PROBLEM-BASED LEARNING IN UNDERGRADUATE SCIENCE

In the PBL process, student learning is motivated using a problem, puzzle, or complex scenario presented in the same context, as it would be encountered in real life. Information needed to investigate the problem is not initially provided. Instead, when first presented with the problem, students organize their ideas and previous knowledge related to it, and attempt to define its broad nature. As they brainstorm initial hypotheses, the students find that they need to consult additional resources to fill in conceptual holes. They identify this needed information by posing questions that help to define why the information is needed − how it relates to the problem resolution. They then assign one another the responsibility for researching this information before the next class meeting, and discuss the best sources (textbook, library, Internet, etc.) for finding the needed information. When students reconvene, they teach one another the results of their research on the questions posed in the previous session, ideally integrating their new knowledge and skills into the context of the problem.

The students continue to define new areas of needed learning (digging progressively deeper into the underlying content and assumptions) as they work through the problem, which typically enfolds in several stages through progressive disclosure. The PBL cycle thus provides a means for students to learn concepts in the context of their applications, and a forum for them to hone their ability to think critically, to find and process new information, to communicate effectively, and to become influential members of productive teams.

Problem-based learning as a formal cycle of teaching and learning strategies had its origins in medical schools to facilitate learning basic science concepts in the context of clinical cases. In this earliest PBL setting, students typically worked in groups of eight to ten, guided by a faculty facilitator. The role of the group facilitator was to guide, probe, and support students' initiatives, not lecture, direct, or provide easy answers. The group facilitator thus monitored both the quality of the information and intellectual arguments, and the quality of group interactions.

This original medical school model is generally not applicable to typical undergraduate courses for many reasons, including class size. However, the collection of strategies encompassed by PBL can be reassembled in ways that are appropriate for undergraduate courses and students without necessarily comprising its essential nature.

For example, a faculty instructor can facilitate many classroom groups by serving as a “roving” facilitator who walks around the classroom to listen to groups’ conversations and pose and answer questions when appropriate. The PBL instructor in this setting may choose to use PBL problems that are structured so that they allow for natural interventions for instructor guidance, whole class discussions, or short clarifying lectures to move students beyond conceptual impasses.
The whole class discussions can be tailored to provide feedback on group progress, to challenge students to examine the underlying assumptions of evidence they apply to the problem's resolution, and to guide students by encouraging them to consult good quality resources. Faculty using this model in essence supply in a structured and planned way the guidance supplied in a more extemporaneous and informal way in the original PBL model.

Another model for monitoring multiple PBL groups in an undergraduate classroom is the use of peer group facilitators – undergraduates who have completed a PBL course who return to work alongside the faculty instructor as guides for one or more groups. In both instances, the roving facilitator or peer facilitator model, PBL in the undergraduate setting is accompanied by use of typical cooperative or collaborative learning structures – that is, drafting by students of group contracts or guidelines, rotation of student roles as group members (for example, recorder, reporter, discussion leader, accuracy coach), and peer evaluation of performance as group members.

The relative absence of PBL instructional materials can be a major roadblock to implementation of PBL in a particular discipline. To incorporate the goals of PBL, these problems must be complex enough to engage students attention for several class periods or longer, and challenge students to think critically as they explore new content areas.

Fortunately, collections of these materials are becoming more readily available – for example, the PBL Clearinghouse (accessible through a secure server at https://www.mis4.udel.edu/Pbl and the LifeLines OnLine collection offered through BioQUEST available at http://bioquest.org/lifelines; see PBL resources list).

My first encounter with PBL was introduced to the University of Delaware (UD) in 1992 in a workshop to prepare faculty to teach in a new Medical Scholars Program. A group of science faculty immediately recognized the potential of the method and adapted it to their introductory science courses.

PBL at UD has since expanded to impact thousands of students and 30% of the faculty in an array of undergraduate disciplines. My role in this effort was to co-design and implement a number of PBL courses in the biological sciences (both small and large enrollment), and to develop (with Harold White in UD's Department of Chemistry & Biochemistry) a formal in-service support program for undergraduate peer facilitators.

Materials and methods from one of these courses (introductory biology for science majors) are published in Thinking Towards Solutions (Brooks Cole, 1998; see PBL resources list), and summarized in a recent essay on PBL in biology in Cell Biology Education (Vol. 2, pp. 78-81; see PBL resources list).

With a group of PBL faculty on my campus, I also co-founded and continue to co-lead a faculty institute that was created in 1997 with support from NSF's Institution-Wide Reform program. The institute uses a “faculty mentoring faculty” model to help faculty to develop a new PBL course or adapt an existing to incorporate active, group learning strategies such as PBL.

The institute’s calendar of interactive workshop sessions (including development of PBL curriculum materials and assessment of student learning in this context) can be accessed at http://www.udel.edu/inst.