1 What is problem-based learning?

Professor Case asks:

> "Here's a toaster that isn't working, fix it! or better still, improve it."

On the other hand, Professor English begins:

> "Today we are going lo study the flow of electricity through metals, then we'll look at..."

Professor Case is using a *problem* situation to drive the learning, She doesn't tell us the name of the course, the textbook we should purchase or what we have to study. All we know is that we need to discover:

> - What we need to know about the fundamentals relating to what makes a toaster Work, and
>
> - How we can apply that new knowledge to solve the posed problem.

Professor English outlines the *subject* discipline and its structure to drive the learning. He usually does it in the context of the name of the course with an assigned textbook. He, like Professor Case, will also use problems, but in a different way. The problems may be posed and a solution given by Professor English to illustrate how to apply the knowledge.

Both approaches use **problems** but for two completely different reasons. Case uses problems to drive the learning. English uses problems to illustrate how to use the knowledge **after** you have learned it.

In this Chapter we define problem-based learning, explore the advantages and disadvantages of PBL, and suggest how to make the most of the PBL formal.

2.1 What Is PBL?

You would be amazed to realize how much you *already* know about a subject. Yet. subject-based learning assumes you know very little and proceeds to lay out the information in a preselected sequence. Although, you may already know some of it, you are forced to read it all "in case you miss something," Subject-based learning presents what

the teacher (or text author) thinks you need to know. In problem-based learning, your task is to discover what **you** need to know to address the "problem posed." Figure 2-1 contrasts subject-based with problem-based learning.

PBL can be a research project, a case method, a design project, a trouble-shooting situation, a clinical encounter, an educational approach called Guided Design, or a self-directed, self-assessed, small learning group. The options often depend on who is responsible for directing the activity: teacher-directed or student-directed. Table 2-1 illustrates the interaction between how we organize the subject and how we distribute the responsibility. PBL addresses how we organize the subject. Thus, the traditional lecture is "subject-based" and "teacher-directed." Case studies can be "problem-based" and, often. are "teacher-directed." The variation of PBL that is the focus of this book is "small group, self-directed PBL" which is "problem-based" and "student-directed."

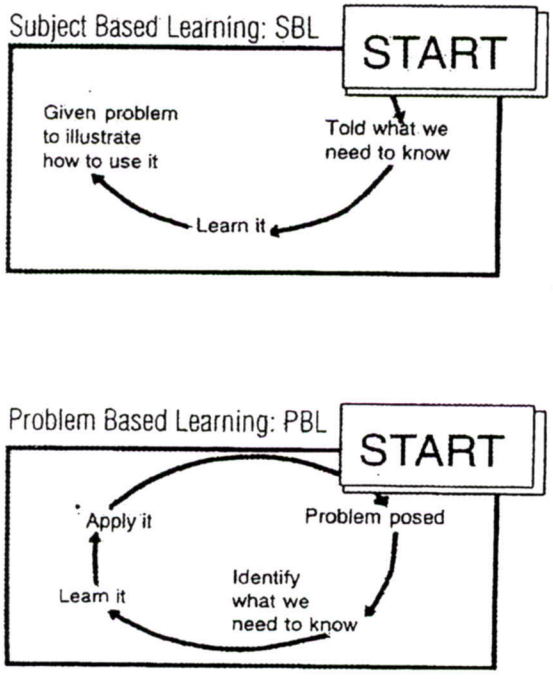

Figure 2-1 Subject-based versus PBL

Eight tasks

1. Explore the problem, create hypotheses, identify issues. Elaborate.

2. Try to solve the problem with what you currently know. From this will come a clearer idea of what you know already that is pertinent.

3. Identify what you do **not** know and therefore what you need to know because your lack of that knowledge is impeding the solution of the problem.

4. Prioritize the learning needs, set learning goals and objectives, and allocate resources so that you know what is expected of you by when. For a group, members can identify which tasks each will do.

5. Self-study and preparation,

6. For a group, share the new knowledge effectively so that all the group learn the information.

7. Apply the knowledge to solve the problem.

8. Give yourself feedback by assessing the new knowledge, the problem solution and the effectiveness of the process used. Reflect on the process.

Regardless of who owns the responsibility, the key for PBL is that the focus is to use a problem situation to drive the learning activities on a need to-know basis. Eight tasks to guide you through the experience of PBL are given in box to the right. These tasks, especially numbers 4 and 6, vary depending on whether you are using PBL as a individual or as a group. As an individual you would omit task 6.

Table 2-1 Options for learning

	Responsibility		
	Teacher directed	**Teacher guided**	**Student directed**
Subject-based	lecture	PSI	self-study
			homework
			peer teach
			SDL contract
	discussion		Co-op learn
	workshops		
	games, roles, simulations.		role play
Problem-based	case studies	"Guided design"	SG,SDL,PBL research

2.2 Advantages and Disadvantages

The advantages and disadvantages are as follows.

2.2-1 Advantages of PBL

Having a problem at the beginning provides a concrete application and motivates us. The way we memorize the knowledge provides links and experiences that help us recall and use the knowledge at a future time. Specifically, embedding the knowledge, old and new, in the context of the problem helps us to integrate the knowledge. Thus, problem-based learning helps us lo learn and comprehend new material far better than subject-based learning. Problem-based learning usually synthesizes a broad range of subjects and topics.

This is highlighted in Figure 2-2 for a problem in criminology in the Case of the Dinged Stop Sign.

> Case of the Dinged Stop Sign.
>
> Detective Frank Kolaski needs lo identify exactly where the f.7 m tall suspect BOZO Armstrong was standing when the shots were fired. He located a bullet in a telephone pole at an angle of 60° with an apparent dimple or ding in a metal stop sign 2.3 m above the street. Bozo claims he was standing facing the stop sign but 50 m away from it and at an angle of 60° the other side of the pole. The bullet hole was 3.2 m off the ground. The telephone pole is 10 m away from the slop sign.

In traditional education, teachers would *lecture* on Geometry and we would have a full course in Geometry. Then, we would have a course in Physics, and Ballistics, and Materials, and Criminology. and Psychology. When we had completed all those courses we might encounter the "Case of the Dinged Stop Sign." As we worked on this problem we would be applying selected portions from each of those six courses. Contrast this with PBL where we have **not** had any courses. From our analysis of the problem we would identify that we need lo know something from each course. We might see connections across courses. Thus, in PBL we take a horizontal collection of information that is pertinent to this problem. We learn a little about each and synthesize it to solve the problem. Figure 2-2a illustrates the status after one problem. Figure 2-2b shows us part way through a course. In the subject-based approach, we might have completed courses in Geometry and Physics. We know a lot about these two; we know nothing about the others. In the PBL approach, our next problem might be the Case of the torpedoed cruiser. Such a problem would extend, in Geometry, our knowledge about the shape of ships; in Physics, about buoyancy. Thus, the problems are used to build up ever-enriching layers of new knowledge across disciplines. This layering process is illustrated in Figure 2-3 where concepts B are
layered on concepts A, This idea of building up our knowledge successively is an important concept to master. We

will call it the principle of successive development.

2.2-2 Disadvantages of PBL

The first apparent disadvantage is that you may be uncomfortable with PBL simply because you are so used to subject-based learning. Traditionally, we learn Geometry, English, Chemistry, Mathematics. Traditionally, we pass exams in Physics, Biology and French. We are not used to studying "The Case of the Dinged Stop Sign" or "The Case of Harry Strange."

The second apparent disadvantage is that sometimes in PBL it seems that the amount we learn from each case is less and that we would like to have learned more depth. In PBL we are learning new knowledge by successively adding more depth with each new problem we solve, That is, for the **first** problem we consider, our tendency is to "want to know it all." But we can't! If we try, we run out of resources. For example, in the case of the "Dinged Stop Sign," our tendency is to **want** to know everything about geometry, everything about particle mechanics, everything about ballistics, everything about materials. everything about criminology and everything about psychology. And all in 3 minutes! We must learn to limit that tendency **of wanting** lo know everything from one problem. Instead. we can begin to move modestly by using what we **need** to know for this particular problem. (Enrichment is possible after the problem has be completed; but we must not get mired down in details lo such an extent that we don't solve the case.) This challenge will be more acute for those of us whose personal learning style prefers the details. (We discuss personal style and its implications in Chapters 5 and 7. If you need to know something more about it right now, the annotated index will lead you to the information.)

A third apparent "disadvantage" is that with PBL we lake longer to learn the same subject content. But, in fact, this illusion of "wasted time" is related to two factors:

i) We like the PBL format so much that we often elect to learn more depth than is needed at that time, We learn because we are interested; not to pass an exam.

ii) We are developing other skills besides acquiring knowledge, We are applying our problem solving skills, inquiry skills and thinking skills explicitly. We are not merely memorizing what some else tells us to memorize.

Finally, a fourth challenge is that the PBL approach assumes that we are good at problem solving; that we are aware of our problem solving processes. We may not be, at first. Hence, we need to conscientiously develop that skill as we learn the "subject knowledge."

2.3 Making the Most of the PBL Format

From a learning viewpoint, all research points to the advantage of the PBL format. We learn more, we learn better and the knowledge is integrated and memorized in more accessible and applicable

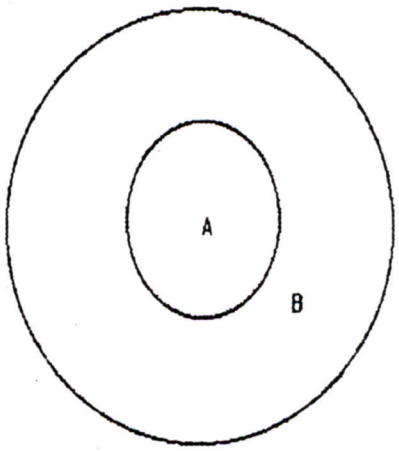

Figure 2-3 Build up knowledge successively in ever-enriching layers

a. After the first Case

Geometry	Physics	Ballistics	Materials	Criminology	Psychology
Case 1: 3D angles	trajectory motion, Newton's laws, reflection	type of armament, type of bullet, speed, effect of weather	stop sign, would the bullet go through or bounce off? materials for bullet, could any striations on the bullet after it had bounced off a sign be matched with a gun?	would this criminal use a gun, motives, details of the crime scene	could Frank fool Bozo into believing he could get valuable evidence from this situation and wring a confession from Bozo?
full course on geometry	full course on physics				

b. After several Cases

Geometry	Physics	Ballistics	Materials	Criminology	Psychology
Case 1: 3D angles	trajectory motion, Newton's laws, reflection	type of armament, type of bullet, speed, effect of weather	stop sign, would the bullet go through or bounce off? materials for bullet, could any striations on the bullet after it had bounced off a sign be matched with a gun?	would this criminal use a gun, motives, details of the crime scene	could Frank fool Bozo into believing he could get valuable evidence from this situation and wring a confession from Bozo?
Case 2:					
Case 3:					
full course on geometry	full course on physics				

Figure 2-2 Comparing Subject-based with PBL

forms. However, to make the most of this approach, we need to reflect on our skill at problem solving.

We also need to resist the crutch of returning to the familiar subject-based formal.

2.4 Summary

Problem-based learning uses a posed problem to drive the learning. From our analysis of the problem, we define what information is pertinent to solve the problem, identify the new knowledge we need, learn the new knowledge and then apply it to solve the problem. We benefit most from the experience, if we reflect on the learning process afterwards.

Videotapes are available that demonstrate PBL in action. For medical school contexts, consult Daitz or Suzuki. I prefer the former. For engineering contexts, use Wales or Woods.

2.5 References

Daitz, B. {undated) "Learning Medicine," The University of New Mexico School of Medicine, 2400 Tucker Dr., Albuquerque, NM 87131.

Kardos, G. (1971) ECL-174 "To Find a Bullet," Center for Case Studies in Engineering, Rose Hulman Institute of Technology, Terra Haute, IN 47S03-3999

Suzuki, D. (undated) "Doctors of Tomorrow" from the CBC program "The Mature of Things," Filmaker's Library, 124 East 40lh St., New York, NY 10016.

Wales, Charley(1974) "Guided Design," Center for Guided Design, University of West Virginia, Morgantown, WV.

Woods, D.R. (1993) "The MPS SDL program," 24 min videotape, Department of Chemical Engineering, McMaster University, Hamilton, ON.

2.6 Exercises

2.1 For the Case of the Dinged Stop Sign, the, problem statement was short. Yet, in Figure 2-1 2, at least six different issues were expected. I For example, the words .". needs to know exactly where..," "Detective" and "suspect"' lead to the subjects of criminology and psychology. Would you prefer that the initial problems statement be more detailed (such a details of the crime, the time of day, the weather, the occasion) or do you prefer to "le that come out as the case evolves"?

2.2 As illustrated in Figure 2-2, you will nave to resist the temptation lo "learn everything about a subject in the first case. For example the full course in Physics may be about particle mechanics; you should focus primarily on those parts of particles mechanics that are important to the case. You need to have confidence that the other cases will give yon an opportunity to learn the rest of the Physics. Think about how you are going to resist the temptation to try to learn everything. Write out your ideas and discuss them with a classmate.

2.3 A variation on the Case of the Dinged Stop Sign is given by Kardos (1971) "To Find a Bullet."

2.4 What criteria might you (and your group) use to help you limit the amount of new knowledge you try to bring to each case?

2.5 What opportunities does **PBL** offer to you? Use Table 1-6 as a guide.