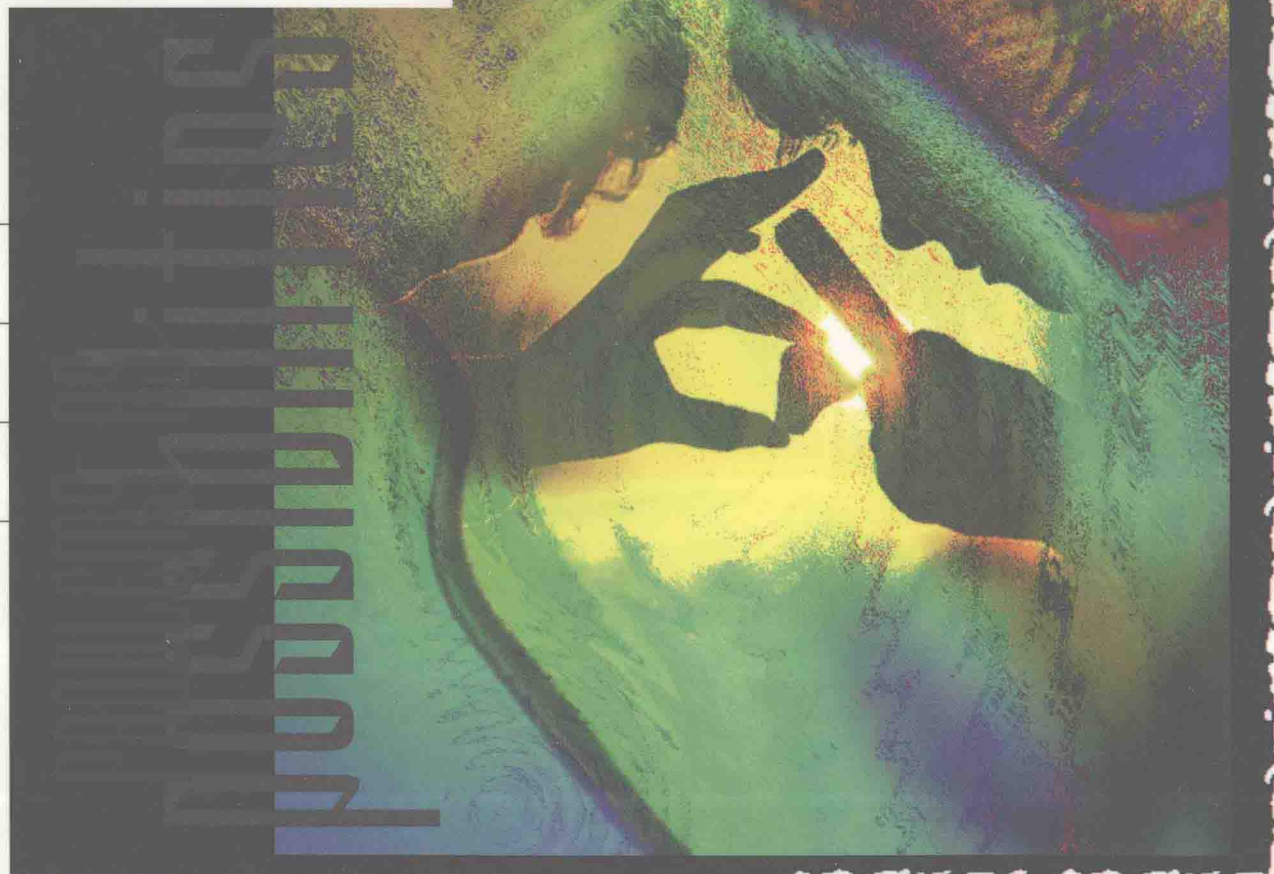


# PROBLEMS AS possibilities

**Problem-Based  
Learning for  
K-12 Education**



L I N D A   T O R P   A N D   S A R A   S A G E

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**Problem-Based**

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*To Clyde Torp—my husband, mentor, and best friend*

*To Andy Sage—my son—who enriches my life every day*

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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

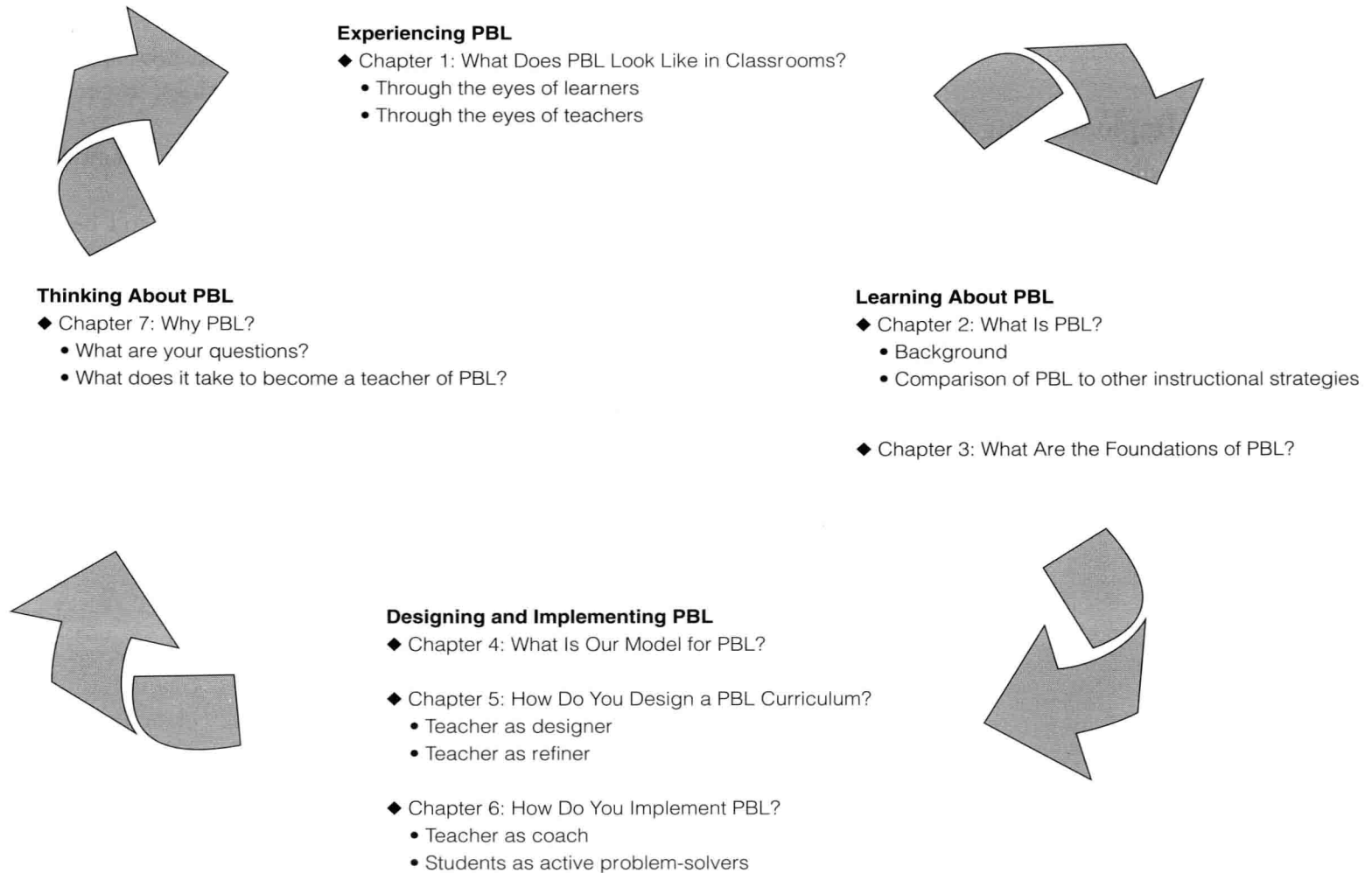
learners and opens the door to the process of becoming a teacher of PBL.

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***



# 1

## 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 business-people—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:

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: