Problem-Based Learning for K–12 Education

PROBLEMS AS POSSIBILITIES

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Association for Supervision and Curriculum Development
Alexandria, Virginia USA
To Clyde Torp—my husband, mentor, and best friend

To Andy Sage—my son—who enriches my life every day
# Problems as Possibilities:
## Problem-Based Learning for K–12 Education

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INTRODUCTION

We can't put it together. It is together.
—Whole Earth Catalog 1971

WHETHER THINKING ABOUT THE UNIVERSE, THE AMBIGUITIES OF LIFE, OR THE WONDERS OF LEARNING—EDUCATORS REALIZE THAT THE WHOLE IS SO MUCH MORE THAN ANY COLLECTION OF PARTS. AS THEY WORK WITH LEARNERS OF ALL AGES, THEY CONSTANTLY STRIVE TO CREATE EXPERIENCES THAT ARE HOLISTIC AND CONNECTED. ONES THAT ENABLE STUDENTS TO TACKLE THE COMPLEXITIES FACING US AS CITIZENS IN A GLOBAL COMMUNITY, AS WELL AS IN EVERYDAY SITUATIONS. ONES THAT REVEAL A NEED TO BE OPEN-MINDED AND ADAPTABLE. ONES THAT CONSIDER THE INTERRELATEDNESS OF SYSTEMS, BOTH NATURAL AND CONTRIVED.

We journey through life encountering, grappling with, and resolving problems that present powerful opportunities for learning. Ask people to describe a time in their lives when they really learned something that they
remember with understanding today. Most will not recall a formal educational experience. Many will relate struggling with a problem such as dealing with the death of a parent. What needs to be done? Who needs to know? How will they cope with the news? Is there an estate or mounting liabilities? What are the legal issues? These are just a few of the questions begging consideration and a balanced response.

Messy, ill-structured problems like that one capture our attention and draw us into their depths. They focus our investigation and thinking, bringing us closer and closer to comprehension and resolution. These problems present holistic learning experiences. They expose and connect rich content and essential skills. They catalyze critical and creative thinking. And they place us in situations that demand decisions based upon sound criteria, taking into account conflicting interests and incomplete information. This is problem-based learning—where the problem comes first and learning is fueled through the problem’s investigation and resolution.

Since 1992, the Center for Problem-Based Learning at the Illinois Mathematics and Science Academy (IMSA) has investigated and applied the principles of problem-based learning (PBL). Our work there has described how problem-based learning is applied in elementary, middle, and high school settings. We have measured the effects of defined aspects of a problem-based approach. And we have shared our experience and learning with hundreds of educators across the country. (See Appendix for more information on IMSA’s Center for Problem-Based Learning.)

This book is a natural extension of that work. But how do we represent a dynamic concept like problem-based learning in a way that enables understanding and encourages application? What can we say in print on the static pages of a book that would meet the needs of a diverse group of learners?

In thinking through our problem as authors, we clearly heard the voices of educators with whom we have worked. Their needs were as diverse as their interests. Some were captivated by stories of real classroom experiences. What happened? Why were the students intrigued by the problem? Others wanted to know about problem-based learning. Where did it come from? How does it relate to other ideas about teaching and learning that are part of the educational scene? Many needed to get involved from the inside and design their own problem-based units. Where do they begin? How does the teacher coach the learning process? All would eventually construct meaning, but their pathways differed.

Our book offers opportunities to learn about PBL from multiple perspectives. All readers will find strong connections to their own classroom experience while learning about problem-based learning.

Experiencing PBL
Chapter 1 tells stories through the comments of teachers and students who have experienced PBL. Vignettes from several grade levels and contexts enable readers to see PBL’s possibilities.
Learning About PBL
Chapter 2 provides an overview of problem-based learning, and Chapter 3 presents background information. We hope these chapters supply answers for those who need to know, What is it and where does it come from?

Designing and Implementing PBL
Chapters 4, 5, and 6 allow readers to play with an idea and make it their own. These chapters present practical information to enable educators to design and develop PBL curriculum and plan for instruction in a PBL classroom.

Thinking About PBL
Chapter 7 offers answers for those who need to know the “whys” to find their way through an idea. It builds a solid foundation for PBL as a valuable innovation for today’s learners and opens the door to the process of becoming a teacher of PBL.

Different pathways through these chapters help serve the needs of different learners:
- If you are intrigued by context and how ideas play themselves out in authentic settings, begin with Chapter 1.
- If you want to know the origins and the grounding of ideas, begin with Chapter 2, 3, or 7.
- And if you must roll up your sleeves and become immersed in the “how” of things, begin with Chapter 4, 5, or 6.

Wherever you begin (see the figure “Overview of Problems as Possibilities” on p. 4.), come full circle to experience the possibilities of problem-based learning as a natural integrating focus for relevant curriculum and meaningful student learning.
FIGURE I.1
Overview of Problems as Possibilities

Experiencing PBL
- Chapter 1: What Does PBL Look Like in Classrooms?
  - Through the eyes of learners
  - Through the eyes of teachers

Thinking About PBL
- Chapter 7: Why PBL?
  - What are your questions?
  - What does it take to become a teacher of PBL?

Learning About PBL
- Chapter 2: What Is PBL?
  - Background
  - Comparison of PBL to other instructional strategies

- Chapter 3: What Are the Foundations of PBL?

Designing and Implementing PBL
- Chapter 4: What Is Our Model for PBL?

- Chapter 5: How Do You Design a PBL Curriculum?
  - Teacher as designer
  - Teacher as refiner

- Chapter 6: How Do You Implement PBL?
  - Teacher as coach
  - Students as active problem-solvers
WHAT DOES PROBLEM-BASED LEARNING LOOK LIKE IN CLASSROOMS?

To educate is to take seriously both the quest for life's meaning and the meaning of individual lives. . . . Through telling, writing, reading, and listening to life stories—one's own and others'—those engaged in this work [teaching] can penetrate cultural barriers, discover the power of the self and the integrity of the other, and deepen their understanding of their respective histories and possibilities.

—Witherell and Noddings 1991, pp. 3-4

AS WE WORK WITH EDUCATORS FROM AROUND THE COUNTRY, we have come to appreciate the power of story. Strong connections are sparked when we relate how teachers organize problem-based learning (PBL) experiences and how students respond. Our partners are enthusiastic and thoughtful PBL practitioners from whom we learn a great deal. We'll begin with their words—their stories.
At Elementary Schools

One important story is being written at Westgate Elementary School in Arlington Heights, Illinois. Educators have been using PBL at least four years, examining how it works best with young students, and adapting the process to a point where their school community—administrators, teachers, students, parents, and businesspeople—enthusiastically support PBL.

In a recent problem, 1st through 5th grade students investigated difficulties their former principal was having maintaining a healthy flower garden at home. Students examined soil and plant samples from her garden, read about how to grow healthy plants, searched the Internet, contacted local experts, and conducted experiments on growing plants under different conditions.

Several students had difficulty getting adults to take them seriously. Michael, a 4th grader, called a local plant nursery for information about watering plants. The person answering the phone said, "Just don't give them too much water," and then hung up.

Students discussed his dilemma. Andy suggested that Michael should have called back and asked, "How much water is too much?" or kept them on the phone by saying, "Wait a second," or something similar. Eventually the group located an individual who would answer questions to their satisfaction. Students learned something about perseverance and differences among adults.

Teachers at Westgate are excited about how students are learning, and students are excited about learning. Here are their comments:

The way they're doing their experiments and thinking about their experiments before they just rush into doing them—they're reading them over and predicting and deciding whether they're going to be helpful or not—they've definitely surpassed my expectations at this point.

—Linda Zakarian, 1st/2nd Grade Teacher

I saw the kids learn a ton of information about plants, and they know that if they're going to have a garden, they need to really read directions, and they need to know some conditions of sunlight and water. They got out of it what I wanted them to get out of it. They're much more knowledgeable about plants, but I didn't have to do it from a textbook. . . . I've learned to constantly push the kids to keep thinking. If they come up with one answer, don't stop there, because the likelihood is there are at least five more answers.

—Melissa Rabin, 3rd/4th Grade Teacher

[Things have to work together] like the sun and the water. You have to know if it's going to rain or not, and you have to know where to plant your flowers so they get the right amount of sun or shade they need. I think it's weird that sometimes things don't need very much sun but they need a lot of water.

—Richard, 4th Grade Student*

Both students and teachers like the authenticity of PBL, as shown in these comments:

*All student names are fictitious.
I like PBL because it's challenging and fun, because you're learning something new; every problem's a little different 'cause you're going for different goals in the solutions.

—Cal, 4th Grade Student

Some kids question when you're teaching basic skills: "Why do we have to learn this? When are we ever going to do this?" [With PBL] You're showing them a reason, a specific, real-life situation. I'm teaching them basic skills, but I'm giving them a reason.

—Linda Zakarian, 1st/2nd Grade Teacher

Ruth, a student in Zakarian's class, said she liked the plant problem because she could help the former principal solve a real problem. Ruth's mother echoed her daughter's excitement:

Ruth talked a lot about the plant problem; we discussed it a lot. I was impressed with the sources they went to for information, phone calls they made; [they even went] as far as getting an analysis of the soil—that they would think about that. Also, I could see on her face that she was very thrilled that she was able to find out information that an adult was very interested in. . . . but also that she just received this level of respect from an adult. It really boosted her confidence. . . . I think problem-based learning empowers children to be real active participants in the world around them when they get the opportunity.

As we interviewed students, we found they identified other skills they had learned during PBL experiences. They described how they helped each other locate and understand information in the plant problem:

[I use a highlighter pen] if there's a picture there with a whole bunch of things, . . . you can highlight [some parts] so you won't need to keep reading it; it tells you what you're reading.

—Jennifer, 1st Grade Student

Some of the people [in my group] looked at pictures and got a little information; then if I read and found something, I would think: Would that make sense? Is it important or not? Sometimes it would be important for this but not important for this . . . like all the stuff I read in this book about seeds—I found that animals help scatter seeds; that is important. But the picture was showing a bird taking a cherry, so I wasn't sure [if that was important] because [the principal] might not have any of those kinds of trees.

—Kristen, 2nd Grade Student

Others talked about how they worked in their collaborative small groups while gathering information and determining solutions:

Last year we did a couple of problems, so I’ve learned last year and this year how to work together and what to do when something is going wrong, like when half of the group wants to go to the learning center and half doesn't; you want to stay here and break down the information. . . . I learned how to compromise with them: "Well, let's split up into two groups."

—Wendy, 2nd Grade Student
I had all new friends [1st graders] at my table, so I said, “You guys can help me make up some stuff to write down, and we’ll put it on a big sheet of paper.” I didn’t just say, “Okay, I’m going to write this down, I’m going to do this and that,” and do all of it.
—Ruth, 2nd Grade Student

Students completed a pre- and post-test in which they were asked to develop instructions on how to grow plants successfully. For her pre-test, Andrea, a 3rd grader, drew four pictures, with little accompanying information (mentioning seeds, sun, and rain). On a post-test in May, however, seven months after completing the plant problem, Andrea wrote instructions that included 10 necessary components for healthy plant growth: soil, seeds, water, fertilizer, sun, rain, carbon dioxide, respiration/breathe, chlorophyll/food, and space to grow (all spelled correctly!). Andrea is a special education student.

Many members of the learning community at Westgate report that they can spot students who have had several experiences with PBL by their behavior. These students are better at dealing with conflicts in the lunchroom or on the playground. They also approach learning differently in the classroom, asking more questions, and refusing to let go of issues until they are satisfied they understand it thoroughly, even to the extent of assigning themselves homework. Another experienced PBL teacher at Westgate, Christine Vitale Ortlund, mentions that now many students don’t just ask to learn by solving problems, they actually demand it.

At Middle Schools
An essential part of the middle school story is to find engaging, authentic problems where students are placed in a role and situation that hooks them—at this age they are typically interested in everything but academics. One teacher, whose students took the role of village board members examining overdevelopment in Barrington, Illinois, explains how role playing helps students think outside their immediate world:

If you ask [8th graders] to do something, their first reaction is, “Who cares? I don’t care—it doesn’t affect me.” But if they have a role, then they have to look at it from someone else’s perspective and point of view. So they can no longer be a smart aleck 8th grader who doesn’t care, but they have to put themselves in some other shoes. So what’s fun [the role] for an elementary student becomes even more important as a middle schooler, because it forces them to get into it and to look at [the problem] from a perspective that you’d want them to see it from.

—Maggie Oberg, Language Arts Teacher
Barrington Middle School, Prairie Campus
Barrington, Ill.

Several other middle school teachers recognize the importance of students knowing that they own a real problem and that they can really affect their schools or communities:
What Does Problem-Based Learning Look Like in Classrooms?

If you give them [8th grade students] a role of power, then they really buy into this. We've done two problems where kids have been put in the position of making recommendations... about school district policy to school board members, a superintendent, and a principal. And [the students] walked away from that saying, "We could say something. We had something to say and adults listened to us... We may have actually done something for our school—something that's really going to directly affect us."

—Karoline Krynock, Science Teacher
Barrington Middle School, Prairie Campus
Barrington, Ill.

Some students were immediately hooked when they realized they owned the problem... Once they could see that their ideas were indeed valid (or why they were not) according to criteria they provided for themselves, then the grin appeared and momentum picked up.

—Mary Biddle, Social Studies Teacher
Franklin Middle School, Champaign, Ill.

Middle school students can learn a great deal of academic content in well-designed and well-implemented PBL experiences. Karoline Krynock and her PBL teaching partner, Louise Robb, conducted classroom research showing that their PBL students learned as much or more content in a problem designed around the issue of possible genetic causes for aggressive behavior than did students in a more traditional genetics unit (Krynock and Robb 1996). Krynock says that her students learn more "real science" in PBL than in any other teaching method she has used. Robb sees an additional advantage:

Another positive thing is that when you "go public"—we've had some panels of experts come in and hear solutions from our groups—the adults are just astounded by the depth of [students'] knowledge and the kinds of things they've been able to deal with. We've gotten nothing but positive feedback... The kids are asking just incredibly complex questions, which show they do have a lot of understanding of content.

—Louise Robb, Language Arts Teacher
Barrington Middle School, Prairie Campus
Barrington, Ill.

PBL provides many opportunities for students to interact with each other and with content:

The most recent picture of my students working in the library gathering information for a PBL exercise includes different images:

• Students excited about learning.
• Students struggling to learn more about (or understand more in depth) a complicated issue.
• Students who would not normally even talk to each other working together on a topic.
• Students engaging in lively conversations about school work.
• Students sharing magazines and information (not MAD but Scientific American).

—Nancy Baird, Gifted Resource Teacher
Franklin Middle School, Champaign, Ill.

Lisa Nicholson, a special education teacher at Burr Ridge Middle School in Burr Ridge, Illinois, has found PBL to be an effective strategy with a wide range of students.
With a science teacher, she cotaught two problems for several years—one on deer overpopulation in their area, and one on HIV-positive middle school students. She says that although all students benefit from the real-life problems the teachers have presented in PBL, it is particularly important for special education students, who often don’t want to learn or have difficulty learning unless they see a reason behind it. PBL also allows her students to use the learning style that is best for them. And they can demonstrate their knowledge through many different assessment formats, such as oral presentations, debates, and posters.

Other teachers mention that dealing with authentic problems helps students think about ethical aspects of issues they might not have otherwise considered. At the end of a PBL experience dealing with HIV/AIDS, Krynock reported that her class felt strongly that they had an obligation to educate others to reduce fear surrounding the disease. She was surprised and impressed by their maturity and empathy in considering how an HIV-positive student might feel and their subsequent desire to be proactive in providing education with their peers:

Even if we had read a hundred short stories and memorized a million AIDS pamphlets, I don’t know that they would have learned the valuable lessons they learned from the short [time] we spent examining this problem.

—Karoline Krynock, Science Teacher
Barrington Middle School, Prairie Campus
Barrington, Ill.

At High Schools

Consider this problem designed as a precursor to reading To Kill a Mockingbird:

Students are members of the Alabama Historical Society, which has been contracted to research a family’s background during the time period of the novel To Kill a Mockingbird. What was going on in the family during the time period of the novel? How reliable is the information the historical society uncovers? If controversial information about family members arises, who needs to know—or not?

—Yolanda Willis, Language Arts Teacher
East Aurora High School, Aurora, Ill.

Even though her students normally enjoyed this book, Willis reports that PBL enhanced this American literature unit:

I think the kids were more into what they were doing; it seemed more relevant to them, especially with the social studies teacher [an expert on the 1930s] coming in and talking with them . . . . What really grabbed them . . . was when I brought the guy in who said that the original person the students were researching had lynched his grandfather. So then it became more of an ethical problem—the kids had to go back to their problem statement and decide: “Maybe we shouldn’t even be doing this.” Before that, it was: “Okay, we’ll do this; we’ll do all the research and make all the pictures.” But when [that ethical dimension] came in, they were like: “Wow!” It really blew them away.
Teachers can design PBL problems around interdisciplinary issues as well. Another teacher relates this story of student empowerment:

There’s a metamorphosis that you cannot even begin to contemplate. I listened to one girl who was being interviewed by the [Chicago Tribune] on the phone. Crissy said, “I never knew I could do all this; I didn’t know I was such a good thinker; I didn’t used to be able to get up in front of people and speak. ...” I love to see the depth of their thinking and hear realizations that they’re operating on a different level. ... I like to see the metamorphosis in staff that are the audience for their exhibitions. Administrators are seeing kids differently. Other teachers are saying, “Yes, kids can do.” I’ve always believed kids can do anything, but it’s so exciting to see that happen.

—Ellen Jo Ljung, Language Arts Teacher
Glenbard West High School, Glen Ellyn, Ill.

Real-life problems can become PBL problems, as shown in these examples:

- Bernard Hollister, a social science teacher, coteaches a PBL course, Science, Society, and the Future (SSF), for seniors at the Illinois Mathematics and Science Academy (IMSA). SSF students recently started the year with a problem Hollister designed around lunchroom waste in U.S. schools. As he puts it, students began “stripping away the layers of the onion” when they discovered that lunchroom waste was only the tip of this problem. The real problem seemed to be flawed methodology and strong political motivations in the congressional study they were using.

- Also at IMSA, science/physics teacher David Workman has used PBL for a number of years. One of his recent problem units in his Integrated Science course revolved around finding the best possible design for retention/detention ponds in the immediate school vicinity. There had been severe flooding in the community last year. In this course, students investigate “problem platforms,” which expose physical and biological problematic contexts—such as pond life or habitation on Mars. Such exposure allows students to be involved in several different PBL experiences.

- John Thompson, an IMSA science/biology teacher, uses PBL in several science classes. For a predator unit in his ecology class, John focuses on the central issue of wolf reintroduction into natural habitats. Each year he updates this core problem to reflect a current real-world scenario.

- A science/chemistry instructor, Richard Dods, has developed a biochemistry course around realistic problem scenarios, such as learning about isoenzymes by diagnosing, as cardiologists, the source of chest pain in the character Miles Silverberg from television’s “Murphy Brown.”

High school students participating in PBL clearly enjoy the strategy as well as find it beneficial in preparing them for their future:
I like Comm-Tech [Communications Technology course] because it's a class where you take all the material you've learned and you use it... Other classes teach you what to learn; this class teaches you how to learn. I think I'll actually use this class when I move on into computer science and electrical engineering; it teaches you how to solve problems on the job.

—Don, Student in Ellen Ljung's class
Glenbard West High School, Glen Ellyn, Ill.

[PBL] is a different approach to education. Instead of: "Here's a sheet of vocabulary words, memorize them," you could say, "Well, this happens, you know—why? Now go find out. See what you can find out about the why or the how of something..." There's usually not one right answer. There can be more than one answer, or there isn't one; you form a new question and go from there.

—Cindy, Student in John Thompson's Ecology Class
Illinois Mathematics and Science Academy, Aurora, Ill.

The skills I learned in [John Thompson's] ecology class have been helpful both in terms of the research and studying that I've done for my college courses and also the research that I've done for my own research career... That series of thought processes that takes you from complete ignorance to a knowledge that's focused and can answer a specific question is a very useful thing to know, and it's a very difficult skill to learn, I think, in most school settings.

—Elizabeth Pine, Former IMSA Student
1993 Westinghouse Science Talent Search Competition Award Winner

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Stories from teachers, students, and parents are powerful. But what is this thing called problem-based learning? What do we know about PBL? What do teachers and students do in PBL? How can you design problems for your class? How can you write your own PBL story? These questions and others are addressed as you investigate PBL in this book.
WHAT IS PROBLEM-BASED LEARNING?

NEARLY EVERY DAY, WE FACE POSSIBILITIES AND PROBLEMS that affect our personal and professional lives. The ability not only to cope but also to identify key issues, access information, and effectively work our way through these situations contributes to success in whatever we pursue. Building a mental network of these experiences enables us to make connections through association and interpretation. This "context-building knowledge gives form to everything we do or think or feel, on the job, in the voting booth, in the home" (Broudy 1982, p. 578).

Most of us are familiar with teaching models in which we first learn identified content and processes through lecture, direct instruction, and guided discovery. Then we apply this new learning in well-structured situations, problem sets, and forced-response items designed to see if we understand or have mastered what was taught. This teaching paradigm, with a teach, learn, and apply sequence, has been the standard in our schools for quite some
time. Roles are clear: Teachers teach; students learn. If only it were that simple.

Problem-based learning refocuses our practice to what some call a learning paradigm. PBL confronts students with a messy, ill-structured situation where they assume the role of the stakeholder or “owner” of this situation. They identify the real problem and learn whatever is necessary to arrive at a viable solution through investigation. Teachers use real-world problems and role playing as they coach learning through probing, questioning, and challenging student thinking. Here are some examples:

Second grade students serve as advisors to NASA. A planet much like Earth has experienced massive destruction of the elements in its biosphere. What is causing the destruction of plant life? Can new plants from Earth be successfully introduced to help save the planet’s environment? How can we find out?
—Rawls Byrd Elementary School, Virginia

Middle school students act as scientists with the State Department of Nuclear Safety. Some people in a small community feel their health is at risk because a company keeps thorium piled above ground at one of their plants. What are the critical issues? Who else is concerned? What is the extent of our authority? What action, if any, should be taken?
—Summer Challenge Program Illinois Mathematics and Science Academy, Illinois

High school basic composition students serve as consultants to the warden of a women’s correctional facility. They examine the potential causes of recidivism among women prisoners. Why don’t these women succeed in society? What communication skills would help the women improve their chances? How can these “consultants” design a program to address prisoner needs?
—East Aurora High School, Illinois

Defining Problem-Based Learning
Problem-based learning is focused, experiential learning (minds-on, hands-on) organized around the investigation and resolution of messy, real-world problems. It is both a curriculum organizer and instructional strategy, two complementary processes. PBL includes three main characteristics:

• Engages students as stakeholders in a problem situation.
• Organizes curriculum around this holistic problem, enabling student learning in relevant and connected ways.
• Creates a learning environment in which teachers coach student thinking and guide student inquiry, facilitating deeper levels of understanding.

We see a PBL curriculum as providing authentic experiences that foster active learning, support knowledge construction, and naturally integrate school learning and real life, as well as integrating disciplines. The problematic situation is the organizing center for curriculum. It attracts and sustains students’ interest with its need for resolution while exposing multiple perspectives. Students are engaged problem solvers, identifying the root problem and the
What Is Problem-Based Learning?

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conditions needed for a good solution, pursuing meaning and understanding, and becoming self-directed learners. Teachers are problem-solving colleagues who model interest and enthusiasm for learning and are also cognitive coaches who nurture an environment that supports open inquiry (see Figure 2.1 on p. 16).

Overview of PBL Design and Implementation

Designing and implementing a PBL unit are two interrelated processes that balance the needs of students and the curriculum within a particular learning context. Figure 2.2 (see p. 17) shows the main elements in the two processes.

Problem Design

Teachers select possibilities for problem situations by scanning their curriculum and local newspapers, and speaking with community members and colleagues. They think about the characteristics and needs of their learners, looking for ways to hook students:

The problematic situation has the seeds of interest within it. Students can relate to people attempting to deal with the unknown and living under adverse conditions (Barell 1995, p. 122).

In considering problem possibilities, teachers assess opportunities for “curriculum payback,” including integrating across disciplines and making community connections. This exploration leads to identifying a problem that will enable students to make meaningful connections between school and life while providing educators with powerful curricular connections:

Problematic situations are robust in that they contain within them significant concepts worth thinking about (Barell 1995, p. 131).

Educators seek out or design scenarios that provide rich opportunities for demonstrating learning through projects, presentations, or other means authentic to the situation. Here is a graphic representation of the PBL process:

![Diagram](image)

ill-structured problem × (seeds of interest + significant concepts + real-world connections) = powerful opportunities for learning

To develop a PBL unit, teachers decide on a role to frame the students’ involvement in a chosen problem. “The learning experience provides students with opportunities to take different perspectives on the subject” (Barell 1995,
Which perspective will intrigue students and provide the greatest opportunity for engagement? We want students to own the problem and the inquiry, and make a personal investment in the solution. A shift in perspective can profoundly affect problem resolution. Imagine how different the problem of the endangered spotted owl in old growth forests in the Pacific Northwest appears from the perspective of legislator, lumberman, environmentalist, and retailer in a local community.

Unit development also includes selecting appropriate information and community resources, and creating materials to support student learning.

**Problem Implementation**

Planning for instruction requires an appreciation of the teaching and learning events of PBL, along with an understanding of the teacher's role as cognitive coach. Through hundreds of classroom observations, we have found several events that
are essential for successful PBL experiences. As teachers construct a teaching and learning template, they have clear goals for each event, and the goals support student thinking at different levels. As teachers coach students toward these goals, they anticipate embedding essential instruction and assessment at critical points during problem investigation. We detail these teaching and learning events in Chapter 4, but for now, let's consider the natural flow of problem-based learning as students meet, investigate, and resolve a problem.

The Flow of a PBL Learning Experience

Students assume the role of a stakeholder in the problem scenario. We want our learners to get inside the learning situation and own the problem. It is important that their role be one in which they will naturally have some say in the outcome or resolution. If they are to make recommendations to the mayor about traffic flow during a major event in their city, which role would provide them a greater voice or influence? Members of the Department of Transportation? Downtown retailers? Middle school students?

That is not to say that students should shift roles for every problem. What if their school needs major renovation and a building addition? Who better to examine the school's physical environment in relation to the learning needs of middle grade students, and to make recommendations to the architect and school board? What is important is that the role and situation are complementary and provide a platform for influencing the outcome.
We also want students to make an empathic connection with the situation; in other words, we want them to care about what happens. Sylwester (1995) states:

We know emotion is very important to the educative process because it drives attention, which drives learning and memory (p. 72).

Later he goes on to say:

By separating emotion from logic and reason in the classroom, we’ve simplified school management and evaluation, but we’ve also then separated two sides of one coin—and lost something important in the process (p. 75).

Students are immersed in an ill-structured problematic situation. Such a situation is messy and complex. Not enough information is provided, so the situation requires inquiry, information gathering, and reflection. As information is gathered and evaluated, what was thought to be the root problem or puzzlement may change, opening up new avenues for investigation. Students uncover diverging assumptions, conflicting evidence, and varying opinions about the situation. Even when students decide upon a solution, there are probably multiple options for achieving it. A problematic situation is changing, tentative, and has no simple or fixed solution.

Why, then, do we center PBL around these types of problems? Matthew Lipman (1991) in Thinking in Education makes a strong argument in favor of ill-structured problems:

Where students have no sense that anything has been left out or is incomplete, they have no need to go beyond the information given. In contrast, the partial, the fragmentary, and the problematic taunt us to complete them or resolve them (p. 68).

Students must analyze, synthesize, and evaluate to gain a sense of the whole and formulate a viable solution. Well-structured problems, on the other hand, provide the information, the compass, and a clear destination for the problem solver, tapping only the lower-level thinking skills of knowledge, comprehension, and application.

What does such work mean for younger students? Do we hold back PBL experiences until children near middle school age? Not at all. Primary grade students engage in PBL scenarios with a vigor and enthusiasm that surprises and delights their teachers. These children are not limited by the notion that all information is located between the covers of an encyclopedia. They pursue information by phoning, questioning, and experimenting. Like good investigators, they know the value of probing beyond first-level answers by asking “Why?” again and again and again. Problematic scenarios appropriate for younger students abound. Just as beauty lies in the eye of the beholder, what makes something a problem resides in the mind of the learner.

For example, a problem scenario described in Chapter 1 explains how 1st graders were enlisted to help their principal solve the mystery of why her garden wouldn’t grow properly. They learned more about plants, growth, and conditions for life than they would have from any story and
What Is Problem-Based Learning?

Windowsill garden. What’s more important, they experienced the critical connection between learning and life.

Students identify what they know and need to know. From what they know of their role, the situation, and the limited information provided, students clarify and share what they know. This process helps them access prior knowledge and begin to make connections. The ill-structured problem compels students to identify what they know and need to know to resolve the tension of a problem situation (Boud and Feletti 1991). Almost concurrently, they begin to understand the situation more fully. From this point, a natural progression occurs to categorize information needs and potential sources while parceling out tasks.

Teachers may be concerned about students taking a wrong turn or going down a blind alley as they plan or gather information. Students will, on occasion, do just that. But in doing so, they will undoubtedly learn from the experience. Often, knowing what doesn’t work or apply in a given situation is every bit as valuable as knowing what does. The messiness of authentic problem solving—including an occasionally seemingly nonproductive detour—yields rich learning:

Students in a summer youth program worked at an area forest preserve. In years past, they were given explicit directions about the building and placement of bat houses within the preserve. Following a shift to a PBL program frame, students were challenged to accomplish the same goal, but this time, they investigated the native bats and their habitat, designed the bat houses, and placed them appropriately. Despite this need for inquiry coupled with predictable meandering, these students accomplished a great deal more with noticeable interest and enthusiasm when the goal was problemized as compared to when the goals were explicit (Benoit 1996).

Students define the problem to focus further investigation. Once students are immersed in their role and the problematic situation, they gather and share information among the other class members or their team. This activity enables all to gain a holistic understanding of the problem. Collecting information often takes on a life of its own—intriguing threads are followed, personal interests take over, and the inquiry becomes blurred. Coaching students to come to a clear statement of what they believe to be the central issue of the problem, along with a list of several conditions that need to be satisfied for a good solution, is essential. Many teachers with whom we work post evolving problem statements in the classroom to help tighten and target the investigation.

It is likely that students will engage in more than one cycle of inquiry—sharing what they have discovered, identifying what else they need to know, and refining their problem statement as they learn more—before they are ready to consider some sort of resolution. Motivated by their inquiry, students become self-directed learners. A key is to interest them in the learning experience:

Teaching is generally a delightful experience when we focus on activities that student brains enjoy doing and do well, such as exploring concepts, creating
Students generate several possible solutions and identify the one that fits best. With appropriate coaching, they discuss an emerging picture of the real problem, perhaps several times before they are ready to generate possible solutions. After developing the solutions, they evaluate them in light of the problem statement’s central issue and identified conditions. According to Sylwester (1995), the brain is well suited for this type of activity:

Our brain is currently much better than a computer at conceptualizing ambiguous problems—at identifying definitive and value-laden elements that it can incorporate into an acceptable general solution (p. 119).

Once students select the solution that fits best, they prepare to present their findings. They may choose to share the problem and their solution by using concept maps, charts, graphs, proposals, position papers, memos, maps, models, videos, or a home page on the World Wide Web—whatever is authentic to their role and the situation. Students offer this solution in a performance assessment situation, ideally interacting with the problem’s real stakeholders and responding to stakeholder questions and concerns. If appropriate, these stakeholders may even implement the solution.

For example, students at Steinmetz High School in Chicago were participants in a problem-based service learning project. They identified a problem within their community at a local hospital. The hospital had recently located some biohazardous waste that had been stored since the 1930s. The students took on the problem and investigated the legal, ethical, waste management, and health concerns inherent in this problem. They arrived at a viable solution and presented it to the hospital board. The board adopted their proposal.

As a thinking and learning process, problem-based learning empowers students as learners and doers to translate imagination and thought into actuality as well as to reflect on the process and proposed solution.

What Are the Essential Elements of Problem-Based Learning?

Many formats for presenting and implementing PBL units are possible; however, the following parameters remain consistent:

1. The problematic situation is presented first and serves as the organizing center and context for learning.

2. The problematic situation has common characteristics:
   - It is ill-structured and messy.
   - It often changes with the addition of new information.
   - It is not solved easily or with a specific formula.
   - It does not result in one right answer.
What Is Problem-Based Learning?

Students are active problem solvers and learners; teachers are cognitive and metacognitive coaches.

Information is shared, but knowledge is a personal construction of the learner. Discussion and challenge expose and test thinking.

Assessment is an authentic companion to the problem and process.

A PBL unit is not necessarily interdisciplinary, but it is always integrative.

What Are the Benefits of Problem-Based Learning?

Although PBL plays out differently in varying settings, from primary to graduate classrooms, particular benefits have surfaced at all levels. At the Illinois Mathematics and Science Academy (IMSA), a core group of teachers has designed and implemented problem-based learning units and courses since the early 1990s. Their experiences and reflections coupled with findings from the research literature present a profile of PBL’s benefits (see Gallagher, Rosenthal, and Stepien 1992; Stepien and Gallagher 1993). We highlight the benefits here and provide supporting teacher comments describing their experiences with PBL.

 Increases Motivation

PBL engages students in learning through the attraction or pull of problem dissonance or tension. They take on more and delve deeper as they make a personal investment in the outcome of their inquiry. Teacher comments attest to this involvement:

- The most important thing that happened to me is that when I got involved in doing problem-based learning, it was so obvious to me—the difference in the way in which students approached their own responsibilities and activities in the classroom compared to the way students did when I used other methods. . . . They just did different things. I think it was important to me to see that they did different things, because it was clear to me that for their learning to change they had to do different things.
  —David Workman, Science/Physics Teacher
  Illinois Mathematics and Science Academy, Aurora, Ill.

- It’s so much more exciting to see real learning going on. And it’s real—you know, where the kids are really hungry to learn. A kid came back up to me the next day and said, “I went over to the city library and checked out Uncle Tom’s Cabin on my own.” He didn’t act like it was a big thing; I thought it was pretty amazing! That book is 140 years old or something, and he was wading through it.
  —Kris Hightshoe, Social Studies Teacher
  Edison Middle School, Champaign, Ill.
Makes Learning Relevant to the Real World

PBL offers students an obvious answer to the questions, "Why do we need to learn this information?" and "What does what I am doing in school have to do with anything in the real world?" Teacher comments show how learning relevant material in schools affects students:

The last two days, I’ve had my students out doing orienteering. They really enjoyed it. Now in hindsight, I see that problem-based learning is a lot like orienteering through a problem. What I discovered was that I would get them going and they would scurry into the woods with their compasses and try to find the various answers or points that they were seeking. . . . When they came back, there was this great rejoicing in their own accomplishment. I can’t imagine how I could have explained it or the kind of lecture I would have had to give to explain those points in the woods that would have received the same kind of reaction as their actually doing it. . . . There was a problem; the problem was that they find [the point]; when they found it, it was like they had beaten the system. The woods had not beaten them. To me that’s not a bad comparison to what problem-based [learning] is. You go into the wilderness and once you find those things, there is a joy of discovery. I don’t know that the joy of being told is nearly as great.

—John Thompson, Science/Biology Teacher
Illinois Mathematics and Science Academy, Aurora, Ill.

Suddenly the students have real tasks to do and real reasons to want to learn about things. People are taking them seriously as learners; it’s not just a mock situation.

—Lori Hinton, 4th/5th Grade Teacher
Westgate Elementary School, Arlington Heights, Ill.

Promotes Higher-Order Thinking

Coupled with cognitive coaching strategies, the ill-structured problem scenario calls upon critical and creative thinking by suspending the guessing game of, “What’s the right answer the teacher wants me to find?” Students gather information significant to the problem, assessing its credibility and validity. In bringing the problem to acceptable closure with evidence to support decisions, students are held to high benchmarks of thinking. Teachers work to encourage such thinking:

We’ve had some panels of experts come in and hear solutions from our groups. The adults are just astounded by the depth and breadth of their knowledge and the kinds of things they’ve been able to deal with. Even experts came in as resources, thinking they were going to give a canned speech and left [only] five minutes for questions. I said, “Excuse me, but could you present for five minutes, and then we’ll have an hour of questions?” . . . The kids are asking incredibly complex questions that show they have a lot of understanding of content.

—Louise Robb, Language Arts Teacher,
Barrington Middle School, Prairie Campus,
Barrington, Ill.

You’ve got to get used to being able to reflect back the question—bounce it right back—rather than feel the necessity to give the answer. That’s not easy to do.

—Richard Dods, Science/Chemistry Teacher
Illinois Mathematics and Science Academy, Aurora, Ill.
Encourages Learning How to Learn

PBL promotes metacognition and self-regulated learning as students generate strategies for problem definition, information gathering, data analysis, and hypothesis building and testing—and share and compare those strategies with those of other students and mentors. Such challenging work goes on at all grade levels:

I think it's critical for a kid to be able to formulate the process: "That's what I know and that's what I need to know." If they can begin to think about how they are thinking that way, they could know either where to get the stuff or add to whatever they know... They are much more adaptable—now I'm going to start talking like an ecologist here—but their ability to adapt to whatever intellectual or challenging environment they are put in, is lots better—was it Pasteur who said, "Chance favors the prepared mind"? The question is, How do you prepare the mind? Is it simply by knowing more stuff? Or knowing how to approach the problem?

—John Thompson, Science/Biology Teacher
Illinois Mathematics and Science Academy, Aurora, Ill.

First-graders are not inhibited. They're ready to hit the phones, go on the Internet, go ask their neighbors. They are open to inquiry, and they're not afraid of that challenge. They're able to define for themselves aspects of the work that interest and challenge them... It's a whole new way for these kids to not just be able to think, but to do.

—Emily Alford, Former Principal
Westgate Elementary School, Arlington Heights, Ill.

Requires Authenticity

PBL engages student learning in ways that are similar to real-world situations and assesses learning in ways that demonstrate understanding and not mere replication. Teachers report on the results of providing authentic situations and assessment:

It wasn't clear to me how powerful the method was until almost two-thirds of the way through that first year, when it became obvious that significant groups of kids were taking off totally on their own and going in powerful directions that we had hoped would occur, but weren't guaranteed would occur. And the kids kept coming to us and saying that this is the way it ought to be. They were doing things that were just astonishing. I still remember—[a student]—who went off to the conference on the West Coast. She became... in a year one of the prime experts on ELF (electromagnetic low frequency) fields and biological systems in the country. She knew as much as the experts.

—David Workman, Science/Physics Teacher
Illinois Mathematics and Science Academy, Aurora, Ill.

Simulated problems certainly can have value, but how can you compare a simulation with the power of real-world problem solving that has genuine results? Some of my students were able to convince a previously adamantly opposed village board to allow a pilot run for a local dance club, while others developed a Web site and brochure for a local pet shelter to help it gain needed publicity.

—Ellen Jo Ljung, Language Arts Teacher
Glenbard West High School, Glen Ellyn, Ill.
A Landscape of Instructional Strategies
In thinking about the benefits of PBL and students as knowers, thinkers, and doers, we have chosen to differentiate problem-based learning from a range of instructional strategies. We know that each strategy has its place in a teacher's instructional repertoire, and we see clear differences when considering the role of the student, teacher, and problem, along with other key factors (see Figure 2.3).

Summary
We have described what problem-based learning is and how it develops student dispositions toward inquiry and decision making based on evidence, not assertion. Both from the literature and our experience, we know that in PBL, students gather and apply knowledge and skills from multiple disciplines and sources as they assess an array of plausible solutions for a relevant ill-structured problem. In the next chapter, we delve into the background of PBL and examine how PBL enables students to emerge as open-minded, adaptable, complex thinkers able creatively and critically to assess the ever-changing world around them.
### Figure 2.3
Comparison of Instructional Strategies

<table>
<thead>
<tr>
<th>Type of Instruction</th>
<th>Role of the Teacher</th>
<th>Role of the Student</th>
<th>Cognitive Focus</th>
<th>Metacognitive Focus</th>
<th>Role in the Problem</th>
<th>Problem</th>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture</td>
<td>As expert:</td>
<td>As receiver:</td>
<td>Students replicate received knowledge and apply in testing situation.</td>
<td>None: Study skills are the responsibility of the student.</td>
<td>As a student: Learns about things outside personal experience or “over there” (Heathcote and Herbert 1980).</td>
<td>• Well structured</td>
<td>Organized and presented by instructor.</td>
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<td>• Directs thinking</td>
<td>• Inert</td>
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<td>• Holds knowledge</td>
<td>• Inactive</td>
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<td></td>
<td>• Evaluates students</td>
<td>• Empty</td>
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<tr>
<td>Direct Instruction</td>
<td>As conductor:</td>
<td>As follower:</td>
<td>Students practice and replicate received knowledge and apply in testing situation.</td>
<td>Guided practice provides tacit focus upon strategies.</td>
<td>As a student: Learns about things outside personal experience or “over there” (Heathcote and Herbert 1980).</td>
<td>• Well structured</td>
<td>Organized and presented by instructor.</td>
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<td></td>
<td>• Orchestrates learning</td>
<td>• Responsive</td>
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<td>• Guides rehearsal</td>
<td>• Semi-active</td>
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<td></td>
<td>• Evaluates students</td>
<td>• Waits for teacher's lead</td>
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<td>Case Method</td>
<td>As consultant:</td>
<td>As client:</td>
<td>Students apply received knowledge and own experience in case resolution.</td>
<td>Strategies learned are applied to cases, not necessarily independently.</td>
<td>As a student: Learns about things outside personal experience or “over there” (Heathcote and Herbert 1980).</td>
<td>• Well structured</td>
<td>Most is organized and presented by instructor.</td>
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<td></td>
<td>• Lectures</td>
<td>• Responsive</td>
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<td>• Sets the environ-</td>
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<td>• Applies own</td>
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<td>• Advises</td>
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<td>• Evaluates students</td>
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<td>Discovery-Based Inquiry</td>
<td>As mystery writer:</td>
<td>As detective:</td>
<td>Students apply “discovered” truths to the construction of other constructs and principles.</td>
<td>Inquiry process learned is applied to investigations, not necessarily independently.</td>
<td>As a student: Learns about things outside personal experience or “over there” (Heathcote and Herbert 1980).</td>
<td>• Well structured</td>
<td>Most is organized and presented by instructor.</td>
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<td></td>
<td>• Combines parts that lead to discovery</td>
<td>• Picks up clues</td>
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<td>• Seeks out evi-</td>
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<td>Problem-Centered Learning</td>
<td>As resource:</td>
<td>As problem solver:</td>
<td>Students synthesize received knowledge and individuality in the resolution of problems within curricular context.</td>
<td>Problem-solving process learned is applied to problems, not necessarily independently.</td>
<td>As a student: Learns about things outside personal experience or “over there” (Heathcote and Herbert 1980).</td>
<td>• Moderately structured</td>
<td>Most is organized and presented by instructor.</td>
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<td>• Explicitly teaches content and problem solving</td>
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<td>• Crafts divergent solutions</td>
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<th>Role in the Problem</th>
<th>Information</th>
</tr>
</thead>
</table>
| **Simulation and Gaming** | As stage manager:  
• Manages situation  
• Sets simulation/game in motion  
• Watches from the wings  
• Debriefs situation | As player:  
• Experiences simulation/game  
• Reacts to emergent conditions/variables  
• Active | Students learn about themselves, their roles in life situations, and about the reality modeled.  
• Learning exposed during the debriefing process.  
• Experience interpreted and evaluated in reflection. | As a player or pawn:  
Reacts to events that are part of personal experience or "here" to relate to things "over there" (Heathcote and Herbert 1980). | • Moderately structured  
• Presented as a strategy to understand self and events | Most is organized and presented by instructor. |
| **Mantle of the Expert (Roles)** | As travel agent:  
• Enables learning from within group  
• Maps ways in which students will discover what they need to know to complete task  
• Guides their journey  
• Debriefs situation | As traveler:  
• Actively experiences the journey  
• Acts within and through a historical perspective | Students reconstruct classroom communication, creating a dialectic where they learn at the conceptual, personal, and social levels.  
• The eminent pressure of the lived experience activates prior learning.  
• Teacher simultaneously models and coaches. | As a doer:  
Walks in the time of the event, learning about events "here" (Heathcote and Herbert 1980). | • Tightly focused, but somewhat ill-structured  
• Presented as a situation that demands interaction with the social system | Most is organized and presented by instructor. |
| **Problem-Based Learning** | As coach:  
• Presents problematical situation  
• Models, coaches, and fades  
• Engages in the process as co-investigator  
• Assesses learning | As participant:  
• Actively grapples with the complexity of the situation  
• Investigates and resolves problem from the inside | Students synthesize and construct knowledge to bring resolution to problems in a way that meets the conditions that they themselves set forth.  
• Teacher models and coaches as needed.  
• Students develop strategies to enable and direct their own learning. | As a stakeholder:  
Immerses in the situation, learning about events "here" (Heathcote and Herbert 1980). | • Ill-structured  
• Presented as a situation within which a compelling problem is yet to be defined | Little is presented by instructor without students identifying a need to know. Most is gathered and analyzed by students. |


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