was due to the Web component, or to the restructured face-to-face sessions.

Synchronous versus asynchronous PBL

Unfortunately, no studies directly compared synchronous PBL to asynchronous PBL. The results of the existing research may allow some assumptions to be made, although the small sample sizes call for caution when making generalizations.

Of the eight studies consulted for this review, only four (Cheaney & Ingebritsen, Dennis, Stromso et al., and Taradi et al.) made use of synchronous discussion capabilities. The biotechnology at Iowa State was gradually phasing out synchronous interaction in favor of asynchronous communication. The other four interventions used asynchronous discussion in the PBL units. Two of the studies used Web-based PBL as an adjunct to traditional PBL (de Leng et al. and Taradi et al.) so the results of these blended interventions will not be considered in this section. The four remaining asynchronous interventions (Sargeant et al., Chan et al., Chen et al., and Cheaney & Ingebritsen) sought to answer different questions, so the results can not be combined in any statistically significant manner. However, a few similarities exist.

The Sargeant study (2000) looked at using an online bulletin board as a method of delivering continuing medical education (CME). Investigators found that most participants only logged on to the bulletin board once, and that most messages were posted during the last two weeks of the month-long course (p.S51). The learners tended to post messages but not respond to existing ones, meaning that actual "discussion" was sparse (p.S52). The lack of group discussion casts doubt on whether this intervention can truly be termed problem-based learning.

Similarly, a study by Chan and colleagues (1999) used email listserv software to deliver CME. The eleven participants sent only 24 messages over a two-month period (p.56). The lack of small group interaction again indicates that this was a case-based intervention, but not one that used true PBL methodology.

Chen's work with MIS students in Taiwan (2006) found more active discussion on asynchronous bulletin boards, but like the participants in the studies above, many students waited until the end of the semester to start posting. Dividing the total number of cases by the total number of student messages showed that students posted an average of only one message per case: "This finding indicates that most of the students were not motivated to learn via the online discussion forum" (p.81).

At the Medical College of Georgia, synchronous chat was the means by which students generated and discussed learning issues, and then reconvened to pose potential solutions to the problems (Dennis, 2003). Analysis of the chat room logs identified quite a few off-topic remarks, as well as longer time on task than the comparative face-to-face groups (p.207).

Discussion

Eight studies were reviewed in this paper. None were randomized controlled trials, and none measured the same endpoints as any of the other studies. Can educators make any assumptions from all of this disparate research?

The first question asked about student satisfaction with distance-based PBL. The research indicates that there are significant hurdles to overcome for students to be satisfied with the distance learning PBL experience. Neither synchronous nor asynchronous methods were rated highly in any of the studies which asked students to evaluate value or satisfaction.

These findings point to the need to require learners in an asynchronous PBL course to log in regularly and often, and to respond to the postings of colleagues in addition to making their own. Only then will distance-based PBL simulate the rich, back-and-forth discussion that is such an important part of traditional PBL. These findings also demonstrate the need for clear instruction on the roles and importance of small groups in the PBL methodology. Newcomers to both problem-based learning and the online environment should be given instruction in both – not just instructions on how to use the online tools. The lack of substantive discussion in all of the studies indicates that asynchronous bulletin boards may not be the best method of small group PBL interaction.

The fact that students spent more time both on and off task in synchronous discussion groups could be explained by two factors:

1. The facilitator was not trained in ways to keep the online discussion focused and efficient.
2. The students needed extra time and off-topic chat to "build community" in the online environment.

This result may indicate that synchronous online PBL groups should be expected and allowed to spend additional time developing personal relationships and building a

learning community. These outcomes are more natural, perhaps even effortless, in a traditional classroom. This finding also points out the need to have highly trained online facilitators who are familiar not just with the content and with the PBL method, but with strategies for structuring and directing online discussion.

The second question asked whether learning outcomes in distance-based PBL matched those of comparable face-to-face PBL courses. Results were mixed. One CME workshop found no significant difference between a group of learners enrolled in an Internet PBL course and a similar group given access to materials but not to discussion or colleagues. This finding initially sounds encouraging, until study authors revealed that neither group scored better on the post-test than on the pre-test. In this case, Internet-based CME was not a successful intervention.

A group of Iowa State students did a PBL unit in a distance-based biotechnology class. These students scored one-half a letter grade lower on a test covering the material than colleagues covering the same material in a traditional lecture-based format. The study authors theorized that PBL may be best suited to teach higher-level and critical thinking skills rather than lower-level recall of facts, concepts and procedures. This insight provides guidance for the appropriate use of PBL in a distance environment. As stated earlier, authors of a recent review of minimally guided instruction pointed out that novices learn a content area differently than experts practice using that content. Perhaps PBL has a place in upper level and expert level courses and workshops, rather than at the beginning of an individual's study of a particular subject.

In two studies reviewed, distance-based PBL took place in conjunction with face-to-face sessions. This made it difficult to evaluate the distance intervention by itself, as outcomes could not be traced back to the online portion of each course. In one blended learning solution, learning outcomes were higher when compared with outcomes from the same course taught in the classroom only. In the second blended learning intervention, students thought the virtual learning environment supported preliminary discussion and later case reporting, but not the self study process within PBL. Further research is needed on the value of the online environment at different points in the PBL process.

Conclusions

Insufficient evidence exists to recommend a distance-based approach to problem-based learning. In fact, several existing barriers are so large that educators should recommend *against* using distance-based PBL at this time. Problem-based learning appears to be very effective when certain conditions are met:

- Groups are led by a very effective tutor, comfortable with both the subject matter and the PBL process.
- Friendly but competitive discussion takes place in small groups.
- Students know each other, work efficiently together, and enjoy interactive problem-solving.

These conditions are extremely difficult to meet in distance education. Distance learning environments are becoming more sophisticated, but still cannot mimic the rich discussion, discovery, and community available to students in a traditional classroom. For these reasons, PBL should be left to that traditional classroom until educators, instructional designers, and course developers can design creative solutions to overcome the communication and technical barriers of existing systems.

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