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*The design of the problem can be a key to success in using problem-based learning. This chapter discusses characteristics of effective problems that will elicit higher-order thinking among students.*

# Designing Problems to Promote Higher-Order Thinking

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A crucial aspect of problem-based learning (PBL) is the actual design of the problem to be solved (Jonassen, 2000). Without a carefully designed problem, professors may believe that they are inspiring students to analyze, research, and solve problems; in reality, though, they may only be using a simple problem with a well-defined solution, which results in a scavenger hunt for information from resources that the professor has provided (White, 2001).

Designing a problem for higher-order thinking may seem like a daunting task for a professor who is unfamiliar with PBL. However, in this article, I describe two stages for designing a PBL problem. In the first stage, professors must consider the educational purpose of the problem. In the second stage, professors must design the problem to meet the intended purpose. After discussing these two stages, I offer practical examples of problems and discuss how they meet the criteria for a well-designed problem.

## Determining the Purpose of the Problem

Professors should have a clear purpose in mind when deciding to use PBL. In other words, professors who use PBL must ask a fundamental question: "What am I trying to accomplish by assigning this problem?" Unless professors address this question, they are likely to end up with problems that do not serve their intended purpose.

Most basically, PBL should enhance and promote the goals of a course or program of studies, not serve as a digression in curriculum and pedagogy. The problem that serves as a basis of PBL activity, then, should promote students' knowledge and skills that have been clearly defined as intended course or program outcomes (Barrows, 1996; Drummond-Young and Mohide, 2001).

Duffy and Cunningham (1996) offer five purposes for implementing problems: guiding; testing; illustrating principles, concepts, or procedures; fostering the processing of content; and providing a stimulus for activity. First, professors might use a problem simply to guide students toward certain content or approaches. In other words, the problem is designed simply to focus the students' attention toward salient course concepts. Second, a problem may serve as a test. When professors use problems as tests, they are creating a situation where students must apply course knowledge. Sometimes these problem-tests are simplistic, such as addressing exercises from the end of a textbook chapter. Third, a problem can be used to illustrate the principle, concept, or procedure that is the focus of the problem. In this respect, professors introduce problems for students to solve as an alternative to lecture. Instead of the professor explaining a principle, defining a concept, or guiding students through procedures, professors assign problems that will force students to inductively discover explanations, definitions, and processes. Fourth, problems can serve as a vehicle for promoting thoughtfulness among students. In this case, professors are using problems primarily as a basis to stimulate and train thinking skills. Fifth, problems may serve as stimuli for activity. This fifth purpose is the most ambiguous for assigning problems to students. The notion of stimulating activity is broad, and students might engage in a variety of activities to solve the problem. A well-designed problem that meets this fifth purpose will force students to think on high levels as they struggle to bring order to the ambiguity.

## Designing Problems to Promote Higher Activity

As I have pointed out, PBL problems can serve a variety of purposes. All of these purposes have some merit, but the highest purpose of PBL in general is to stimulate student activity and engagement. In this section, I suggest criteria for a problem that will stimulate activity—and thus higher thinking—among students.

**Appropriate for Students.** A good problem should be based on an analysis of students' current content knowledge. If a problem is to serve as a stimulus for higher-order and critical thinking, students must find the problem to be challenging (Duch, 2001). Therefore, professors should assess students' current knowledge of the content inherent to a problem and design that problem slightly beyond what students currently know. As a result, students will not be able to solve the problem without slightly extending their knowledge base and their skills. This extension will move students beyond simply regurgitating what they already know; they will have to develop a deeper (or broader) understanding of the content to solve the problem at hand (Duch, 2001).

**Ill Structured.** Closely allied to this issue of appropriateness for students is the issue of problem structure. Jonassen (2000) notes that problems generally can be characterized as either well structured or ill structured. Well-structured problems can guide students toward salient processes in a course and can be effective for demonstrating simple rules, concepts, and procedures. The solutions to well-structured problems are ones the learners can find from limited sources.

Ill-structured problems, on the other hand, are messy like the problems that are faced in everyday life and in professional practice (Delisle, 1997; Duch, 2001; Jonassen, 2000). Not all the elements of the problem are known, and ill-structured problems possess several solutions or perhaps no solution. Ill-structured problems also are not confined by discipline boundaries (Stinson and Milter, 1996), so students may need to draw from a number of different fields to solve the problem.

If the professor's goal in designing the problem is to foster higher-order activity among students, then the problem should be relatively ill structured. The distinction is important because recent research has thrown into question the assumption that learning to solve well-structured problems will facilitate the ability to solve ill-structured problems (Jonassen, 2000).

**Collaborative.** Problems designed to promote higher-order thinking should require collaboration among students (Gijselaers, 1996). Sometimes when professors design collaborative assignments, students each complete a part of the assignment, and then they assemble the parts for submission to the professor. This puzzle-piecing approach is not sufficient in a PBL assignment where the problem is designed to foster higher-order thinking among students (Drummond-Young and Mohide, 2001; Duch, 2001). Rather, professors should design the problem so that the group must synthesize their ideas and make decisions throughout the course of the PBL activity.

Allen, Duch, and Groh (1996) go beyond arguing that strong problems require collaboration. They suggest that viable problems for promoting higher-order thinking engender controversy among members of the group. The acts of synthesizing ideas, making decisions, and resolving controversy will require students to socially negotiate learning issues inherent to the problem and defend among themselves the feasibility of those solutions (Duch, 2001).

**Authentic.** As professors consider authentic slants to problems that serve as the basis of PBL, they should be aware of two aspects of authenticity. First, in some respects, the problem is authentic only if it is grounded in students' experiences. That is, if a problem is too theoretical and out of touch with students' experiences and daily lives, they will not be engaged by the problem (Delisle, 1997; Mayer, 1998).

Second, even if a problem is not based in students' current experiences, it may be authentic if it relates to students' future plans and expected careers (Delisle, 1997; Stinson and Milter, 1996). PBL problems should be more than theoretical exercises. Professors should design problems that require students to apply content in ways indicative of emerging professionals.

**Promotes Lifelong and Self-Directed Learning.** To some extent, a problem that meets the other criteria offered in this section will likely motivate students to become lifelong and self-directed learners. That is, if a problem is appropriate for learners, authentic, and requires collaboration, then students will feel empowered and understand the ways that problem-solving skills can benefit them throughout life.

Examining two of these criteria can provide insights into the connection among lifelong learning, self-directed learning, and other criteria offered in this section. A problem that is authentic is likely to encourage lifelong problem solving and self-directed learning. When students solve a problem that is of real interest to them, they will probably find their own solutions to be inadequate. Therefore, they are more likely to become self-directed learners and pursue further analysis of and alternative solutions to the problem.

Furthermore, as students work collaboratively, they likely will assimilate a variety of approaches toward solving problems. That is, students learn from each other how to solve problems. Because of this type of assimilation, each student will learn new and novel—at least to that student—approaches for acquiring knowledge and solving problems (Barrows, 1996; Gijselaers, 1996). Students can use these new approaches throughout life.

## Examples of PBL Problems

Numerous examples of PBL problems might be helpful for promoting a better understanding of problem design. After each example, I offer an analysis of the problem in light of characteristics of good problems for higher-order thinking.

**Example Problem One.** The following problem might be indicative of a case-based problem given to first-year ophthalmology students:

> A sixty-year-old man complains of murky vision. He also says that when he reads, he sees only parts of letters. In reviewing the patient's case, you discover a history of retinal disease in his family. Also, you discover that he has had some symptoms of neurological disease, diabetes, and hematological problems.
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> Before you leave class tonight, you must address the following questions: First, from what you have learned about retinal disease, which is most relevant to the goal of correctly diagnosing and treating the patient, the history of neurological disease, diabetes, or hematological problems? Second, after your group agrees on one answer in the first question, determine some resulting learning issues that need to be researched to diagnose this patient's problem.

> Based on the decisions that your group makes tonight, you should devise a plan for researching the various issues. Two weeks from tonight, your group will present a diagnosis based on the issues that you determined as relevant. Based on this diagnosis, you will recommend an appropriate form of treatment or further diagnostic tests that you would need to conduct to determine treatment.

An examination of this problem reveals several characteristics that will promote higher-order thinking among students. We can assume that the problem is appropriately ill structured for ophthalmology students because no one clear path exists toward a diagnosis. In fact, it is unclear that students will even have enough information to make a diagnosis, as opposed to suggesting further testing to determine a diagnosis. Because of this ill structure, the students in the group must collaboratively make decisions about the steps for solving this problem. This ill-structured nature of the problem also gives it an authenticity because ophthalmologists must diagnose patients' disorders and determine regimens for treatment.

**Example Problem Two.** The following problem might be one given to students in a first-year undergraduate advertising course.

> Smalltown is one of the fastest growing towns in the area. It prides itself on its new bike trail that includes paved areas and beautifully landscaped natural settings. According to the Smalltown police chief, the bike trails are the target of vandals who have painted graffiti on the asphalt trail and on trees in more scenic and natural parts of the trail. Furthermore, the bike trails are constantly littered with empty water bottles, old tires, broken skateboard wheels, and rusty bicycle chains. There have even been two arrests for public drunkenness on the trail. The chamber of commerce has hired you to launch a local advertising campaign that will inspire some civic pride in the trail and develop a sense of community ownership of the trail.
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> Based on this information, work as a group to reach consensus on the exact nature of the problem, analyze an audience for the advertising campaign that you likely could reach, develop criteria for measuring a "good" campaign for reaching that audience, and develop an outline for three different campaigns that meet your criteria and thus might be successful.

As with the first example problem, this problem requires students to work collaboratively to reach numerous decisions. This problem also is authentic because it requires students to develop an advertising campaign based on careful audience analysis. This problem is ill structured in that there is no one exactly right advertising campaign, and in fact, advertising campaigns might not solve the problem at all. Despite this ambiguity, though, as students work together to define an audience, devise criteria for a successful campaign, and brainstorm ideas for the campaign, they will be engaging in the systematic creative process that they are likely to repeat numerous times throughout their career in the field of advertising.

## Summary

Research on learning and cognition has yielded well-grounded principles from which to design PBL problems that promote higher-order thinking among students. In this article, I have discussed some of these principles, and I have provided example problems that contain these principles. The bad news is that there is no step-by-step method for developing a good problem for PBL. The good news is that by paying attention to these characteristics, professors can create problems that are likely to challenge and motivate students.

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