Health Professions Education

Volume 2 | Issue 2 Article 3

2016-10-10

Problem-Based Learning: An Overview of its Process and Impact on Learning

Elaine H.J. Yew
Office of the Provost, Singapore Management University, Singapore, elaineyew@smu.edu.sg

Karen Goh
Centre for Educational Development, Republic Polytechnic, Singapore

Recommended Citation

Yew, Elaine H.J. and Goh, Karen (2016) "Problem-Based Learning: An Overview of its Process and Impact on Learning," *Health Professions Education*: Vol. 2: Iss. 2, Article 3.
DOI: 10.1016/j.hpe.2016.01.004
Available at: https://hpe.researchcommons.org/journal/vol2/iss2/3

Available online at www.sciencedirect.com

ScienceDirect

Health Professions Education 2 (2016) 75–79

www.elsevier.com/locate/hpe

Problem-Based Learning: An Overview of its Process and Impact on Learning

Elaine H.J. Yew[a,*], Karen Goh[b]

[a]*Office of the Provost, Singapore Management University, Singapore*
[b]*Centre for Educational Development, Republic Polytechnic, Singapore*

Received 14 January 2016; accepted 17 January 2016
Available online 4 May 2016

Abstract

In this review, we provide an overview of the process of problem-based learning (PBL) and the studies examining the effectiveness of PBL. We also discuss a number of naturalistic and empirical studies that have examined the process of PBL and how its various components impact students' learning. We conclude that the studies comparing the relative effectiveness of PBL are generally consistent in demonstrating its superior efficacy for longer-term knowledge retention and in the application of knowledge. Studies on the process of PBL, however, are still inconclusive as to which component(s) of PBL most significantly impact students' learning, although causal studies have demonstrated that all the phases of PBL are necessary in influencing students' learning outcomes.

Keywords: Problem-based learning; Learning processes; Small-group collaboration; Self-directed study; Effectiveness of learning

1. Introduction

Problem-based learning (PBL) has been widely adopted in diverse fields and educational contexts to promote critical thinking and problem-solving in authentic learning situations. Its close affiliation with workplace collaboration and interdisciplinary learning contributed to its spread beyond the traditional realm of clinical education[1] to applied disciplines such as health sciences, business studies and engineering. With this growing practice and popularity of PBL in various educational and organisational settings,[2–4] there has been an increasing number of studies examining its effectiveness on the quality of student learning and the extent to which its promise of developing self-directed learning habits, problem-solving skills and deep disciplinary knowledge[5–7] achieves its intended result. Much of the earlier studies on PBL have examined the effects of this approach within the curriculum,[8,9] with more recent studies delving deeper to examine how the processes within PBL lead to positive learning outcomes. This paper reviews a number of studies on the effectiveness and impact of PBL and how students learn in the process.

2. Overview of PBL

In brief, PBL is a pedagogical approach that enables students to learn while engaging actively with

*Correspondence to: Singapore Management University, 81 Victoria Street, Singapore 188065, Singapore. Tel.: +65 97621777.
E-mail address: elaineyew@smu.edu.sg (E.H.J. Yew).
Peer review under the responsibility of King Saud bin Abdulaziz University for Health Sciences.

http://dx.doi.org/10.1016/j.hpe.2016.01.004

meaningful problems. Students are given the opportunities to problem-solve in a collaborative setting, create mental models for learning, and form self-directed learning habits through practice and reflection.[8,10,11] Hence, the underpinning philosophy of PBL is that learning can be considered a "constructive, self-directed, collaborative and contextual" activity.[12] (p39) The principle of constructivism positions students as active knowledge seekers and co-creators who organise new relevant experiences into personal mental representations or schemata with the help of prior knowledge.[13,14] This is further reinforced by social theories of learning that postulate the merits of social interaction in cognitive development.[15]

In a typical PBL setting, learning is triggered by a problem which needs resolution. Dewey explains the cognitive element of learner engagement by describing how the origin of thinking is some "perplexity, confusion, or doubt" that is triggered by "something specific which occasions and evokes it."[16] (p12) Students make connections to this "perplexity, confusion, or doubt" by activating their individual and collective prior knowledge[17] and finding resources to make sense of the phenomenon; they also engage in peer learning through small-group discussions[18] and consolidate their learning through reflective writing.[19] Beyond enabling students to make sense of the concepts and subject matter, this learning experience is also likely to help students "develop understandings of themselves and their contexts, and the ways and situations in which they learn effectively".[20] (p9)

PBL as a pedagogical strategy appeals to many educators because it offers an instructional framework that supports active and group learning—premised on the belief that effective learning takes place when students both construct *and* co-construct ideas through social interactions and self-directed learning.[21,22] Its implementation can vary across institutions and programmes, but in general, it can be viewed as an iterative process made up of first, a problem analysis phase, a period of self-directed learning and lastly, a reporting phase.[8,23,24] A tutor—also known as a facilitator—acts as a guide to scaffold students' learning, particularly in the problem analysis and reporting components of the PBL tutorial, as well as facilitate students' inquiry paths as they make sense of their ideas through discussion and sharing.

3. Studies on the effectiveness of PBL

Proponents of PBL claim that it helps improve the quality of learning by developing students' reflective, critical and collaborative skills. Studies on the effectiveness of PBL appear to be mixed, but have generally shown that students who have experienced PBL achieve similar or less learning gains when it comes to short-term knowledge acquisition when compared to students in a lecture-based learning environment.[25] However, in terms of longer-term knowledge retention, the results are significantly in PBL's favour.[9,26] In particular, Strobel and van Barneveld[27] analysed a number of meta-analyses on the effectiveness of PBL and found that PBL is more effective than traditional approaches when the measurement of learning outcomes focused on long-term knowledge retention, performance or skill-based assessment and mixed knowledge and skills. It was only when the focus was on short-term knowledge acquisition and retention that PBL appeared less effective. PBL therefore appears to be a superior and effective strategy to "train competent and skilled practitioners and to promote long-term retention of knowledge and skills acquired during the learning experience" [27] (p55).

The majority of studies on the effectiveness of PBL has focused on the field of medicine. Studying the effect of PBL in applied domains and professional education also offers new perspectives on its influence on student learning outcomes. The field of nursing education, in particular, has devoted a substantial amount of research to exploring the effectiveness of PBL in healthcare training in order to prepare nursing professionals for a growing range of patient care services. A meta-analysis of studies related to the effectiveness of PBL in nursing education[28] revealed that PBL has positive effects on student satisfaction with training, clinical education and skills development. Another review of related literature on the effect of PBL on developing nursing students' critical thinking[29] showed a positive relationship between the implementation of PBL as an instructional model and improvements in critical reasoning. Many of these studies are often localised, and their results and methods—while not necessarily generalisable—provide some pedagogical value as guidelines for nurse educators in considering training frameworks to design and deliver healthcare curriculum. More rigorous research is needed to further examine the effects of PBL on student learning outcomes and performance in both academic and workplace situations.

A recent empirical study adds further evidence to the effectiveness of PBL. The authors randomly assigned groups of students to one of three conditions (PBL, lecture-based or self-study groups) and found that students in the PBL group had a higher likelihood of

conceptual change, outperforming those assigned to both of the other two conditions in conceptual tests immediately after the lesson, as well as in a delayed post-test after one week.[30] Although this study is useful in supporting the efficacy of PBL, the authors acknowledged that more still needs to be done to better understand the processes involved within the PBL framework that enhance learning.

The next part of the review focuses on studies that have attempted to examine in greater detail the processes and mechanisms where PBL achieves its effectiveness.

4. Studies on the process of PBL

There are a number of naturalistic descriptive studies on the process of PBL. One such study analysed the students' collaborative interactions in the problem analysis and reporting phases of the PBL process,[31] with the authors finding out that elaborations and co-constructions both occurred during these PBL phases, but that elaborations were taking place less frequently compared to co-constructions. In a follow up study, the authors illustrated in detail the impact of collaboration on learning, showing how questions, reasoning and conflict led to elaborations and co-constructions by students during the reporting phase.[32] However, there were no descriptions of the self-directed learning phase of the PBL cycle. The study also did not examine how (if at all) such interactions impact on students' learning achievements.

Another study similarly analysed in detail how students construct their knowledge in a PBL tutorial throughout the problem analysis and reporting phase. [33] The discourses of students and facilitators were examined and described to show how both groups played important roles in the collaborative and collective knowledge building. This study provided important insights into how an expert facilitator effectively used open-ended metacognitive questions to facilitate students' discussion and how students' collective knowledge developed throughout verbal interactions within the PBL tutorial. However, the relationship, if any, between the quality of students' verbal contributions with their subsequent learning achievements were not examined here.

The studies discussed above mainly examined two of the PBL phases—the problem analysis and reporting phases. However, there is much less research examining the phase of individual, self-directed study. One study examining the self-directed learning phase investigated the link between student-generated learning issues during the problem analysis phase with what students actually studied during their self-directed study time,[34] with results showing that students only made use of the learning issues that they generated in the problem analysis phase to determine their self-directed study activities to some extent: what they did during the self-study phase was also influenced by factors like tutor guidance and the availability of learning resources. Another study focusing on the self-study phase found that students who studied beyond the learning issues generated by the tutorial group during the initial problem analysis phase achieved better test results.[35] As both these studies relied on students' retrospective self-reports, these results may be somewhat biased.

Although the studies highlighted above provide insight into the specific learning phases of the PBL cycle, there are fewer studies which investigate the entire PBL process inclusive of all phases. One study tested a causal model relating input variables such as problem quality, tutor performance and students' prior knowledge; process variables such as group functioning and time spent on self-directed study; and learning outcomes.[36] The authors found that the quality of a problem influences group functioning, which in turn has a strong impact on how much time is spent on individual study. More time spent on individual study also led to increased learning achievements. This model was further refined in another study that examined in greater detail what actually happens to learners in the processes of problem analysis, individual study and reporting.[37] Here the authors found that the quality of learning issues generated during the problem analysis phase had an influence on the extent to which they were used during individual study. Increased usage of learning issues during self-directed study also had an impact on the quality of students' research in terms of orientating them towards deeper explanations, which then influenced the depth of discussions during the reporting phase. Finally, the 'depth' of reporting positively influenced the students' achievement.

Both of the above causal models are useful in helping us better understand the relationships among the key variables within the PBL process. However, as recognised by the authors, there is a limitation to both studies as the data were obtained from self-reports of students. It has been argued that the research required to understand how students' learning is impacted by the specific phases of the PBL process needs to be focused on the specific learning activities that take place within the phases.[38,39]

One study that attempted to focus on the activities taking place in the PBL process examined in detail the verbal interactions of the entire process of a PBL cycle, including the self-directed learning period.[6] The authors sought to investigate the extent to which PBL engenders certain learning dispositions towards constructive, self-directed and collaborative learning, since theories of learning assume that these learning activities are essential in the learning process. They observed all three activities within the PBL cycle under study, albeit to different extents, with 53.3% of episodes observed as being collaborative; 27.2% self-directed; and 15.7% constructive. Another study used structural equation modelling to demonstrate the validity of the PBL process of problem analysis, followed by self-directed learning, and a final reporting phase as described in the PBL literature.[40] Lack of fit of models with data showed that it is not possible to describe learning in PBL only in terms of collaborative learning, nor only in terms of individual self-directed learning. Rather, t as the sequential influence of one PBL phase to the next was essential in impacting student learning outcomes.

However, another study revealed different findings. Using a subtractive method, the authors showed that the effective component in PBL appears to be engagement with the problem rather than the social collaborative aspect—they found no significant difference in the performance of students who were assigned to a PBL team learning condition and those who were assigned to a PBL individual condition.[41] Both of these groups did significantly better than students assigned to the lecture condition. As the authors emphasised, this does not mean that the social collaborative component of PBL is not necessary; however, more rigorous studies are still required to ascertain the extent to which the various components of PBL impact students' learning.

5. Conclusion

In conclusion, the studies reviewed above suggest that PBL is an effective teaching and learning approach, particularly when it is evaluated for long-term knowledge retention and applications. One gap in earlier studies on the effectiveness of PBL is that the studies tended to focus on medical education. However, there are now increasing number of experimental studies in other disciplines that provide evidence of the superior performance of students learning in PBL conditions as opposed to lecture conditions.[30,41] In terms of which phases or components of the PBL process influence students' learning, causal models suggest that the PBL process, as described by the PBL literature, that begins with problem analysis, followed by self-directed learning and a subsequent reporting phase, is important to predict students' learning, and that having only the collaborative component or the self-directed learning component is insufficient.[40] However, another study suggests that student engagement with the problem is sufficient to enhance students' learning gains over the traditional approach and the collaborative component did not make a significant difference to student learning.[41] More rigorous controlled experimental studies therefore need to be carried out to further uncover the mechanisms behind how PBL works.

Disclosure

Ethical approval: Not applicable.
Funding: None.
Other disclosure: None.

References

1. Barrows HS. Problem-based learning in medicine and beyond: a brief overview. In: Wilkerson L, Gilselaers H, editors. *Bringing problem-based learning to higher education: Theory and practice*. San Franscisco, CA: Jossey-Bass Inc; 1996.
2. Barrett T, Moore S. *New Approaches to Problem-based Learning*. London: Routledge; 2010.
3. Schwartz P, Mennin S, Webb G. *Problem-based Learning: Case Studies, Experience and Practice*. London: Kogan Page; 2001.
4. Hung W, Loyens SM. Guest Editor's Introduction. *Interdiscip J Problem-based Learn* 2012;6(1).
5. Savery JR, Duffy TM. Problem based learning: an instructional model and its constructivist framework. *Educ Technol* 1995;35(5):31–37.
6. Yew EHJ, Schmidt HG. Evidence for constructive, self-regulatory, and collaborative processes in problem-based learning. *Adv Health Sci Educ* 2009;14(2):251–273.
7. Dolmans D, Gijselaers WH, Moust JHC, De Grave WS, Wolfhagen I, Van der Vleuten CPM. Trends in research on the tutor in problem-based learning: conclusions and implications for educational practice and research. *Med Teach* 2002;24(2):173–180.
8. Schmidt HG, Moust JHC. Factors affecting small-group tutorial learning: a review of research. In: Evensen DH, Hmelo-Silver CE, editors. *Problem-based Learning: A Research Perspective on Learning Interactions*. Mahwah, NJ: Lawrence Erlbaum; 2000. p. 19–52.
9. Dochy F, Segers M, Van den Bossche P, Gijbels D. Effects of problem-based learning: a meta-analysis. *Learn Instr* 2003;13(5):533–568.
10. Norman GR, Schmidt HG. The psychological basis of problem-based learning - a review of the evidence. *Acad Med* 1992;67(9):557–565.
11. Hmelo-Silver CE. Problem-based learning: What and how do students learn?. *Educ Psychol Rev* 2004;16(3):235–266.

12. Dolmans D, De Grave W, Wolfhagen I, van der Vleuten CPM. Problem-based learning: future challenges for educational practice and research. *Med Educ* 2005;39(7):732–741.
13. Derry SJ. Cognitive schema theory in the constructivist debate. *Educ Psychol* 1996;31(3 & 4):163–174.
14. Mayer RE. Learners as information processors: legacies and limitations of educational psychology's second metaphor. *Educ Psychol* 1996;31(3 & 4):151–161.
15. Vygotsky LS. *Mind in Society: The Development of Higher Psychological Processes*. Cambridge, MA: Harvard University Press; 1978.
16. Dewey J. *How we think*. Buffalo, N.Y: Prometheus Books; 1910/1991.
17. Barrows HS, Tamblyn RM. *Problem-based Learning: An Approach To Medical Education. New York*. Co: Springer Pub; 1980.
18. Barrows HS. *The Tutorial Process*. Springfield, Ill: Southern Illinois University School of Medicine; 1992.
19. Woods DR. *Problem-based Learning: Helping Your Students Gain the Most from PBL*. Waterdown, Ont.: D.R. Woods; 1994.
20. Savin-Baden M. *Problem-based Learning in Higher Education: Untold Stories*. Buckingham: Society for Research into Higher Education: Open University Press; 2000.
21. Glaser R, Bassok M. Learning theory and the study of instruction. *Ann Rev Psychol* 1989;40:631–666.
22. Palincsar AS. Social constructivist perspectives on teaching and learning. *Ann Rev Psychol* 1998;49:345–375.
23. Barrows HS. *The Tutorial Process*. Springfield, ILL: Southern Illinois University School of Medicine; 1988.
24. Schmidt HG. Foundations of problem-based learning - some explanatory notes. *Med Educ* 1993;27(5):422–432.
25. Pourshanazari A, Roohbakhsh A, Khazaei M, Tajadini H. Comparing the long-term retention of a physiology course for medical students with the traditional and problem-based learning. *Adv Health Sci Educ* 2013;18(1):91–97.
26. Capon N, Kuhn D. What's so good about problem-based learning?. *Cognit Instr* 2004;22(1):61–79.
27. Strobel J, van Barneveld A. When is PBL more effective? A meta-synthesis of meta-analyses comparing PBL to conventional classrooms. *Interdiscip J Problem-based Learn* 2009;3(1):4.
28. Shin I-S, Kim J-H. The effect of problem-based learning in nursing education: a meta-analysis. *Adv Health Sci Educ* 2013;18(5):1103–1120.
29. Oja KJ. Using problem-based learning in the clinical setting to improve nursing students' critical thinking: an evidence review. *J Nurs Educ* 2011;50(3):145–151.
30. Loyens SMM, Jones SH, Mikkers J, van Gog T. Problem-based learning as a facilitator of conceptual change. *Learn Instr* 2015;38:34–42.
31. Visschers-Pleijers AJ, Dolmans D, Wolfhagen IH, Van der Vleuten CP. Exploration of a method to analyze group interactions in problem-based learning. *Med Teach* 2004;26(5):471–478.
32. Visschers-Pleijers AJ, Dolmans D, de Leng BA, Wolfhagen I, Van der Vleuten CPM. Analysis of verbal interactions in tutorial groups: a process study. *Med Educ* 2006;40(2):129–137.
33. Hmelo-Silver CE, Barrows HS. Facilitating collaborative knowledge building. *Cognit Instr* 2008;26(1):48–94.
34. Dolmans D, Schmidt HG, Gijselaers WH. The relationship between student-generated learning issues and self-study in problem-based learning. *Instr Sci* 1995;22(4):251–267.
35. Van den Hurk MM, Wolfhagen I, Dolmans D, Van der Vleuten CPM. The impact of student-generated learning issues on individual study time and academic achievement. *Med Educ* 1999;33(11):808–814.
36. Gijselaers WH, Schmidt HG. Towards a causal model of student learning within the context of a problem-based curriculum. In: Norman Z, Schmidt HG, Ezzat E, editors. *Innovation in Medical Education. An Evaluation of its Present Status*. New York: Springer Publishing Company; 1990. p. 95–113.
37. Van den Hurk MM, Dolmans D, Wolfhagen I, Van der Vleuten CPM. Testing a causal model for learning in a problem-based curriculum. *Adv Health Sci Educ* 2001;6(2):141–149.
38. Dolmans D, Schmidt HG. What do we know about cognitive and motivational effects of small group tutorials in problem-based learning?. *Adv Health Sci Educ* 2006;11(4):321–336.
39. Hak T, Maguire P. Group process: The black box of studies on problem-based learning. *Acad Med* 2000;75(7):769–772.
40. Yew E, Chng E, Schmidt H. Is learning in problem-based learning cumulative?. *Adv Health Sci Educ* 2011;16(4):449–464.
41. Pease MA, Kuhn D. Experimental analysis of the effective components of problem-based learning. *Sci Educ* 2011;95(1):57–86.

Elaine H. J. Yew is Deputy Director at the Office of the Provost, Singapore Management University.

Karen Goh is Deputy Director at the Centre for Educational Development, Republic Polytechnic, Singapore.