ENGAGING STUDENTS WITH PROBLEM-BASED LEARNING

03.07.09 | agenda

8.30 – 9.00a	**ACTIVITY:** Tourism PBL warm-up
9.00 – 10.00a	**PRESENTATION:** PBL fundamentals
10.00 – 10.30a	**ACTIVITY:** Oceanography PBL KWL
10.30 – 10.45a	**BREAK**
10.45 – 11.30a	**PRESENTATION:** PBL templates
11.30 – 12.00n	**ACTIVITY:** Draft a PBL scenario
12.00 – 12.30p	**LUNCH**
12.30 – 1.00p	**PRESENTATION:** Assessment in PBL
1.00 – 2.00p	**ACTIVITY:** PBL integration clinic

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part 1: what is PBL?

A Sample Problem…

Your team is a media consulting group that helps businesses and governmental agencies design public outreach efforts. You have been contacted by the State of North Carolina Chamber of Commerce to help with the design of a new tourism website for the State. They have few ideas, but have expressed the desire for "an entertaining and informative site that will dramatically increase visitors to North Carolina."

Your task is to develop a compelling presentation—a "pitch"—that outlines the features of this new website.

What is Problem-Based Learning?

- PBL is an instructional strategy that requires students to solve engaging, complex, ill-defined, "real-life" problems with divergent solution
- Students are actively engaged in shaping learning goals and methods
- Students usually work collaboratively in groups
- Faculty serve as facilitators and coaches

Who are Digital Kids?

- Digital kids are hyper-communicators
- Digital kids are multi-taskers
- Digital kids are goal oriented
- Digital kids have inflated expectations about school and the world of work

Digital Natives and Immigrants

Digital Native Learners	Digital Immigrant Teachers
Prefer receiving information quickly from multiple multimedia sources.	Prefer slow and controlled release of information from limited sources.
Prefer parallel processing and multitasking.	Prefer singular processing and single or limited tasking.
Prefer processing pictures, sounds, and video before text.	Prefer to provide text before pictures, sounds, and video.
Prefer random access to hyperlinked multimedia information.	Prefer to provide information linearly, logically, and sequentially.

Digital Natives and Immigrants

Digital Native Learners	Digital Immigrant Teachers
Prefer to interact/network simultaneously with many others.	Prefer students to work independently rather than network and interact.
Prefer to learn "just-in-time."	Prefer to teach "just-in-case" (it's on the exam).
Prefer instant gratification and instant rewards.	Prefer deferred gratification and deferred rewards.
Prefer learning that is relevant, instantly useful, and fun.	Prefer to teach the "canon," even if it's not relevant or enjoyable.

What Are Other Strategies?

PBL Compared to Direct Instruction:

Direct Instruction	Problem-Based Learning
Students are passive recipients of knowledge	Students actively construct knowledge
Convergent on the "one right answer"	Divergent solutions, no "one right answer"
Teacher-centered and directed	Learner-centered and co-directed
Well-structures outcomes and procedures	Ill-structured, emergent outcomes and procedures

PBL Compared to Direct Instruction:

Direct Instruction	Problem-Based Learning
Predetermined, fixed response format	Open-ended, flexible, multiple response formats
Teachers provide a one-way flow of information	Teachers coach students and act as co-learners
Assessment used to differentiate students	Assessment used to improve learning

What are the Benefits of PBL?

- Authenticity and Relevance
- Higher-Order Thinking Skills
- Subsumption
- Motivation
- Metacognition and Self-Reflection
- Cooperation
- It Works!

What Skills are Learned in PBL?

- Content Knowledge
- Problem-Solving
- Communication
- Collaboration
- Technology
- Self-Regualtion
- Evaluations
- Making Connections

How is Technology Used in PBL?

- Transition from:
  - Teaching about technology (informatics)
  - Teaching with technology (courseware and software)
  - Learning with technology (technology as a tool)
- Efficiency: "*A difference in degree becomes a difference in kind.*"
- Richness in Knowledge Work
- Authentic Audience and eFolios
- Ease of Communication

How are PBL Units Designed?

It's as simple as ABCD…

- Assessment
- Background materials
- Case scenario/Problem statement
- Display of student work

How are PBL Units Assessed?

- Pre-Assessment: Prerequisite Knowledge
  - KWL, discussions, quizzes
- Formative/Process: Checking-in
  - Blogs, discussions, coaching
- Summative: Learning Outcomes
  - Rubrics, student work, peer- and self-assessment
- What about the Content!?
  - Traditional assessment is OK, too…

How is Background Content Taught?

- Pathfinders
  - A pathfinder is a page of weblinks prepared in advanced to make searching more efficient
- Readings
- Media
  - Podcasts, YouTube, etc
- Student Presentations
  - Students conduct preliminary research on the topic and present findings to class
- PBL provides a great opportunity for "new literacies"

What is a Good PBL Scenario?

- Compelling Scenario and Learner Roles
- Clear Curriculum Connections
- Ill-structured
- Problems Evolve with More Information
- Divergent Solutions
- Rich Information and Media Resources Available
- Multidisciplinary and Integrative

What are Learning Products in PBL?

The "Term Paper of the Future"

- Multimedia Presentations
  - Video and Audio
- Statistical Analyses and Models
- Graphics
  - Diagrams, Maps, Charts, Graphs, Animation, Posters, Brochures, Slide show
- Databases
- Web Pages
- Other Creative Activity

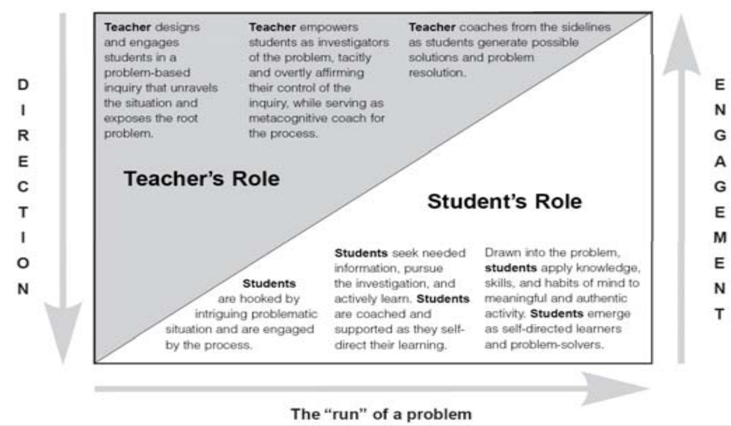
How are PBL Units Implemented?

- Develop/Select Unit Goals
- Develop the Problem Scenario
- Introduce the Problem
- Brainstorm (KWHL) to Define the Activity
- Refocus the Problem
- Find and Share Information (Pathfinders)
- Develop Proposed Solution Products
- Present Problem Solutions
- Evaluate the Process and Products

What is a KWHL Chart?

What do we KNOW	What do we WANT to learn	HOW will we learn	What have we LEARNED

How do Teachers' and Students' Roles Change in PBL?



What are Good Questions in PBL?

- Probes: ask students to delve deeper into an idea
  - *Can you say more about that?*
- Challenges: prompt students to support claims
  - *How do you know that to be true?*
- Redirects: bring students back to the problem
  - *Before our discussion you said _____;what do you think now?*
- Goal-setting: help students set goals for their solutions
  - *Where do you think we can find out that information?*
- Monitors: encourage students to monitor and report their problem-solving processes
  - *Do you have enough information to report?*

What are PBL Coaching Strategies?

Facilitating Understanding:

- Diagnosing needs
- Mentoring learning
- Encouraging process
- Questioning thinking
- Modeling inquiry
- Providing instruction

Managing the Learning Process:

- Adapting the PBL process
- Focusing the problem
- Managing work groups
- Monitoring engagement
- Assessing in process

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part 2: PBL design templates

What is Teaching for Understanding?

- Big and Important Ideas = “Throughlines”
- Performances of Understanding
- Ongoing Assessment

http://learnweb.harvard.edu/alps/tfu/index.cfm

Some Successful PBL Model Units: Mathematics

- Design a Package
- Recycling School Debris
- Build a Bridge
- Design a Playground
- Design a Mall
- Very Amusing
- You Call that Service?!
- Sweet Quality Control
- Good Eats
- Hit the Slopes
- Flooring the School
- Fundraising with Swag
- Patient Zero
- 5 Out of 4 Dentists
- Family Vacation
- Energy Choices
- Wanted: Mathematicians

Some Successful PBL Model Units: Science

- Design a Peace Garden
- Plant a Seed
- Adopt a Classroom Pet
- Don't Bug Me!
- Genetic Counseling
- Stem-Cell Research Policy
- Design a Nature Park
- The Plague
- Colonize the Oceans
- Reclaim That Dump
- Crop Circle Controversy
- To Clone or Not to Clone
- Not in My Backyard!
- Zoo Habitat
- Stop Deforestation

Some Successful PBL Model Units: Language Arts

- Student News Website
- What Light Through Yon Window Breaks?
- Return of Son of the Sequel, Part 3
- Hall of Fame
- Propaganda Website
- Ban-a-Book
- Recast a Character
- Publish a Magazine
- We Could a Make a Million
- The Lost Tale
- Rewrite the Ending
- Rewrite a Speech
- Build a Library
- Build a Blog/Vlog

Some Successful PBL Model Units: Social Studies

- Urban Nutrition Project
- Run for Mayor
- Immigration Policy
- There Oughta Be a Law
- Intercultural Lunch Menu
- International Children's Bill of Rights
- The 14th Colony
- Amend the Constitution
- Under Secretary of State
- Rebuild 'Nawlins
- Urbane Planning
- Lost Tribe of X
- World Trade Agreement
- Southern Reconstruction
- Rebuild Iraq
- Write a Constitution
- Tourism Website

Some Successful PBL Model Units: Fine Arts

- On the Air
- Public Art Works
- Mural Painting Traditions
- Art for Sale
- Add an Influence
- Ban That Song
- Salon des Refuses
- Virtual Museum
- Web Contractors
- T-Shirt Sale
- Summer Concert Series
- Project: Decorate
- Give It Back?

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part 3: PBL assessment and evaluation

How is Student Work Assessed?

- Traditional Tests
- Structured Self-Assessment
  - Surveys
  - Learning Logs
- Structured Peer-Assessment
  - SWORD
  - Web 2.0
- Rubrics
  - http://www.rubristar.com
- EPortflios

What is a Generic Rubric?

	Exemplary	Proficient	Developing	Unsatisfactory	Not Observed	Comments
TECHNICAL						
Length	4	3	2	1	--	
Audio Quality	4	3	2	1	--	
Image/Video Quality	4	3	2	1	--	
Use of program features	4	3	2	1	--	
CONTENT						
Organization	4	3	2	1	--	
Research	4	3	2	1	--	
Thoroughness	4	3	2	1	--	
Audience	4	3	2	1	--	
Engagement	4	3	2	1	--	

How is PBL Evaluated?

- Did the problem meet key curriculum goals?
- Did the problem build students' thinking skills?
- Did the problem connect with the outside world?
- Did the problem emerge from student interests?
- Was the problem the right level for the students?
- Were sufficient resources available?
- Are changes necessary before this problem is used with this level of students again?

PBL Design Guiding Questions:

Identify a major throughline or learning goal. "When this course is over, it's really important for my students to know__________________?" Write this goal in student friendly language: "I can describe…." Or "I know how important…." Or "The impacts of __________________were __________________."

What knowledge product will your students create: essay, letter, white paper, presentation, website, video, podcast, slide show, diagram, chart, map, brochure, poster, etc?"

How will you assess their learning and the quality of their work? What criteria or questions will you use to guide your assessment? How will you assess the contributions/learning of each student?

Draft a problem-statement or scenario. Does the problem promote convergent or divergent solutions? Does it encourage students to apply what they already know? Is it engaging? Is it ill-defined? Does it promote collaboration/cooperation? Does it promote creative use of technology?

What resources are available for your students? Are there a variety of websites? Primary and secondary sources? Video clips, images, audio programs, graphics? What types of resources will you suggest or permit: refereed primary sources only? Popular media, Wikipedia? Can you assemble a pathfinder?

How will you introduce the problem? KWHL? Student presentations? An introductory assignment? Discussion questions? The problem scenario alone?

How will you manage the learning process? How will you monitor the progress of students/small groups?

How will students present their knowledge products?

How will you evaluate the quality of your teaching?

Levels of Questioning in PBL

Cognitive-Level Questions:
How reliable is________? How valid is________?
Have you considered________?
Tell me more.
What if________?
What do you mean?
What is going on here?
Where does this fit?
Who needs to be considered?
Do we have enough facts to suggest________?
How reasonable is________?
Can everyone define________?
If what Ann and Liz say is true, do you still believe________
How does this apply to________?
What is your hunch (hypothesis or best guess) about this?
Why is this important?
Metacognitive-Level Questions:
Are you sure?
What still needs to be done?
What solutions are emerging?
Where do you see gaps or ambiguities?
Where can we start?
What is your strategy?
How can we fit this all together with________?
Who will do this? By when?
What have you accomplished?
How can we learn more about this?
Have you considered________ (process or strategy)?
What in your goals or strategies needs to change?
What conclusions have you drawn?
Have you reached your goal?
How could you go about this?
Why is this process important?
What do you want to accomplish?
What obstacles do you see?
What has worked best for you so far?
Epistemic-Level Questions:
How do you know? Do we need to know more? Why? What makes you say that? How will you decide when you know enough to solve this problem? How will you determine your best solution? What can we know? To what degree of certainty? What is at stake here? If________, then________? How does that relate to our problem statement? How does your role (perspective) influence your knowing and concerns?

What Is Problem-Based Learning?

(from Delisle, R. (1997). *How to use problem-based learning in the classroom.* Alexandria, VA: Association for Supervision and Curriculum Development.)

> *To organize education so that natural active tendencies shall be fully enlisted in doing something, while seeing to it that the doing requires observation, the acquisition of information, and the use of a constructive imagination, is what needs to be done to improve social conditions.*
>
> —Dewey 1916, 1944, p. 137

All education involves either problem solving or preparation for problem solving. From mathematical calculations ("What does this equal?") to literary analysis ("What does this mean?") to scientific experiments ("Why and how does this happen?") to historical investigation ("What took place, and why did it occur that way?"), teachers show students how to answer questions and solve problems. When teachers and schools skip the problem-formulating stage—handing facts and procedures to students without giving them a chance to develop their own questions and investigate by themselves—students may memorize material but will not fully understand or be able to use it. Problem-based learning (PBL) provides a structure for discovery that helps students internalize learning and leads to greater comprehension.

Origin of Problem-Based Learning

The roots of problem-based learning can be traced to the progressive movement, especially to John Dewey's belief that teachers should teach by appealing to students' natural instincts to investigate and create. Dewey wrote that "the first approach to any subject in school, if thought is to be aroused and not words acquired, should be as unscholastic as possible" (Dewey 1916, 1944, p. 154). For Dewey, students' experiences outside of school provide us with clues for how to adapt lessons based on what interests and engages them:

> *Methods which are permanently successful in formal education go back to the type of situation which causes reflection out of school in ordinary life. They give pupils something to do, not something to learn; and the doing is of such a nature as to demand thinking, or the intentional noting of connections; learning naturally results (Dewey 1916, 1944, p. 154).*

More than 80 years after that was written, students still learn best by doing and by thinking through problems. Educators who use problem-based learning recognize that in the world outside of school, adults build their knowledge and skills as they solve a real problem or answer an important question—not through abstract exercises. In fact, PBL originally was developed for adults, to train doctors in how to approach and solve medical problems.

Traditionally, medical schools taught doctors by requiring them to memorize a great deal of information and then to apply the information in clinical situations. This straightforward approach did not fully prepare doctors for the real world where some patients might not be able to identify their symptoms or others might show multiple symptoms. Though students memorized basic medical information for tests in their courses, they did not know how to apply the information to real-life situations and so quickly forgot it.

Recognizing that Dewey's maxim held true for medical education, I toward Barrows, a physician and medical educator at McMaster University in Hamilton, Ontario, Canada, wanted to develop methods of instructing physicians that fostered their own capabilities for reflection outside of school in ordinary life. For Barrows, the ultimate objective of medical education was

> *to produce doctors capable of managing health problems of those who seek their services, in a competent and humane way. To do this, the doctors must have both knowledge and the ability to use it (Barrows 1985, p. 3).*

While most medical schools focused on providing knowledge, Barrows thought this was just the first of three interdependent elements:

> *(1) an essential body of knowledge, (2) the ability to use knowledge effectively in the evaluation and care of patients' health problems, and (3) the ability to extend or improve that knowledge and to provide appropriate care for future problems which they must face (Barrows 1985, p. 3).*

Medical schools generally agreed on the content that should be taught; how this material should be learned remained an issue. Barrows developed problem-based learning to

allow [medical] students to integrate, use, and reuse newly learned information in the context of patients' problems; the symptoms, signs, laboratory data, course of illness, etc., provide cues for retrieval in the clinical context (Barrows 1985, p. 5).

This led to his first educational objective for PBL:

> *The medical students we educate must acquire basic science knowledge that is better retained, retrieved, and later used in the clinical context (Barrows 1985, p. 5).*

Barrows designed a series of problems that went beyond conventional case studies. He didn't give students all the information but required them to research a situation, develop appropriate questions, and produce their own plan to solve the problem. This cultivated students' "clinical reasoning process" as well as their understanding of the tools at their disposal. He found that PBL also developed students' abilities to extend and improve their knowledge to keep up in the ever-expanding field of medicine and to learn how to provide care for new illnesses they encountered. Students who were taught through PBL became "self-directed learners" with the desire to know and learn, the ability to formulate their needs as learners, and the ability to select and use the best available resources to satisfy these needs. Barrows and Tamblyn defined this new method, problem-based learning, as "the learning that results from the process of working toward the understanding or resolution of a problem" (Barrows and Tamblyn 1980, p. 18). They summarized the process as follows:

1. *The problem is encountered first in the learning sequence, before any preparation or study has occurred*
2. *The problem situation In presented to the student in the same way it would present in reality.*
3. *The student works with the problem in a manner that permits his ability to reason and apply knowledge to be challenged and evaluated, appropriate to his level of learning.*
4. *Needed areas of learning are identified in the process of work with the problem and used as a guide to individualized study.*
5. *The skills and knowledge acquired by this study are applied back It) the problem, to evaluate the effectiveness of learning and to reinforce learning.*

6. *The learning that has occurred in work with the problem and in individualized study is summarized and integrated into the student's existing knowledge and skills (Barrows and Tamblyn 1980, pp. 191-192).*

Problem-Based Learning and the School Improvement Movement

Although the PBL method outlined in the preceding section originally was designed for medical schools, it has been adopted by a growing number of K-12 schools working to raise student achievement. Students educated for the world of the 21st century must develop habits of thinking, researching, and problem solving to succeed in a rapidly changing world. Yet, too many children in traditional education are not developing these increasingly vital abilities.

Thinking and problem-solving skills are not explicitly measured on a national basis. But studies show that while students are making progress in learning basic skills, only a small percentage perform at desired grade levels and master higher-order thinking.

For example, on the National *Assessment of Educational Progress* (NAEP) reading test, 57 percent of 17-year-olds scored below the level necessary to "find, understand, summarize, and explain relatively complicated literary and informational material" (National Center for Education Statistics 19%, P. 114). Only 10 percent of students scored in the top two levels (proficient and advanced) on the NAEP history test. And while more than half of 17-year-olds (59 percent) could answer "moderately complex procedures and reasoning," only 7 in 100 showed a mastery of "multi-step problem solving and algebra" (National Center for Education Statistics 1996, p. 122). In science, less than half (47 percent) could "analyze scientific procedures and data," with only 10 percent able to "integrate specialized scientific information" (National Center for Education Statistics 1996, p. 126). Clearly, while students are taught the basics, they are unable to proceed to understanding and using advanced knowledge.

Problem-based learning fits right into the movement for higher standards and greater achievement. PBL asks students to demonstrate an understanding of the material, not just to parrot back information with a few word changes. Research and teachers' experience have demonstrated that active instructional techniques like PBL can motivate bored students and raise their understanding and achievement. These student-centered strategies build critical thinking and reasoning skills, further students' creativity and independence, and help students earn a sense of ownership over their own work.

In classrooms where educators employ active learning strategies, students talk to each other, not through the teacher, and they initiate and manage many of their own activities. In these classes, the teacher serves as a guide to learning, providing room for students to increase their independence and build their own creativity. The teachers rely less on textbooks, using them as only one of a number of valid information sources that include everything from the Internet to community members. Similarly, schools using active learning become more flexible, allowing teachers greater freedom to direct their students and structure their own courses. They recognize that helping students master information needed to solve a problem and building their analytical reasoning skills are at least as important as memorizing a predetermined answer.

Present State of Problem-Based Learning

Since Barrows first used PBL at McMaster University in the mid-1960s, PM. "has caused a small revolution in the medical community" (Albanese and Mitchell 1993), and it was cited by a U.S. News and World Report issue reviewing medical schools:

> *Since the late 1970s, New Mexico has been a pioneer in reforming medical education and training. It was the first U.S. medical school to embrace a curriculum built around a case study method—the problem-based approach adopted six years later by Harvard (Sarnoff 1996, pp. 92-94).*

PBL is presently used in more than 60 medical schools worldwide and also in schools of dentistry, pharmacy, optometry, and nursing. It is also used in high schools, middle schools, and elementary schools in cities, suburban counties, and rural communities. Teachers have been trained at the Problem-Based Learning Institute in Springfield, Illinois; the Center for Problem-Based Learning at the Illinois Mathematics and Science Academy in Chicago; and the Center for the Study of Problem-Based Learning at Ventures In Education in New York City.

PBL offers K-12 teachers a structured method to help their students build thinking and problem-solving skills while students master important subject knowledge. It empowers students with greater freedom while providing a process that teachers can use to guide and lead students. Most of all, PBL transfers the active role in the classroom to students through problems that connect to their lives and procedures that require them to find needed information, think through a situation, solve the problem, and develop a final presentation.

At this point, you may wish to look at one of the "practical" chapters (Chapters 7 to 11) before proceeding. Reading through some actual PBL problems may help you understand the background information in Chapters 2 to 6.

Developing a Problem

(from Delisle, R. (1997). *How to use problem-based learning in the classroom.* Alexandria, VA: Association for Supervision and Curriculum Development.)

> *A large part of the art of instruction lies in making the difficulty of new problems large enough to challenge thought, and small enough so that, in addition to the confusion that naturally attending to novel elements, there shall be luminous familiar spots from which helpful suggestions may spring.*
>
> \- Dewey 1916, 1944, p. 157

Using problem-based learning (PBL) frees a teacher from the limitations of the textbook and the school's instructional materials. For a teacher using PBL, any incident or event, whether inside or outside the school, can spark a PBL problem that is linked to students' lives. For example, a teacher in a school with racial tensions could craft a problem on ways to promote greater understanding among different groups. During elections, teachers could create a PBL problem through which students develop a children's platform to send to candidates. Any issue or problem in which students have a personal interest or connection can become an effective PBL unit.

There is no limit to the variety of purposes behind PBL problems. Teachers can develop problems to address students' mastery of curriculum, to improve the community, or to solve interpersonal problems in the classroom. A problem can seek to change an unacceptable school or neighborhood situation or to celebrate a neighborhood achievement. Problems can be designed for part of a particular course, or they may be spread out throughout the curriculum. They can be specific to a single content area or interdisciplinary in nature; they can be designed by one teacher working alone or collaboratively for team teaching.

Whether selected from existing PBL materials or designed from scratch, problems should be developmentally appropriate, grounded in student experience, and curriculum based. Problems should accommodate a variety of leaching and learning strategies and styles, and they should promote the acquisition of knowledge as well as the development of skills. In addition, the problem should be ill-structured so that as students perform additional research, they discover the problem's complexity and understand that it may have a number of solutions.

Regardless of the purpose for which a problem has been selected and designed, a teacher generally follows the process of selecting content and skills, determining availability of resources, writing a problem statement, choosing a motivation activity, developing a focus question, and determining an evaluation strategy. Figure 4.1 contains a checklist for developing an ill-structured problem.

Selecting Content and Skills

To select content objectives, a teacher would refer to curriculums developed by the district and the state. For example, a New York City teacher of 8th grade social studies would first go to New York City's *Curriculum Framework: Knowledge, Skills and Abilities Grades PreK-12* to find out what is required of that subject and grade:

> *The Grade 8 program traces the human experience in the United States from 1816 to the present. It ties major political, economic, and social trends in United States history to parallel trends and time frames in New York State history (Board of Education of the City of New York 1995, p. 180).*

The frameworks also have lists of what students would be expected to know and do by the end of the course. For example, consider these two points in the New York City framework:

- Demonstrate an awareness of the social, economic, and political changes in New York State and United States history, brought about by industrialization.
- Demonstrate an ability to access, analyze, evaluate, and present, orally or in writing, data related to New York State and United States history, brought about by industrialization (Board of Education of the City of New York 1995, p. 180).

Based on these frameworks and the current employment situation in New York City, the teacher could create a problem in which students act as a consulting firm hired by a corporation to produce alternatives to closing their old factory. Or the teacher could develop a problem on improving conditions in modern sweatshops.

In addition, teachers may consult standards and curriculums developed by national subject-specialty groups, such as the National Council of Teachers of Mathematics or the National Council on the Social Studies, for information and skills that could be included in PBL problems.

Once the teacher has determined the content of the PBL problem, the next stage is to determine what the students should be able to do by the time the problem is solved, the teacher also needs to decide how the problem could help students acquire those skills. For example, if the teacher believes that students need to improve their interpersonal skills, the problem could require them to interview other students and produce a group project. If the teacher believes students need to practice writing business letters, the problem could require writing to a manufacturer of a shoddy product. If the teacher wants students to read and discuss a specific author's canon of work, comparing and contrasting materials, the problem could ask them to develop a museum exhibition on the writer. The skills the problem should help students develop can come out of the teacher's own experience with the class, the curriculum, or the district's frameworks.

Determining Availability of Resources

A teacher does not want students to struggle with a project for lack of information. Before writing or choosing a problem, the teacher must ensure that students will be able to find the information necessary to solve it. Generating lists of resources available in the classroom, school, and larger community could help students when they become stuck. The teacher also can check the resources available in the library or the school's procedures for using the Internet. Other staff members and community residents can be useful sources of information if they are available and accessible to students. Depending on building rules, students may be able to use the school's duplicating facilities, telephones, and fax machines. The district curriculum office or other district offices also may be of assistance.

Writing a Problem Statement

When the teacher has determined content and skills objectives and collected the necessary resources, the next step is to write the problem statement. A problem statement should

- be developmentally appropriate,
- be grounded in student experience,
- be curriculum based,
- accommodate a variety of teaching and learning strategies and styles, and

- be ill-structured.

Developmentally Appropriate. Problem selection or design should take into account the intellectual development and social-emotional needs of students. For example, the question of prejudice and tension between groups is appropriate for middle and high school students:
The principal of the school is concerned about the tensions that seem to exist between individuals and among different groups in the school. He wants to learn what can be done to lessen the tensions and foster more harmony among students. He has asked this class to prepare a presentation for him, his cabinet, and the school's student government.

Grounded in Student Experience. To build, as Dewey put it, "luminous familiar spots" into "problems large enough to challenge thought," these problems should be grounded in the experiences of students (Dewey 1916, 1944, p. 157). These experiences may be from students' homes or cultures or their peer groups. They may come indirectly from television, radio, or the movies, or they may be the result of school experiences. The closer the problem is to students' daily lives and something they care about, the harder they will work. For example, students' actual complaints about not being able to play on the school's basketball court led a teacher to draft the following problem:

Several 5th and 6th graders have complained that the bigger children on the playground will not allow others to use the basketball area. You have been asked by the head teachers of the upper grades to look into the matter and come up with a series of recommendations that will allow any student who wishes to use the basketball court.

Curriculum Based. Problems should be vehicles by which students obtain knowledge from a variety of disciplines. Problems should promote the acquisition of appropriate skills and content knowledge found in the district's frameworks or the teacher's curriculum. Good problems creatively combine students' lives and what they see and do every day with topics froth the course syllabus. Problems could include material not normally studied if it helps students build important skills or leads them to important information. Problems may also explore links between subjects. For example, an art and English class might combine for a problem on public art:

> *The subway station is going to be improved at a cost of $5 million. By law, 2 percent of this money is to be devoted to public art in the station. You are members of a committee that has two tasks. The first is to set up the rules and regulations for artists who wish to submit entries. The second is to determine the criteria or guidelines for selecting the winning designs.*

Variety of Teaching and Learning Strategies and Styles. Teachers and students have different ways of teaching and learning. A problem should not be so rigid that it has only one right solution, one way of reaching a solution, or one way of instructing students. Problems should be designed to allow success for teachers with different teaching styles as well as for the variety of student learning styles in the classroom. The problem should promote a range of activities that allow students of different levels to contribute to the solution. For example, the following problem might be worked on by students individually or in groups, researching library materials, contacting publishers, or interviewing adults about books they use:

> *The Caribbean, a region of islands populated by English-, French-, and Spanish-speaking inhabitants, is the former home of many of our students or their parents. Our school library does not contain*

> *materials that adequately reflect the culture of this region, and you have been asked to submit a plan for remedying this situation.*

Ill-Structured. Unlike a thinking exercise that includes all necessary information or a traditional project that requires students to use information they already know, PBL problems should be designed so that students must perform research to gather the information needed for possible solutions. It should require students to think through information they already know and to find additional information, interpreting preexisting knowledge in light of new data they discover. In addition, the problem should lead students to discover that there may be a number of solutions. For example, students in a class with large numbers of immigrants would find the following problem immediately relevant, and they already would know a great deal about immigration. However, solving the problem would require them to find specific figures about jobs, taxes, and the economic impact of immigrants:

The newspapers have recently reported that many people are concerned about the number of immigrants arriving in the United States and how they are taking away jobs, being supported by taxpayers, and using up scarce resources. They are saying that we should no longer allow immigrants to come to the United States. You and your classmates have been asked by your state representative to look into these claims and to make some suggestions as to how he could deal with this issue.

Choosing a Motivation Activity

Once the teacher has written or chosen the problem, she should think of ways to show its connection to students' lives. Generally, the teacher deliberately includes relevance to students as one of the criteria for selecting or designing a problem. Still, the teacher should think of ways to introduce the subject and make the links explicit.

The greater students' involvement in an issue, the greater their investment in its solution and the harder they will work. For example, in the case of the social studies teacher using the preceding problem on immigration, she knows that many of her students come from immigrant families or have immigrant friends from such families, so this issue will touch them personally. The teacher can help build the issue in their minds by starting the class with articles calling for a reduction of benefits to immigrants or demanding a strong crackdown on illegal immigrants. The teacher can ask students if they know people who were born in other countries, and they can mark those countries on the map. This would lead into a discussion about immigration that then will make the students more excited about solving the problem.

Developing a Focus Question

Once the teacher has written the problem statement, she should develop a question that will help students focus on their task after they become interested in the problem. In the immigration problem, the teacher might ask, "Now that we've talked about immigration and know what problem we have to solve, let's focus on 'How is immigration good or bad for the country?' or 'How do immigrants use resources?'"

Determining an Evaluation Strategy

Evaluation strategies with problem-based learning are as varied as those used in any classroom. Mastery of content could be assessed using a pre-post test, or it could be assessed using a debate format where the teacher has a checklist of items to be rated on a five-point scale. For each problem, the teacher should integrate a product or performance that is used to evaluate mastery of content, skills, and the process of problem solving itself. Chapters 5 and 6 provide additional information on evaluation.

When students are motivated and understand the importance of an issue to their own lives, the teacher can introduce a carefully crafted problem that gains their full attention. Students who see the relevance of their work to their own lives are more likely to be active workers rather than passive observers, enthusiastic learners rather than reluctant listeners. Once a problem is developed and students are connected to it, the teacher can follow the PBL process as outlined in the remainder of this book.

Checklist for Developing a Problem		
Have I	**Yes**	**No**
Selected appropriate content?		
Determined availability of resources?		
Written a problem statement that		
Is developmentally appropriate?		
Is grounded in student experience?		
Is tied directly to the curriculum?		
Allows for variety in teaching and learning strategies?		
Is ill-structured?		
Chosen a motivation activity?		
Developed a focus question?		
Determined evaluation strategies?		

How Do You Assess Learning In And Through Problem-Based Learning?

(from Torp, L. and Sage, S. (2002). *Problems as possibilities; Problem-based learning for K-16 education.* Alexandria, VA: Association for Supervision and Curriculum Development).

When planning a pbl experience, of course you keep your learners in mind. Your goals are clear. You've targeted learning standards, mapped out instructional strategies, and arranged for plentiful resources, but what about assessment? At the Illinois ASCD Conference in 1993, Roger Farr spoke with conviction about assessment, capturing in one sentence its essence, "How do you know a good one when you see one?" In this chapter, we look briefly at the general topic of assessment; then we examine assessment through the lens of PBL.

Focusing Our Assessment Vision

Several years ago, Steven Covey (1990) made the phrase, "Begin with the end in mind!" well known as one of the seven habits in his book, The Seven Habits of Highly Effective People. This guiding principle is known in many professions as backwards planning. Before entering the teaching profession, one of the authors learned quickly as a production scheduler for a major television manufacturer that arriving at where you need to be demands that you know where you are going. That concept holds especially true when designing curriculum, whether it's problem-based or not.

Principles of Instruction

In Basic Principles of Curriculum and Instruction (1949), Ralph Tyler set forth four questions about curriculum planning and assessment that remain valid today. To his four basic questions we have added a number of follow-ups that apply directly to the discussion of PBL.

1. What educational purposes should the school seek to attain?

- Are national standards useful in deciding what students need to know, apply, and value?
- Which state learning standards apply?
- Has your local school district defined goals and standards?
- What are your goals for your students?

2. How can teachers select learning experiences that are likely to be useful in attaining these objectives?

- What is developmentally appropriate for your students?
- Have you considered the interests of your students?
- Who needs to have input into the selection process?

3. How can you organize learning experiences for effective instruction?

- Direct instruction?
- Discovery learning?
- Concept attainment?
- Problem-based learning?
- In other words, what instructional strategy fits the purposes and the specific learning experiences?

4. How can you calculate the effectiveness of learning experiences?

- How do you know that what you intended actually happened?
- You wanted them to learn something—did they?
- How well did they learn it? What evidence do you have?

- Was this learning experience worth repeating?
- Does it need to be modified? How?

Ralph Tyler had a great deal of respect for teachers and the important work that they do, as do we. Tyler spoke of teachers' assessment practices and the need to use common sense, but he noted with remorse that "the only problem with common sense is that it's so uncommon" (Riddings-Nowakowski, 1981).

Tyler believed that learning takes place through the student's active behaviors. In other words, a student learns by doing, not by watching and listening to what the teacher does. As educators, we need clarity about what we want students to know and do—and, as Roger Farr said, to know it when we see it.

Bloom's Taxonomy

Over the years, many people have contributed to our ability to know learning when we see it. One such researcher was Benjamin Bloom. He and his colleagues (Bloom & Krathwohl, 1956) developed a classification system (or taxonomy) for three overlapping domains of intellectual behavior important in learning (cognitive, affective, and psychomotor).

We are concerned most often in the classroom with the six areas of the *cognitive* domain. Particular behaviors characterize this domain, and certain verbs signal the activities that accompany them.

The *affective domain* relates to emotions, attitudes, appreciations, and values, like enjoying, respecting, and supporting. This domain includes behaviors indicating attitudes of interest, concern, and responsibility; an ability to listen and respond to others; and an ability to demonstrate attitudes that fit the situation and the field of study.

FIGURE 7.0: Bloom's Taxonomy			
Knowledge	arrange define duplicate label	list memorize name order	recognize relate recall repeat
Comprehension	classify describe discuss explain express	identify indicate locate relate report	restate review select translate
Application	apply choose demonstrate dramatize employ	illustrate interpret operate practice schedule	sketch solve use write
Analysis	analyze appraise calculate categorize compare	contrast criticize differentiate discriminate distinguish	examine experiment question test
Synthesis	arrange assemble collect compose construct create	design develop formulate manage organize plan	prepare propose set up write
Evaluation	appraise argue assess attach choose compare	defend estimate evaluate judge predict rate	score select support value

Psychomotor learning is displayed through physical skills like coordination, manipulation, grace, strength, and speed—activities that use fine motor or gross motor skills. Verbs related to this domain include bend, grasp, handle, operate, reach, relax, shorten, stretch, write, and perform.

Facets of Understanding

Today, Grant Wiggins and Jay McTighe continue to sharpen our focus relating to assessment so that we see valued learning outcomes more clearly. They propose six facets of understanding (1998) that provide further insight into students' comprehension.

- *Explanation*—articulating not just the what, but also the why and the how of a thing
- *Interpretation*—bringing an explanation into the realm of personal experience
- *Application*—taking knowledge and skill from the learning experience and using it in a different circumstance (time, distance, discipline, context, etc.)
- *Perspective*—looking into a thing and emerging with one's own insights and point of view
- *Empathy*—getting inside another person's feelings and worldview
- *Self-knowledge*—knowing what you know and what you don't know and how your own frame of reference (culture, ignorance, style, etc.) distorts or frames your perception

Wiggins and McTighe propose that these facets are not a theory of how we understand, but rather of how educators recognize student understanding or misunderstanding when they see it. What can we see or hear or experience through a student's product or performance (paper, story, presentation, drama, model, experiment, etc.) that signals understanding? The clarity of each instance of assessment and its contribution to the whole picture—much like the facets of a gem—add to our insight into the student's understanding. Taken together they tell us much more than any one facet alone. Figure 7.1 presents a matrix of some questions teachers can ask to assess these facets in the context of problem-based learning. For example, what is the effect of empathy on the way a student tries to solve a problem?

Assessment Through the Lens of PBL

As we have worked to clarify assessment in problem-based learning, we have come to see varying possibilities and perspectives.

From the Perspective of Learning Coaches. As learning coaches, we need to find out what students are actually learning in the midst of the problem-based experience.

- What are students grasping? Do I need to provide embedded instruction to support learning?
- What do they still need to know to be able to identify the central problem? Do they need other resources? What questions do I pose to prompt their thinking in that direction?
- Are some students charging ahead or lagging behind? How can I provide for their needs through support or additional challenge?

Coaches/teachers also need information about other aspects of the students' learning life, as follows:

- Identify specific knowledge or skills that students are lacking, but recognize that instruction is not appropriate at this time. Students may also have a firm grasp of the complexities of a tangential issue/concept that you were planning to teach next month.

FIGURE 7.1: Understanding by Design and PBL			
Facet of Understanding	**Explanation**	**Interpretation**	**Application**
Perspective	Does a stakeholder's perspective influence the relevant details of an explanation?	Does a stakeholder's perspective skew his or her interpretation of the facts of a situation?	Do the skills and knowledge that a stakeholder brings to a situation have an effect on the potential solution or resolution?
Empathy	If students truly recognize the collective ownership of a problem, are they able to sense the feelings/values of other stakeholders?	Do students take into account the positions of others when generating possible solutions?	In devising potential solutions, do students consider and incorporate the synergy of varied skill and knowledge bases?
Self-Knowledge	Do students recognize multiple layers to an explanation? Or do they recognize that they lack sufficient knowledge and thus need to investigate?	Are students able to set aside who they are enough to be able to step into another's worldview?	Do students apply relevant knowledge and skills to the effective resolution of the problem? Can they call on information that was learned through the problem, in this course, in other courses, or in life?

From the Perspective of Assessors and Evaluators

As assessors, we also need information for our roles in communicating grades and scores for accountability purposes:

- How do we, as professionals, manage our conflicting roles? How do we put aside the intimate, personal role of teacher and coach to become the objective, impersonal assessor and communicator of data who assigns a grade—excellent or poor, A or F, 50 percent or 100 percent, satisfactory or unsatisfactory?
- How do we communicate information about a student's achievement to parents?
- How does the system communicate information about students' achievement to the community?

As evaluators of programs, we need information about activities, units, or programs that will ensure continuous improvement of our educational system and our own personal practice.

- Does this program enable students to become self-directed learners?
- Are students aware of their own personal learning styles, and do they use such knowledge to map effective strategies for learning, study, and project completion?
- Does the program demonstrate collective knowledge and skill mastery while maintaining student interest in and enthusiasm for learning?

From our experience, we have identified five essential questions to consider when planning assessments:

- Why must we assess learning?

- What do you need to know to conduct an assessment?
- What forms—product or performance—might that assessment take? (quiz, paper, memo, chart, poster, video, tall tale, service project, small group collaborative work plan, etc.)
- How will the assessment take place? (proctored setting, classroom, take-home, one-on-one assessment interview, juried performance, portfolio review panel, etc.)
- The concluding and overarching question encompasses two concerns: Who will receive the information—and how will they use it? Depending on the answers, we know what stakes—and stakeholders—are involved.

From the Perspective of the Context

Assessing student learning in PBL is always done in the context of the problematic situation. Such assessment is designed for teachers to monitor the thinking and dispositions of the student and to subsequently adjust the learning experience, or as J. G. Brooks and Brooks (1999) put it, "Assessment and teaching [are] merged in service to the learner" (p. 91). We could also think of such assessment as developing a "model" of the student (von Glasersfeld, 1993) in which teachers gain an understanding of the conceptual structures in the students' heads so they may better teach students to learn. Finally, assessment serves the important purpose of evaluating student attainment of significant outcomes identified for the PBL experience.

We see two clear purposes for assessment: assessment for learning and assessment of learning.

Assessment for Learning. By assessment for learning, we mean assessment that helps to serve the learning process in some way—by providing information meaningful for either the teacher or the learner during the learning process. Most often, this is nongraded assessment in the form of feedback, adjustment, refocusing, and coaching. Remember that mistakes are part of the learning process. Learners who are penalized for making errors or rewarded for making on-target responses often shut down and become overly cautious and do not fully participate at all levels—intellectually and emotionally.

When teachers assess for learning, risk taking is maximized, though this is still a fragile type of behavior in classrooms today. But teacher/coaches can provide substantial safety nets for students who take risks: Through even-handed responses (written, audible, or facial); through coaching and mentoring; and through data-collection practices that signal opportunities for continued learning, teachers can use assessment that enhances the learning process.

Assessment of Learning. By assessment of learning, we mean assessment that aids documentation and decision-making in some way:

- By providing information relative to expectations (goals, standards, benchmarks, stated performance, or proficiency levels).
- By providing information relative to the comparison or placement of students (overall class performance, performance relative to another group—whether local, state, or national) within a group or against another individual or group.

Mistakes are expected and help to differentiate one student's performance from another student's performance, one class's performance from another class's performance, or one school's performance from another school's performance—and so on.

When teacher/coaches reflect high levels of concern or anxiety about potential results, risk-taking is minimized and replaced by high levels of caution. Students pick up on this anxiety and match it. Teachers and students recognize the stakes involved. Results are fixed and are used to determine a terminal outcome, one that signals an end to this learning experience. This end-point could be the end of a project, a unit of study, a semester, a course, an academic year, a transition point from elementary to middle school, from middle school to high school, from high school to college, or a terminal degree—bachelors, masters, doctorate, and so forth.

The matrix in Figure 7.2 helps to clarify the what, why, and when of assessment in and through PBL both for and of learning.

A PBL Learning Experience: Bubonic Plague Example

To illustrate the assessment possibilities in and through PBL, we highlight a problem that Bernie Hollister, a master social science teacher, designed, developed, and refined to engage students in thinking about the plague in the United States and the variables that contribute to its spread or containment. According to Hollister:

> *Plague cases have occurred every year in the United States since the 1970s, and no one seems to have a convincing and definitive reason why they occur in relatively few states: California, Colorado, Arizona, and New Mexico having the majority of the cases. Of course, this lack of a "right" answer connects beautifully with PBL, and that is why we construct a problem around plague.*

Students take on the role of epidemiologists to examine CDC (Centers for Disease Control) data from outbreaks of bubonic plague in the United States during 1988 (http://www.imsa.edu/~bernie/plaguedata1988.html) and 1993 (http://www.imsa.edu/~bernie/plaguedata1993.html). In the following sections, we look at each stage of the PBL assignment and discuss what aspects of assessment apply to each.

Meet the Problem. Students as CDC epidemiologists are charged with investigating plague cases reported in 1988 and 1993. They engage in either small or large group discussion about what is known from limited information.

Assessment for Learning. Coaches systematically question students according to Bloom's lower levels (knowledge, comprehension, application): Where are most of the plague cases found? When do they occur? During this aspect of PBL we firmly believe that all assessment serves teaching and learning and, as such, is diagnostic. Nothing is graded at this stage.

Know/Need to Know. Students as epidemiologists chart what they know, think, and need to know to better understand the situation. Groups or individuals take on aspects of the investigation to bring new knowledge to the team.

Assessment for Learning. Systematic questioning continues at higher levels (analysis, synthesis, evaluation) interspersed with metacognitive and epistemic questioning

- What is bubonic plague? Is it caused by a bacterium? By a virus? Is it something else?
- What are the animal vectors that help it spread? How does it spread—or does it—from one human to another?

FIGURE 7.2: Assessment in and Through PBL		
PBL Assessment	**Assessment for Learning**	**Assessment of Learning**
Assessment in PBL	This type of formative assessment informs ongoing learning, coaching, and embedded instruction (planned and/or situational) experience. Students rely on this information to adjust their learning and performance expectations.	This type of summative assessment provides information about knowledge and skill proficiency during the run of the PBL during the run of the PBL experience. Students are aware that they will be graded" on these assessments that target specific knowledge sets, skills, or strategies.
Assessment Through PBL	This type of formative assessment informs ongoing instructional needs in the course or class that go beyond the scope of the PBL experience. Students are usually unaware of this information as it triggers actions by the teacher to set up situational groups or to modify course plans to better meet learning needs.	This type of summative assessment provides information about knowledge and skill integration, application, and competencies, evident through PBL experiences, and more traditional pedagogies and assessment practices. Students are aware of this type of information as it relates to the authentic assessment of research paper, projects, problem investigations, and presentations where analytic or descriptive rubrics provide an overall assessment and a grade.

During this aspect of PBL we firmly believe that, again, all assessment serves teaching and learning and, as such, is diagnostic. Nothing is graded at this stage, either.

Gather and Share Information. Students gather relevant information from multiple sources and glean pertinent facts to share with the group through charting, jigsaw, abstracts, discussion groups, and so forth.

Assessment for Learning. Questioning continues using probing and challenging information. Assumptions increase. Coaches need to ensure that students are focused on the science of plague and to coach learning in that direction.

- How is plague diagnosed? How is it cured? Does a vaccine exist? What are the morbidity and mortality rates?
- Is the microorganism that causes contemporary plague the same as Black Death? How might we determine this?
- How can one make intelligent inferences from the data? What are those inferences?

Assessment of Learning. As students build a knowledge base, expectations for conceptual understanding are high.

- Interim responses to supervisor's questions are presented in the form of telephone messages or some other form of intermediate communication.
- Presentations, memos, charts, and matrices of the findings of subgroups are shared with the entire class. With a larger problem, students will form targeted investigative groups, yet all need to know and understand critical information uncovered by each of the groups.

- Concept or mind mapping of the known information takes place, and the relationships become evident or begin building.

Defining the Problem Statement. With the situation, their background knowledge, and other information gathered and shared, students formulate a tentative problem statement to focus the inquiry.

Assessment for Learning. Whether individuals, small groups, or the full class generates problem statements, they provide insight into students' holistic understanding of the problem at hand and a baseline to assess their growing understanding.

Assessment of Learning. As students build a holistic understanding of the overarching problem, coaches should convey their expectation that students grasp the situation and elicit written problem statements from each student that include the issue and the conditions necessary for an acceptable resolution.

FIGURE 7.3: Levels of Questioning in PBL

Cognitive-Level Questions:
Are you sure?
How reliable is________? How valid is________?
Have you considered________?
Tell me more.
What if________?
What do you mean?
What is going on here?
Where does this fit?
Who needs to be considered?
Do we have enough facts to suggest________?
How reasonable is________?
Can everyone define________?
If what Ann and Liz say is true, do you still believe________
How does this apply to________?
What is your hunch (hypothesis or best guess) about this?
Why is this important?

Metacognitive-Level Questions:
Are you sure?
What still needs to be done?
What solutions are emerging?
Where do you see gaps or ambiguities?
Where can we start?
What is your strategy?
How can we fit this all together with________?
Who will do this? By when?
What have you accomplished?
How can we learn more about this?
Have you considered________ (process or strategy)?
What in your goals or strategies needs to change?
What conclusions have you drawn?
Have you reached your goal?
How could you go about this?
Why is this process important?
What do you want to accomplish?
What obstacles do you see?
What has worked best for you so far?

Epistemic-Level Questions:
How do you know?
Do we need to know more? Why?
What makes you say that?
How will you decide when you know enough to solve this problem?
How will you determine your best solution?
What can we know? To what degree of certainty?
What is at stake here?
If________, then________?
How does that relate to our problem statement?
How does your role (perspective) influence your knowing and concerns?

FIGURE 7.4: Questioning Strategies in PBL

Questions are one of our best tools to increase and assess student understanding in PBL. Questions help students think, reflect on their thinking, and consider information and consequences. The following are some examples of different question types:

Probes ask students to go deeper into an idea or concept, such as: Can you say more about that?

Challenges prompt students to support their claims or validate their reasoning, such as: How do you know that to be true?

Redirects bring students back to the problem, such as: Before our discussion you said what do you think now, Jennifer?

Goal-setting prompts help students set goals for their inquiry and solutions, such as: Where do you think we can find out that information?

Monitors encourage students to monitor their inquiry and problem-solving processes, such as: Do you have everything you need to report out in your group?

Iterations of the Investigative Stages of Inquiry. Among the activities that can take place at this stage are know, need to know, and new ideas charting; information gathering and sharing; and refining the problem statement.

Assessment for Learning. Are students aware at this point that demographic questions are as important as the science questions?

- Why is plague limited to rural areas?
- Why don't we have epidemics of plague in large cities?
- Are certain groups more susceptible to plague (gender, age, ethnic, income level, lifestyle, etc.)?

Math questions also surface:

- Can we define an epidemic mathematically?
- If there were only 11 cases of plague in the United States in 1988 and 14 in 1993, how can this be an epidemic?

Questions related to other diseases in the area affected and the correlation between these diseases and climatic conditions ultimately emerge.

Assessment of Learning. As students gain and apply learning, expectations for production or performance can include:

- Memo to the supervisor of the investigation explaining causal linkages
- Graphs depicting susceptibility of different groups
- Mathematical model of the spread of disease
- Written explanation of the definition and classification of epidemic or plague in response to a question from a reporter
- Concept or "mind mapping" of an individual's or a group's understanding of the problematic situation compared to a map of an expert's view of the situation

Generating Possible Resolutions or Solutions. How are the student-epidemiologists, using the information they found, going to address the questions that the investigation posed?

Assessment for Learning. Probe and challenge students' thinking as they generate possibilities:

- Does the proposal take into account the varying stakeholder positions?
- Does this issue fall outside the public's right to know?
- Have students considered the consequences of each potential plan?
- What response would students anticipate, and how might that affect relationships within the community?

Assessment of Learning. As students synthesize information and evaluate options, expectations for support over assertion are expected:

  - Write a report to the CDC director putting forth and assessing the merits of each possible solution
  - Write an impact statement to the appropriate governmental level (mayor, governor, etc.) putting forth and assessing the potential consequences of each possible solution

Presenting the Solution. When students are ready to present the solution, assessment for learning still continues.

Assessment for Learning. A viable resolution or solution should stand up to scrutiny, and students should demonstrate understanding in multiple ways—for instance, using the facets of understanding.

- Explain the situation fully from multiple perspectives. What conclusions do students draw about plague among the Native American population?
- Imagine yourself the brother of a victim. What might you consider to be the pros and cons of full-scale public revelation of the situation? Why?

Assessment of Learning. As students present a specific solution, expectations for organization, clarity, evidence, and a multiperspective understanding of the situation are high. Among the assessable ways that students can present their information are:

- A presentation that conveys the situation, possible causes, anticipated solution, and potential effects in an organized and articulate manner.
- Responding to the questions of stakeholders and experts in the field. The responses should demonstrate knowledge of evidence and empathy, as well as a depth of knowledge that goes beyond the first, "Why?"
- Stakeholder assessment based upon their interactions with students either in a mentoring capacity or as a member of the panel to whom students present findings.
- Peer assessment based upon a rubric co-constructed by the class members.
- "Letter to the Editor" following the misreporting of a student's statement to the press.

Debriefing the Problem. Even after we complete the reports on the experience, more opportunities for enhancing and evaluating learning are available.

Assessment for Learning. Debriefing students' learning process and their knowledge/skill acquisition is a critical and necessary aspect of PBL. Coaches can ask the students:

- Knowing what you know now, would you frame the problem differently?
- Who should hold the ultimate responsibility for deciding disclosure in this situation?
- What benefit or harm is possible here?

- What is the foundational or "big" issue at stake?
- What did you learn academically (science, social science, mathematics, psychology, language arts, cultural issues, political issues, etc.)?
- What can you do now that you didn't think you could do before (skills, self-efficacy, self-directed activity, self-knowledge, interact with public officials, have adults listen to me, etc.)?

Assessment of Learning. As students reflect on their learning experience, expectations for specific knowledge and skill acquisition, as well as self-knowledge about learning style and strategies, become clear.

- Identification of specific, discipline-based content and skills are raised to a conscious level.
- As a result of a thorough debriefing, correcting misconceptions, and perhaps targeted instruction at concepts missed or minimized, assessment through traditional written quizzes or exams are potential means for capturing learning data for reporting and decision-making purposes.
- Student self-assessment of learning gain through a rubric co-constructed by classmates.
- Self, peer, and or teacher assessment relative to knowledge and skill gains toward learning standards valued by school and district.

As promised, multiple possibilities—both for and of learning—abound in a problem-based learning experience.

How Do You Support Problem-Based Learning?

(from Torp, L. and Sage, S. (2002). *Problems as possibilities; Problem-based learning for K-16 education.* Alexandria, VA: Association for Supervision and Curriculum Development).

This chapter examines issues related to developing a PBL initiative—large or small—in your school, university, or community. Many stakeholders are involved in a decision to use PBL—teacher, student, principal, department chair, curriculum coordinator, superintendent or chancellor, parent, or business or community partner. We address concerns or questions such stakeholders often have about PBL.

Why PBL?

John Abbott (1996) makes a strong argument for what he calls the "new competencies"—skills that go far beyond the 19th century basics taught in many schools. The "old competencies" of numeracy, literacy, calculation, and communication are still necessary to function in modern society; but they are not enough. For success in our ever-changing world, the ability to conceptualize problems and solutions is essential. Abbott asserts that the new competencies that must be nurtured and developed include the following:

- *Abstraction*. The mental manipulation of thoughts and patterns in a purposive and ongoing manner.
- *Systems thinking.* The ability to see the interrelatedness of things and the effect of parts upon the whole and the whole upon parts.
- *Experimentation*. The questioning frame of mind that encourages hypothesizing, testing, and evaluating data.
- *Collaboration*. The disposition to be open-minded and adaptable as we co-construct knowledge together.

These competencies parallel the call for workplace know-how highlighted by the Secretary's Commission for Achieving Necessary Skills (SCANS) (U.S. Department of Labor, 1991). Built on a foundation of basic skills, thinking skills, and personal qualities, the SCANS competencies include the following:

- *Resources*. Allocating time, money, and materials.
- *Interpersonal skills.* Working on teams, leading others, negotiating, and showing tolerance.
- *Information.* Acquiring, organizing, evaluating, and interpreting data.
- *Systems*. Understanding social, organizational, and technological systems.
- *Technology*. Selecting and applying technology appropriately.

PBL classrooms are learning communities where information and the construction of knowledge are collective activities. Students who gather, share, and add information to the knowledge pool assess the information for validity and integrate it as appropriate. Expertise grows among community members through dialogue, jigsaw, questioning, reciprocal teaching, and mentoring. Individual learners must then synthesize this knowledge into a holistic understanding of the problem at hand.

"Teaching for understanding" is a phrase heard frequently today in education, but student understanding is an elusive thing to define, let alone capture. Rebecca Simmons (1994), project manager for the Teaching for Understanding Project at Harvard, describes understanding in this way:

> *We want students to be able to employ knowledge in flexible and novel ways, to develop flexible networks of concepts, to use what they learn in school to understand the world around them, and to*

> *develop interest in lifelong intellectual pursuits. But to help students achieve such understanding is no mean feat. (p. 22)*

Diann Musial and Liz Hammerman (1997) of Northern Illinois University describe the intimate perspective of PBL learners:

> *The problem-based learner tends to develop mental patterns that are highly connected to the richness of the problem situation. Such understanding is highly integrated and linked to a variety of real-world situations, perspectives, disciplines, etc. Such learners are able to answer essay questions not only in terms of the definition of terms; they are able to elaborate on the meaning of important ideas and add nuances that are connected to the real world. This is so, not because they have read about those connections, but because they have experienced the connections firsthand. (p. 6) (emphasis in original)*

The challenge of higher education in the face of an information explosion, as well as the demands of the high-performance workplace, has clearly established a need to prepare our students for an increasingly complex environment. Problem solving and the higher-order thinking skills of analysis, synthesis, and evaluation are not learned through direct instruction. They emerge from the direct experience of doing. PBL provides that experience.

How Do We Know That PBL Works?

PBL has a rich history in professional schools (medical, dental, nursing, engineering, and business) going back decades. Research conducted to assess the effectiveness of PBL programs cites certain benefits, including increased motivation, sustained self-directed learning behaviors, long-term knowledge retention, comparable content coverage with traditional approaches, learning for understanding, and the development of professional reasoning strategies (Albanese & Mitchell, 1993; Eck & Mathews, 2000; Hendley, 1996; Vernon & Blake, 1993). Although interesting, this research is not what K-16 teachers, administrators, and parents want to know. Their bottom-line question, "Will it work for my students?" is one that in the end they must answer for themselves.

PBL has been used at the K-16 levels for several years. Anecdotal evidence is highly supportive. Teachers consistently report increased student engagement in the learning process, increased student responsibility for learning, and deeper levels of understanding. Library and media specialists report that students use more library materials, develop effective search strategies, and gain in information literacy. Principals report that discipline referrals and absenteeism decrease. Parents report hearing about what is happening at school without having to ask.

In today's educational climate, one key concern is to do no harm. Two middle grade teachers, Karoline Krynock and Louise Robb (1996), investigated a perennial question posed about any educational innovation: Can students gain the same or greater depth and breadth of knowledge through a problem-based unit as through a standard unit? In a rigorous study, they compared four sections of science classes—two standard, two PBL—on content achievement in a genetics unit in the 8th grade curriculum. Teaching strategies and the curriculum organization differed, but the content was identical. The researchers used and scored a common instrument to assess content achievement or attainment. These results were compared against district-administered standardized test scores aggregated by class. All four classes were directly comparable on this standardized measure of intellectual ability, but the PBL classes scored slightly higher on the genetics content assessment.

The PBL classes were assigned to research a messy, ill-structured problem and provide evidence to support their conclusions. They had to write a persuasive position paper and present their conclusions before a panel of professionals knowledgeable in the field of behavioral genetics. During the problem debriefing, students went beyond the testable material and reported that they learned how to do the following:

- Investigate a complex issue.
- Collaborate with peers as learning colleagues in groups.
- Look beyond print material for information and contact experts directly.
- Present their information to a panel of experts.
- Take a position and defend their conclusions using data.
- Think about multiple solutions instead of jumping to conclusions.

Although this study was well done and is highly regarded (winner of a state-level research award), the important issues here go beyond the study results. These educators are not only able to describe their program clearly to parents, students, and administrators, but also to answer the deeper questions of What works? and How do we know?

Richard Dods (1996), a science/chemistry teacher, writes:

> *Although process is emphasized [in PBL], content is not lost. Ongoing action research studies [in his course] compare students who have experienced PBL biochemistry with those who have experienced biochemistry in an interactive questioning format. Results suggest that the PBL biochemistry approach promotes deeper understanding of biochemical content and longer-term recall of content than the interactive questioning format. (p. 228)*

Dods believes that a student's "problem-based frame of mind" provides a web of understanding that meaningfully connects individual pieces of content. These connections enable access and recall through multiple avenues that support deeper levels of understanding.

What About PBL and Standards?

Although some educators (e.g., Kanstoroom Finn, 1999) believe that constructivist educational methods fly in the face of academic standards, we do not find common sense in that argument. We find the key to achieving standards for all students comes not in restricting how teachers teach, but in setting common goals for students. Constructivist and traditional classroom structures may both be used toward this end:

> *State and local curriculums address what students learn. Constructivism, as an approach to education, addresses how students learn. The constructivist teacher, in mediating students' learning, blends the what with the how. (Brooks, M. G., and Brooks, 1999, p. 22) (emphasis in original)*

Standards can help set benchmarks for students at various levels and encourage high expectations for all students (Glickman, 2000). However, standards can also artificially narrow the range of knowledge, skills, and dispositions we expect from students of various ages. One of the greatest difficulties comes when measurement of student progress toward standards comes from just a single test score, often the state standardized test (Glickman, 2000; Kohn, 2000). Certainly most standardized tests are not designed to assess many of the documented benefits of PBL, like self-directed learning, critical thinking, integrative knowledge, and so on. We are convinced that, as states implement their academic standards, evidence will show that strategies like PBL are even more supportive of achievement than lecture, discussion, and worksheets. This connection is already provable in medical education. We are not convinced, however, that any single measurement—particularly standardized tests—shows the added benefits students gain from PBL.

That said, we understand that teachers across the United States must demonstrate alignment of their curriculum and instruction with standards. When we work with teachers to design problems, we begin with learner characteristics and desired curriculum outcomes. In effect, teachers design PBL experiences around specific standards.

In a middle school class (Sage, Krynock, & Robb, 2000), the teachers aligned their PBL unit with several student and teacher science standards. The problem, examining what should be done with improperly maintained prairie areas on the school campus, enabled students to achieve several national science standards, including:

> *By the end of 8th grade, students should know that… in any particular environment, the growth and survival of organisms depends on the physical conditions. (American Association for the Advancement of Science, AAAS, Project 2061, 1993, p. 117)*
>
> *By the end of 8th grade, students should:*
>
> - *Question claims based on vague attributions.*
> - *Notice and criticize the reasoning in arguments in which fact and opinion are intermingled. (AAAS, 1993, p. 299)*

The two teachers' work in this interdisciplinary, problem-based English and science class correlates with one of the National Research Council's (1996) standards for teachers:

> *[Teachers] work together as colleagues within and across disciplines and grade levels. . . . Teachers of science guide and facilitate learning. In doing this, teachers focus and support inquiries while interacting with students. (p. 32)*

Using PBL in mathematics aligns beautifully with the National Council of Teachers of Mathematics (NCTM) (2000) standards for students and teachers, as well (e.g., Alper, Fendel, Fraser, & Resek, 1996; Erickson, 1999; Sage, Kochanowski, & Shafii-Mousavi, 2001). One of the NCTM standards is problem solving. Teachers are encouraged to help students build the disposition to be analytic and persistent in complex situations. They can do this work by "asking questions that help students find the mathematics in their worlds and experiences and by encouraging students to persist with interesting but challenging problems" (NCTM, 2000, p. 52). Sounds like PBL! Here is an example of a brief PBL experience from the NCTM (2000) standards:

> *A task for middle-grades students presents data about two ambulance companies and asks which company is more reliable. . . . A quick answer found by looking at the average time customers had to wait for each company turns out to be misleading. A more careful mathematical analysis involving plotting response times versus time of day reveals a different solution. (p. 52)*

Standards in the humanities are readily accomplished using PBL as well. One example is Indiana's 10th grade reading comprehension standard #2 (Indiana State Board of Education, 2000, p. 2):

> *Analyze the structure and format of various informational documents and explain how authors use the features to achieve their purposes.*

Example: Analyze an advertisement that has been made to look like the informational newspaper or magazine text around it. Explain why the advertisement would be designed this way and evaluate its effectiveness.

This scenario could easily become PBL, perhaps by placing students in the role of advertising teams designing an ad campaign for a new drUg targeted at senior citizens. In creating their various advertisements, students would look at other similar ads in which the above structure is used. They would have to weigh the ethics of such an approach as they design their own ads.

In the National Standards for Social Studies Teachers (National Council for the Social Studies [NCSS], 1997), as one example, teachers of young children are encouraged to meet standards in Strand VI (Power, Authority, and Governance) by exploring the current governance structures in their school. One kindergarten teacher we worked with aligned a problem with this standard by encouraging students to examine the current lost and found policy in their school to see how efficient, equitable, and fair it was. She knew this problem would be appropriate early in the year because kindergarten students often lose their belongings! They presented their findings to the principal, who changed the policy accordingly.

What About PBL and Technology?

In addition to the standards mentioned, schools are implementing local and national technology standards (see, for example, the National Educational Technology Standards for Students [International Society for Technology in Education, 2000]). PBL is a natural fit for helping students meet technology standards (Sage, 2000a). Technology is critical to PBL in several ways. It can be used as a tool and resource for inquiry, as a collaboration aid, as curriculum, and as assessment. Figure 8.1 gives examples.

First, sources like the Internet and online reference materials are invaluable when students are researching a problem. For example, students can access demographic information on any county in the United States from the U.S. Census Bureau Web site (www.census.gov). This information is important for a number of different kinds of problems. Internet and online resources are often helpful, graphics-oriented resources during PBL inquiry for nonreaders, beginning readers, or ESL students. In its work with low-achieving urban students, Success Lab Learning Centers (Tore, 2000) use authentic Web-based data and expository information about topics of interest to these particular students—chewing gum, ice cream, sporting event statistics, athletic performance, local heroes, and current events—as the organizing focus for PBL work that targets study, research, and information literacy skills. In addition, Stepien, Senn, and Stepien (2000) have developed a number of problem-based learning units that specifically incorporate Internet resources.

Specific software can also help students in their problem-solving work. One of our favorites is Inspiration (www. inspiration.com), which was used to develop a number of the maps and webs in this book. Students can use such visual organizer software to "map" their growing and changing understanding of a problem. Teachers could use students' pre- and post-maps of a problem as one form of assessment. Teachers can also use Inspiration while designing problems to create maps of possibility, as discussed in Chapter 5. Specialized software related to particular discipline-based concepts (such as RAMAS EcoLab, which John Thompson used to model predator-prey dynamics during the wolf problem described in Chapter 6) may be used as one form of instruction during problem solving. Students may also use presentation software such as PowerPoint or HyperStudio to display their results to an expert panel.

Second, increasing numbers of Web-based problems may be appropriate curriculum for your students. One Web site for such problems is the Center for Problem-Based Learning at the Illinois Mathematics and Science Academy (www.imsa.edu/team/cpb1). Several Web-based problems suitable for middle and high school students are available there, including The Case of the Wrongful Projections developed by Bernard C. Hollister (www.imsa.edu/team/cpb1/learning/lincoln/Berniel-FS.html), which presents students with the dilemma of President Lincoln's incorrect U.S. population projections for the 20th century. Another problem available there is the Buffalo Commons problem (www.imsa.edu/team/cpbl/learning/buffalo). This PBL problem guides students, who are role-playing members of a presidential commission, to a number of Web sites that help them consider whether or not land in the central plains should be deprivatized for use as a buffalo commons. The Appendix lists other sites with Web-based problems.

Third, technology may be used as assessment in PBL. For example, students in a technology course can assume the role of course designers to create a computer-based learning program. Students could, as technology consultants, set up and monitor an e-mail listserver or Web site on a particular issue. The opportunities for classroom teachers and technology specialists to collaborate on problems that delve into both academic content issues and authentic technology use are endless!

Finally, online course programs allow for many collaboration options with PBL. Programs such as Oncourse (http://oncourse.indiana.edu) allow teachers to post documents, schedules, and syllabi online, as well as to set up small-group asynchronous discussions or chat rooms. These online group structures are particularly helpful for PBL when groups need time to problem-solve outside of class. In one recent instructional technology course at Indiana University, students used a previously developed online course tool in a challenging PBL unit learned and taught completely online (Orrill, 2000; Sage, 2000b). Although we personally believe such programs will not, and should not, ever completely replace face-to-face classes and in-person coaching, they allow numerous opportunities for teachers to post questions and information online and for students to have more opportunities for group dialogue.

What Are the Potential Barriers to PBL Adoption?

We find that most educators with whom we work recognize the importance of PBL to increase student motivation to deeper levels of understanding. Yet the "coverage" mantra still dominates many areas, often because our major evaluation instruments drive curriculum choices. Many teachers face restrictive schedules or other structures that work against the time necessary for student engagement and teaching for understanding. Teachers also express frustration with a lack of time during the school day for designing new problems.

> *Educators also fear change because of school norms that perpetuate the status quo. Some teachers feel they are out on a limb using PBL in their classes. As one middle school teacher reported overhearing another teacher say, "Where are the worksheets? Where are the tests? . . . They [students] are laughing, they're having fun, they're running around wanting to do research; what is this?"*

Teachers and teaching teams who recognize any or all of these obstacles within their schools work proactively to build and nurture support among colleagues and community. Many have enlisted parents as both allies and resources for PBL units. Others tap the knowledge and expertise of school colleagues to serve as mentors in problem inquiries. Although innovation and change can ignite fears and create barriers, communication and openness reveal unseen possibilities. Here are examples of ways to communicate (Sage, Krynock, & Robb, 2000):

- Explaining PBL and providing resources for various stakeholders (see the following section, "How Can I Explain PBL to Parents and the Community?").
- Clearly aligning PBL experiences with standards (see the previous section, "What About PBL and Standards?").
- Designing problems carefully to consider students' developmental characteristics, interests, and issues (e.g., Beane, 1993), so that students are engaged and effective problem-solvers.
- Providing appropriate support for students new to PBL so they have a successful learning experience.
- Debriefing with students and parents after a PBL experience about what students have learned. (Several teachers we know use their class newsletter or the school newsletter to share information both about the problem itself and what students have learned, including specific learning objectives and standards.)
- Involving as many stakeholders as possible in the PBL process (see the following section, "How Can I Explain PBL to Parents and the Community?").
- Locating a support system of like-minded PBL teachers and schools (see Appendix).

Another essential component is support from administrators—support for PBL as well as support provided through resources and assistance with accessing appropriate information. We find most principals eager to support innovations that enhance student learning.

How Can I Explain PBL to Parents and the Community?

PBL may be very different from the instruction that many of us experienced in our own schooling. In our current standards and testing culture, some parents and community members may have concerns about teachers and schools deviating from more traditional methods of instruction. We have consistently found, however, that parents, administrators, school board members, and community members are impressed when they learn more about PBL, particularly if they have the opportunity to observe students at work.

Encouraging these stakeholders to be involved in PBL as guest speakers with expertise on the problem topic, or as members of a panel to which students present their solutions, can be powerful ways to engender community understanding and support for PBL. Nearly always, adults are im pressed with the seriousness with which students approach the problem, with their knowledge, and with the entire PBL philosophy. Community members we've worked with believe that K-12 schools and undergraduate institutions should be doing more of this type of instruction to prepare students for their eventual place in an information-driven, problem-centered, collaborative work world.

Several simple sentences that may help you share PBL with people totally unfamiliar with the approach arc given here:

- "PBL makes school learning more like real-world learning."
- "PBL helps students learn the same content—just in a different way."

- "Besides learning content, PBL has additional valuable components like helping learners collaborate, problem-solve, make presentations, and talk with experts—many of the things they'll be doing as adults."
- "PBL motivates many students to dig deeper and get `hooked' into issues; they may actually want to go to the library or go online to get more information!"
- "Think about the times in your life when you have really learned something. Often this learning is related to a problem you were facing. The PM. approach encourages students to learn because they want or need to solve a problem, too."
- "Students don't ask, 'Why do I need to know this?' in PBL. The answer is clear: They need to know it to solve the problem."

Schools now have a number of resources available for sharing within their communities information about PBL. This book and others (e.g., Delisle, 1997) are rich resources for people who want detailed information. ASCD also has the helpful Problem-Based Learning Series (Association for Supervision and Curriculum Development, 1997), which includes two videos with a facilitator guide. Another excellent video is Problem-Based Learning: Three Classrooms in Action (Center for Problem-Based Learning, 1997), available from the Center for Problem-Based Learning at the Illinois Mathematics and Science Academy (http://www.imsa.edu/team/cpbl/products/videos.html).

What Does It Take to Become a Teacher of PBL?

We have found that PBL requires a facility to use a coaching style that preservice and inservice experiences often do not address. As an ongoing part of our professional development activities, we asked teachers to reflect on what they were learning about teaching PBL (Sage & Torp, 1997) and concluded the following:

- *Making the transition from teacher as information-giver to teacher as coach is challenging and requires learning new skills.* Teachers discussed giving up the idea that they had to be the experts. Some found it difficult to let go of the sense of control and predictability typical in more traditional instruction; eventually most teachers came to realize that, as a middle school teacher put it, "Not only do I need to let go, I need to stay there [to provide support to students]." Teachers also learned in their role as coach how to question students' thinking and to challenge students to support their conclusions. One staff development coordinator said, "We learned that we needed to focus our language on the language of thinking."
- *Designing problem scenarios requires a sound understanding of problem-based learning, curriculum, and authentic assessment.* Teachers wrestled with the design of problem scenarios as they worked to integrate required curriculum outcomes and incorporate the teaching and assessment of meaningful skills throughout the problem. Considering what content their problems would address also challenged teachers to consider essential knowledge of disciplines rather than automatically using textbook-defined content. As teachers designed assessments, they had to consider how to use them so that the assessment measured student thinking and guided, but did not limit, learning. Teachers also found they were teaching skills, such as writing business letters, in more authentic ways—that is, teaching in the context of the problem rather than in isolation.
- *Learning in a PBL environment is exciting for students and rewarding for teachers.* Teachers found that seeing what students could do led them to trust their students more. Lisa Nicholson, a special education instructor, said, "PBL has proven to me that if you don't give the kids limitations and if you overlook their disabilities, PBL gives them the chance to learn the way they need to learn." Teachers believed that

because PBL encourages students to explore information in different ways—such as through print, telephone, and the Internet—and to learn about authentic problems, PBL was also a motivating strategy for students with varied learning styles and strengths.

We have discovered that teachers of PBL benefit from multiple supports, including active support in their schools from administrators and other teachers. Team teaching has been an effective method of support. If other teachers in the building are not implementing PBL, then teachers need a network of other practitioners with whom to share ideas and find help. The Center for Problem-Based Learning has established such a network for teachers as well as an electronic mail list (see Appendix). This networking is particularly critical for more experienced PBL practitioners to communicate with others who have similar concerns (Gibbons, 1995).

We have found that teachers don't always fully buy in to PBL, particularly to their role as coaches, until they've tried it and seen how powerful the experience is for their students. Teachers find it particularly helpful to see as many examples as possible of PBL problems other teachers at their level have designed and implemented. We have also found that using PBL to teach PBL is essential, so that teachers experience PBL as learners first (Sage & Torp, 1997; Sage, 2001). Like any effective learning experience for students, teachers also benefit from a collaborative climate of learning challenges and appropriate support (see Figure 8.2).

In Closing

For PBL practitioners, PBL's effectiveness is unquestionable. These educators point to many positive effects:

- Students turned off by more traditional approaches emerge as active, engaged learners.
- Students can talk about a topic in depth—not simply answer factual questions.
- Students ask for targeted lessons about what they need to know to solve a problem.
- Students ask good questions that reflect an understanding deeper than any response shows.
- Students know how to locate, evaluate, and use information effectively.
- And, of course, students learn and perform well on content tests.

Problem-based learning has been used in urban and rural settings; with elementary, secondary, college-level, and professional students; with reluctant learners; and with eager learners—in short, with students of all abilities and ages in almost every subject area. PBL consistently receives high marks from students, parents, and administrators whenever the teacher is motivated and well versed in PBL techniques. PBL exposes solid, demanding content; engages students at an emotional level; and fosters skills needed in a complex world. Teachers can use PBL as a curriculum organizer and instructional strategy whenever learning goals demand deeper understandings—whether occasionally or frequently—in tandem with other strategies. We believe PBL is a powerful technique that all teachers should have in their repertoire for the 21st century.

<table>
<tr><td colspan="4">FIGURE 8.2: The PBL Environment: Concerns, Challenges, and Support</td></tr>
<tr><td></td><td colspan="3">Balancing Professional Challenges With Appropriate Support</td></tr>
<tr><td>Fundamental Concerns That Drive PBL Professional Development</td><td></td><td>Challenges</td><td>Support</td></tr>
<tr><td rowspan="3">• What is my role as teacher/coach in PBL?
• What new skills do I need?
• How should we prepare students as citizens in tomorrow's world?
• What knowledge is most critical?
• How do we assess student learning in PBL?
• How do we communicate effectively about PBL to others?</td><td>Context</td><td>• Philosophical differences within school community
• Isolation from professional peers
• Questionable level of administrative support
• Tentative parent/community relations</td><td>• Appropriate resources
• Teaming with colleagues
• Active administrative backing
• Electronic network to facilitate dialogue across sites and across professional contexts</td></tr>
<tr><td>Teaching</td><td>• Integrating complex understandings
• Adopting new practices
• Assuming a new role
• Modifying grounding beliefs
• Modulating concerns</td><td>• Appropriate information when needed
• Collegial dialogue
• Modeling by experienced coaches
• Practice in a safe environment
• Mentoring by PBL practitioners</td></tr>
<tr><td>Learning</td><td>• Creating authentic learning situations that address standards
• Integrating content and process
• Coaching and managing active student learning
• Capturing the effects of PBL teaching and learning</td><td>• Clear learning expectations
• Practice and mentoring
• Evidence of student learning and growth
• Collegial network of PBL practitioners</td></tr>
</table>

Adapted from Torp & Sage (1998), p. 89.

How People Learn: Key Findings

(from National Research Council. (1999). *How people learn: Bridging research and practice.* Washington, DC: National Academy Press.)

How People Learn provides a broad overview of research on learners and learning and on teachers and teaching. Three of those findings are highlighted here because they have both a solid research base to support them and strong implications for how we teach. It is not the committee's intention to suggest that these are the only insights from research that can beneficially be incorporated into practice. Indeed, a number of additional findings are discussed in How People Learn.

1. Students come to the classroom with preconceptions about how the world works. If their initial understanding is not engaged, they may fail to grasp the new concepts and information that are taught, or they may learn them for purposes of a test but revert to their preconceptions outside the classroom.

Research on early learning suggests that the process of making sense of die world begins at a very young age. Children begin in preschool years to develop sophisticated understandings (whether accurate or not) of the phenomena around them (Wellman, 1990). Those initial understandings can have a powerful effect on the integration of new concepts and information. Sometimes those understandings are accurate, providing a foundation for building new knowledge. But sometimes they are inaccurate (Carey and Gelman, 1991). In science, students often have misconceptions of physical properties that cannot be easily observed. In humanities, their preconceptions often include stereotypes or simplifications, as when history is understood as a struggle between good guys and bad guys (Gardner, 1991). A critical feature of effective teaching is that it elicits from students their pre-existing understanding of the subject matter to be taught and provides opportunities to build on—or challenge—the initial understanding. James Minstrell, a high school physics teacher, describes the process as follows (Minstrell, 1989: 130-131):

> *Students' initial ideas about mechanics are like strands of yarn, some unconnected, some loosely interwoven. The act of instruction can he viewed as helping the students unravel individual strands of belief, label them, and then weave them into a fabric of more complete understanding. Rather than denying the relevancy of a belief, teachers might do better by helping students differentiate their present ideas from and integrate them into conceptual beliefs more like those of scientists.*

The understandings that children bring to the classroom can already be quite powerful in the early grades. For example, some children have been found to hold onto their preconception of a flat earth by imagining a round earth to be shaped like a pancake (Vosniadou and Brewer, 1989). This construction of a new understanding is guided by a model of the earth that helps the child explain how people can stand or walk on its surface. Many young children have trouble giving up the notion that one-eighth is greater than one-fourth, because 8 is more than 4 (Gelman and Gallistel, 1978). If children were blank slates, telling them that the earth is round or that one-fourth is greater than one-eighth would be adequate. But since they already have ideas about the earth and about numbers, those ideas must be directly addressed in order to transform or expand them.

Drawing out and working with existing understandings is important for learners of all ages. Numerous research experiments demonstrate the persistence of preexisting understandings among older students even after a new model has been taught that contradicts the naive understanding. For example, in a study of physics students from elite, technologically oriented colleges, Andrea DiSessa (1982) instructed them to play a computerized game that required them to direct a computer-simulated object called a dynaturtle so that it would hit a target and do so with minimum speed at impact. Participants were introduced to the game and given a hands-on trial that allowed them to apply a few taps with a small wooden mallet to a tennis ball on a table before beginning the game. The same game was also played by elementary schoolchildren. DiSessa found that both groups of students failed dismally. Success would have required demonstrating an understanding of Newton's laws of motion. Despite their training, college physics students, like the elementary schoolchildren, aimed the moving dynaturtle directly al t lie target, failing to take momentum into account. Further investigation of one college student who participated in the study revealed that she knew the relevant physical properties and formulas, yet, in the context of the game, she fell back on her untrained conception of how the physical world works.

Students at a variety of ages persist in their beliefs that seasons are caused by the earth's distance from the sun rather than by the tilt of the earth (Harvard Smithsonian Center for Astrophysics, 1987), or that an object that had been tossed in the air has both the force of gravity and the force of the hand that tossed it acting on it, despite training to the contrary (Clement, 1982). For the scientific understanding to replace the naïve understanding, students must reveal the latter and have the opportunity to see where it falls short.

2. To develop competence in an area of inquiry, students must: (a) have a deep foundation of factual knowledge, (b) understand facts and ideas in the context of a conceptual framework, and (c) organize knowledge in ways that facilitate retrieval and application.

This principle emerges from research that compares the performance of experts and novices and from research on learning and transfer. Experts, regardless of the field, always draw on a richly structured information base; they are not just "good thinkers" or "smart people." The ability to plan a task, to notice patterns, to generate reasonable arguments and explanations, and to draw analogies to other problems are all more closely intertwined with factual knowledge than was once believed.

But knowledge of a large set of disconnected facts is not sufficient. To develop competence in an area of inquiry, students must have opportunities to learn with understanding. Deep understanding of subject matter transforms factual information into usable knowledge. A pronounced difference between experts and novices is that experts' command of concepts shapes their understanding of new information: it allows them to see patterns, relationships, or discrepancies that are not apparent to novices. They do not necessarily have better overall memories than other people. But their conceptual understanding allows them to extract a level of meaning from information that is not apparent to novices, and this helps them select and remember relevant information. Experts are also able to fluently access relevant knowledge because their understanding of subject matter allows them to quickly identify what is relevant. Hence, their attention is not overtaxed by complex events.

In most areas of study in K-12 education, students will begin as novices; they will have informal ideas about the subject of study, and will vary in the amount of information they have acquired. The enterprise of education ran be viewed as moving students in the direction of more formal understanding (or greater expertise). This will require both a deepening of the information base and the development of a conceptual framework for that subject matter.

Geography can be used to illustrate the manner in which expertise is organized around principles that support understanding. A student can learn to fill in a map by memorizing states, cities, countries, etc., and can complete the task with a high level of accuracy. But if the boundaries are removed, the problem becomes much more difficult. There are no concepts supporting the student's information. An expert who understands that borders often developed because natural phenomena (like mountains or water bodies) separated people, and that large cities often arose in locations that allowed for trade (along rivers, large lakes, and at coastal ports) will easily outperform the novice. The more developed the conceptual understanding of the needs of cities and the resource base that drew people to them, the more meaningful the map becomes. Students can become more expert if the geographical information they are taught is placed in the appropriate conceptual framework.

A key finding in the learning and transfer literature is that organizing information into a conceptual framework allows for greater "transfer"; that is, it allows the student to apply what was learned in new situations and to learn related information more quickly. The student who has learned geographical information for the Americas in a conceptual framework approaches the task of learning the geography of another part of the globe with questions, ideas, and expectations that help guide acquisition of the new information. Understanding the geographical importance of the Mississippi River sets the stage for the student's understanding of the geographical importance of the Nile. And as concepts are reinforced, the student will transfer learning beyond the classroom, observing and inquiring, for example, about the geographic features of a visited city that help explain its location and size (Holyoak, 1984; Novick and Holyoak, 1991).

3. A "metacognitive" approach to instruction can help students learn to take control of their own learning by defining learning goals and monitoring their progress in achieving them.

In research with experts who were asked to verbalize their thinking as they worked, it was revealed that they monitored their own understanding carefully, making note of when additional information was required for understanding, whether new information was consistent with what they already knew, and what analogies could be drawn that would advance their understanding. These meta-cognitive monitoring activities are an important component of what is called adaptive expertise (Hatano and Inagaki, 1986).

Because metacognition often takes the form of an internal conversation, it can easily be assumed that individuals will develop the internal dialogue on their own. Yet many of the strategies we use for thinking reflect cultural norms and methods of inquiry (Hutchins, 1995; Brice-Heath, 1981, 1983; Suina and Smolkin, 1994). Research has demonstrated that children can be taught these strategies, including the ability to predict outcomes, explain to oneself in order to improve understanding, note failures to comprehend, activate background knowledge, plan ahead, and apportion time and memory. Reciprocal teaching, for example, is a technique designed to improve students' reading comprehension by helping them explicate, elaborate, and monitor their understanding as they read (Palincsar and Brown, 1982). The model for using the meta-cognitive strategies is provided initially by the teacher, and students practice and discuss the strategies as they learn to use them, ultimately, students are able to prompt themselves and monitor their own comprehension without teacher support.

The teaching of metacognitive activities must be incorporated into lc subject matter that students are learning (White and Frederickson, 1998). These strategies are not generic across subjects, and attempts to teach them as generic can lead to failure to transfer. Teaching metacognitive strategies in context has been shown to improve understanding in physics (White and Frederickson, 1998), written composition (Scardamalia et al., 1984), and heuristic methods for mathematical problem solving (Schoenfeld, 1983, 1984, 1991). And metacognitive practices have been shown to increase the degree to which students transfer to new settings and events (Lin and Lehman, in press; Palincsar and Brown, 1982; Scardamalia et al., 1984; Schoenfeld, 1983, 1984, 1991).

Each of these techniques shares a strategy of teaching and modeling the process of generating alternative approaches (to developing an idea in writing or a strategy for problem solving in mathematics), evaluating their merits in helping to attain a goal, and monitoring progress toward that goal. Class discussions are used to support skill development, with a goal of independence and self-regulation.

Implications for Teaching

The three core learning principles described above, simple though they seem, have profound implications for the enterprise of teaching and teacher preparation.

1. Teachers must draw out and work with the preexisting understandings that their students bring with them. This requires that:

- The model of the child as an empty vessel to be filled with knowledge provided by the teacher must be replaced. Instead, the teacher must actively inquire into students' thinking, creating classroom tasks and conditions under which student thinking can be revealed. Students' initial conceptions then provide the foundation on which the more formal understanding of the subject matter is built.
- The roles for assessment must be expanded beyond the traditional concept of testing. The use of frequent formative assessment helps make students' thinking visible to themselves, their peers, and their teacher. This provides feedback that can guide modification and refinement in thinking. Given the goal of learning with understanding, assessments must tap understanding rather than merely the ability to repeat facts or perform isolated skills.
- Schools of education must provide beginning teachers with opportunities to learn: (a) to recognize predictable preconceptions of students that make the mastery of particular subject matter challenging, (b) to draw out preconceptions that are not predictable, and (c) to work with preconceptions so that children build on them, challenge them and, when appropriate, replace them.

2. Teachers must teach some subject matter in depth, providing many examples in which the same concept is at work and providing a firm foundation of factual knowledge. This requires that:

- Superficial coverage of all topics in a subject area must be replaced with in-depth coverage of fewer topics that allows key concepts in that discipline to be understood. The goal of coverage need not be abandoned entirely, of course. But there must be a sufficient number of cases of in-depth study to allow students to grasp the defining concepts in specific domains within a discipline. Moreover, in-depth study in a domain often requires that ideas be carried beyond a single school year before students can make the transition from informal to formal ideas. This will require active coordination of the curriculum across school years.

- Teachers must come to teaching with the experience of in-depth study of the subject area themselves. Before a teacher can develop powerful pedagogical tools, he or she must be familiar with the progress of inquiry and the terms of discourse in the discipline, as well as understand the relationship between information and the concepts that help organize that information in the discipline. But equally important, the teacher must have a grasp of the growth and development of students' thinking about these concepts. The latter will be essential to developing teaching expertise, but not expertise in the discipline. It may therefore require courses, or course supplements, that are designed specifically for teachers.
- Assessment for purposes of accountability (e.g., statewide assessments) must test deep understanding rather than surface knowledge. Assessment tools are often the standard by which teachers are held accountable. A teacher is put in a bind if she or he is asked to teach for deep conceptual understanding, but in doing so produces students who perform more poorly on standardized tests. Unless new assessment tools are aligned with new approaches to teaching, the latter are unlikely to muster support among the schools and their constituent parents. This goal is as important as it is difficult to achieve. The format of standardized tests can encourage measurement of factual knowledge rather than conceptual understanding, but it also facilitates objective scoring. Measuring depth of understanding cm pose challenges for objectivity. Much work needs to be done to minimize the trade-off between assessing depth and assessing objectively.

3. The teaching of metacognitive skills should be integrated into the curriculum in a variety of subject areas. Because metacognition often takes the form of an internal dialogue, many students may be unaware of its importance unless the processes are explicitly emphasized by teachers. An emphasis on metacognition needs to accompany instruction in each of the disciplines, because the type of monitoring required will vary. In history, for example, the student might be asking himself, "who wrote this document, and how does that affect the interpretation of events," whereas in physics the student might be monitoring her understanding of the underlying physical principle at work.

- Integration of metacognitive instruction with discipline-based learning can enhance student achievement and develop in students the ability to learn independently. It should be consciously incorporated into curricula across disciplines and age levels.
- Developing strong metacognitive strategies and learning to teach those strategies in a classroom environment should be standard features of the curriculum in schools of education.

Evidence from research indicates that when these three principles are incorporated into teaching, student achievement improves. For example, the Thinker Tools Curriculum for teaching physics in an interactive computer environment focuses on fundamental physical concepts and properties, allowing students to test their preconceptions in model building and experimentation activities. The program includes an "inquiry cycle" that helps students monitor where they are in the inquiry process. The program asks for students' reflective assessments and allows them to review the assessments of their fellow students. In one study, sixth graders in a suburban school who were taught physics using Thinker Tools performed better at solving conceptual physics problems than did eleventh and twelfth grade physics students in the same school system taught by conventional methods. A second study comparing urban students in grades 7 to 9 with suburban students in grades 11 and 12 again showed that the younger students taught by the inquiry-based approach had a superior grasp of the fundamental principles of physics (White and Frederickson, 1997, 1998).

Bringing Order to Chaos

A benefit of focusing on how people learn is that it helps bring order to a seeming cacophony of choices. Consider the many possible teaching strategies that are debated in education circles and the media: lecture-based teaching, text-based teaching, inquiry-based teaching, technology-enhanced teaching, teaching organized around individuals versus cooperative groups, and so forth. Are some of these teaching techniques better than others? Is lecturing a poor way to teach, as many seem to claim? Is cooperative learning effective? Do attempts to use computers (technology-enhanced teaching) help achievement or hurt it? How People Learn suggests that these are the wrong questions. Asking which teaching technique is best is analogous to asking which tool is best— a hammer, a screwdriver, a knife, or pliers. In teaching as in carpentry, the selection of tools depends on the task at hand and the materials one is working with. Books and lectures can be wonderfully efficient modes of transmitting new information for learning, exciting the imagination, and XXX I1( )iii students' critical faculties—but one would choose other kinds of activities to elicit from students their preconceptions and level of understanding, or to help them see the power of using meta-cognitive strategies to monitor their learning. Hands-on experiments can be a powerful way to ground emergent knowledge, but they do not alone evoke the underlying conceptual understandings that aid generalization. There is no universal best teaching practice.

If, instead, the point of departure is a core set of learning principles, then the selection of teaching strategies (mediated, of course, by subject matter, grade level, and desired outcome) can be purposeful. The many possibilities then become a rich set of opportunities from which a teacher constructs an instructional program rather than a chaos of competing alternatives.

Focusing on how people learn also will help teachers move beyond either-or dichotomies that have plagued the field of education. One such issue is whether schools should emphasize "the basics" or teach thinking and problem-solving skills. How People Learn shows that both are necessary. Students' abilities to acquire organized sets of facts and skills are actually enhanced when they are connected to meaningful problem-solving activities, and when students are helped to understand why, when, and how those facts and skills are relevant. And attempts to teach thinking skills without a strong base of factual knowledge do not promote problem-solving ability or support transfer to new situations.

Designing Classroom Environments

How People Learn proposes a framework to help guide the design and evaluation of environments that can optimize learning. Drawing heavily on the three principles discussed above, it posits four interrelated attributes of learning environments that need cultivation.

1. Schools and classrooms must be learner centered. Teachers must pay close attention to the knowledge, skills, and attitudes that learners bring into the classroom. This incorporates the preconceptions regarding subject matter already discussed, but it also includes a broader understanding of the learner. For example:

- Cultural differences can affect students' comfort level in working collaboratively versus individually, and they are reflected in the background knowledge students bring to a new learning situation (Moll et al., 1993).
- Students' theories of what it means to be intelligent can affect their performance. Research shows that students who think that intelligence is a fixed entity are more likely to be performance oriented than learning oriented—they want to look good rather than risk making mistakes while learning. These students are especially likely to bail out when tasks become difficult. In contrast, students who think that intelligence is malleable are more willing to struggle with challenging tasks; they are more comfortable with risk (Dweck, 1989; Dweck and Legget, 1988).

Teachers in learner-centered classrooms also pay close attention to the individual progress of each student and devise tasks that are appropriate. Learner-centered teachers present students with "just manageable difficulties that is, challenging enough to maintain engagement, but not so difficult so to lead to discouragement. They must therefore have an understanding of their students' knowledge, skill levels, and interests (Duckworth, 1987).

To provide a knowledge-centered classroom environment, attention must be given to what is taught (information, subject matter). why it is taught (understanding), and what competence or mastery looks like. As mentioned above, research discussed in How People Learn shows clearly that expertise involves well-organized knowledge that supports understanding, and that learning with understanding is important for the development of expertise because it makes new learning easier (i.e., supports transfer).

Learning with understanding is often harder to accomplish than simply memorizing, and it takes more time. Many curricula fail to support learning with understanding because they present too many disconnected facts in too short a time—the "mile wide, inch deep" problem. Tests often reinforce memorizing rather than understanding. The knowledge-centered environment provides the necessary depth of study, assessing student understanding rather than factual memory. It incorporates the teaching of meta-cognitive strategies that further facilitate future learning.

Knowledge-centered environments also look beyond engagement as the primary index of successful teaching (Prawaf et al., 1992). Students' interest or engagement in a task is clearly important. Nevertheless, it does not guarantee that students will acquire the kinds of knowledge that will support new learning. There are important differences between tasks and projects that encourage hands-on doing and those that encourage doing with understanding; the knowledge-centered environment emphasizes the latter (Greeno, 1991).

Formative assessments—ongoing assessments designed to make students' thinking visible to both teachers and students—are essential They permit the teacher to grasp the students' preconceptions, understand where the students are in the "developmental corridor" from informal to formal thinking, and design instruction accordingly. In the assessment-centered classroom environment, formative assessments help both teachers and students monitor progress.

An important feature of assessments in these classrooms is that they be learner-friendly: they are not the Friday quiz for which information is memorized the night before, and for which the student is given a grade that ranks him or her with respect to classmates. Rather, these assessments should provide students with opportunities to revise and improve their thinking (Vye et al., 19981)), help students see their own progress over the course of weeks or months, and help teachers identify problems that need to be remedied (problems that may not be visible without the assessments). For example, a high school class studying the principles of democracy might be given a scenario in which a colony of people have just settled on the moon and must establish a government. Proposals from students of the defining features of such a government, as well as discussion of the problems they foresee in its establishment, can reveal to both teachers and students areas in which student thinking is more and less advanced. The exercise is less a test than an indicator of where inquiry and instruction should focus.

4. Learning is influenced in fundamental ways by the context in which it takes place. A community-centered approach requires the development of norms for the classroom and school, as well as connections to the outside world, that support core learning values.

The norms established in the classroom have strong effects on students' achievement. In some schools, the norms could be expressed as "don't get caught not knowing something." Others encourage academic risk-taking and opportunities to make mistakes, obtain feedback, and revise. Clearly, if students are to reveal their preconceptions about a subject matter, their questions, and their progress toward understanding, the norms of the school must support their doing so.

Teachers must attend to designing classroom activities and helping students organize their work in ways that promote the kind of intellectual camaraderie and the attitudes toward learning that build a sense of community. In such a community, students might help one another solve problems by building on each other's knowledge, asking questions to clarify explanations, and suggesting avenues that would move the group toward its goal (Brown and Campione, 1994). Both cooperation in problem solving (Evans, 1989; Newstead and Evans, 1995) and argumentation (Goldman, 1994; HHabermass, 1990; Kuhn, 1991; Moshman, 1995a, 1995b; Salmon and Zeitz, 1995; Youniss and Damon, 1992) among students in such an intellectual community enhance cognitive development.

Teachers must be enabled and encouraged to establish a community of learners among themselves (Lave and Wegner, 1991). These communities can build a sense of comfort with questioning rather than knowing the answer and can develop a model of creating new ideas that build on the contributions of individual members. They can engender a sense of the excitement of learning that is then transferred to the classroom, conferring a sense of ownership of new ideas as they apply to theory and practice.

Not least, schools need to develop ways to link classroom learning to other aspects of students' lives. Engendering parent support for the core learning principles and parent involvement in the learning process is of utmost importance (Moll, 1990; 1986a, 1986b). If one-third of their time outside school (not counting sleeping) is spent watching television, then students apparently spend more hours per year watching television than attending school. A focus only on the hours that students currently spend in school overlooks the many opportunities for guided learning in other settings.

Applying the Design Framework to Adult Learning

The design framework above assumes that the learners are children, the principles apply to adult learning as well. This point is particularly important because incorporating the principles in How People Learn into educational practice will require a good deal of adult learning. Many approaches to teaching adults consistently violate principles for optimizing learning. Professional development programs for teachers, for example, frequently:

- *Are not learner centered.* Rather than ask teachers where they need help, they are simply expected to attend prearranged workshops.
- *Are not knowledge centered.* Teachers may simply be introduced to a new technique (like cooperative learning) without being given the opportunity to understand why, when, where, and how it might be valuable to them. Especially important is the need to integrate the structure of activities with the content of the curriculum that is taught.
- *Are not assessment centered.* In order for teachers to change their practices, they need opportunities to try things out in their classrooms and then receive feedback. Most professional development opportunities do not provide such feedback. Moreover, they tend to focus on change in teaching practice as the goal, but they neglect to develop in teachers the capacity to judge successful transfer of the technique to the classroom or its effects on student achievement.
- Are not community centered. Many professional development opportunities are conducted in isolation. Opportunities for continued contact and support as teachers incorporate new ideas into their teaching are limited, yet the rapid spread of Internet access provides a ready means of maintaining such contact if appropriately designed tools and services are available.

The principles of learning and their implications for designing learning environments apply equally to child and adult learning. They provide a lens through which current practice can be viewed with respect to K-12 teaching and with respect to preparation of teachers in the research and development agenda. The principles are relevant as well when we consider other groups, such as policy makers and the public, whose learning is also required for educational practice to change.

Prioritize the Curriculum: Less is More

(from Dempsey, T. (2008). Prioritize the curriculum: Less is more. *Principal Navigator, 3*(2))

Get your priorities straight! ... Ever heard that before?

Think about the priorities in your own life. How does a "priority" in your own life get deemed a "priority" and not get lost in the other "stuff' that is going on in your world? Would you consider your personal priorities something special or essential for your life beyond today?

Now apply this concept of a personal "priority" to teaching and learning. As educators, we would all agree that we need to prioritize what students learn. So, how do we determine a "priority" from stuff that is "nice to know"? What learning priorities are apparent in our classrooms and schools? Would you consider some learning more important or essential for a student's life beyond today?

It's unlikely to hear an educator declare that there should not be sonic priorities in what one should learn. What is sometimes fuzzy, is a common agreement and articulation of what exactly should be deemed a learning priority given the overload of content and other stuff that is sometimes asked of us. Bill Daggett makes the passionate plea to educators, "If schools are to move forward to rigor and relevance, you must take something off the plate. Learning priorities should *not* be created in a vacuum or held as isolated beliefs."

To be fair to our students, guaranteed learning priorities must he represented and articulated in a curriculum. As educational researcher Robert Marzano (2003) concluded from a meta-analysis of numerous studies, a "guaranteed and viable curriculum is the #1 school-level factor impacting on student achievement" (pp. 23-24). Consider the advice of Grant Wiggins and Jay McTighe, co-authors of the ground-breaking work, *Understanding by Design* (2005), in their work with curriculum development: We cannot stress enough the importance of long-term priorities in planning.

Justifiable decisions about what to teach, what to leave out, what to emphasize, and what to minimize can be made only if there are agreed-upon priorities related to exit-level objectives. With no long-term goals, there is no perspective, hence no check on the teacher habit of merely teaching to short term, content-related objectives. Indeed, the greatest defect in teacher lesson plans and syllabi, when looked at en masse, is that the key intellectual priorities - deep understandings of transferable big ideas, and competence at core performance tasks are falling through the cracks of lessons, units and courses devoted to developing thousands of discrete elements of knowledge and skill, unprioritized and unconnected.

Wiggins and McTighe clearly advocate curriculum development prioritized on learning for deep understanding of big ideas and ability to transfer; this is the grounding principle of a learning priority.

So, how do you determine a learning priority?

Easy, right? In my experience with curriculum development, I've found there's not a universal approach that works for everyone. Given each unique context, there are different routes one can take. It's possible that defining learning priorities could be a K-12 curriculum development team-writing project that takes a year or more once it is field-tested and peer-reviewed. Others may elect to work within grade-level or content-area teams and incrementally develop units using smaller chunks of time. This enables opportunity to field-test and revise before developing a more systemic curriculum.

Regardless of route, developing learning priorities is a process-a process that thoughtfully done will yield huge dividends for both children and teaching staff. It's not as simple as ticking off a grocery list of facts, skills and definitions, pointing to a file cabinet of worn unit folders or merely running off the textbook's table of contents (yes, I've seen this done!).

State or local standards are important, but recognize that standards are not a curriculum. Also, not all standards are equal. Trying to cover each of the standards in instruction leads to the curriculum overload that many teachers feel. The Curriculum Matrix from the International Center is a great place to begin to understand which standards are more important based on state testing and public feedback and research.

The next step in this process is unpacking the state and or local standards for big ideas that bring coherence to all the facts and skills being taught in the classroom

Discrete knowledge and skills become much more relevant when they're tied to a bigger picture, mine conceptual in nature. Consider what's of more long-term value-memorizing a formula OR really understanding why we have the formula and how this formula transfers to different types of scenarios.

Another route is to begin with what you already have. Audit or re-examine present units-of-study through a lens that scrutinizes the learning priority currently present by asking:

What really is the goal or point of this unit?
Is the unit clearly designed to meet the intended goal or is it hoped that students will be able to piece it together on their own? Is the unit content really a priority for what my students should be learning or is it something I just love teaching?
Be warned! For some, this is incredibly soul-searching and deeply personal. Answers to the above may-coalesce into a disappointed realization that it's time to lay-to-rest a treasured unit used for many years. However, it could also yield a realization that this unit is close to meeting the learning goal but just needs some minor tuning for tightening-up the focus. Taking things were already doing and making them better is easier to handle than feeling as if we have to throw away everything we've always been doing and start from scratch.

Vertical grade-level or content-level conversations with teachers that teach your students before and after progressing through your class also yield useful insights. Ask these teachers for a synopsis of key understandings they wish for their incoming or exiting students. These discussions help provide greater clarity as teachers discern what's most important as they examine massive lists of content goals.

Enduring Understanding	**Knowledge**
Governments are created to provide structure and service to maintain order for their people.	Define democracy, monarchy and dictatorship,
Research advances our knowledge about the world.	How to set-up a research paper
The interaction of heredity and experience influences behavior.	DNA
Statistical analysis and data display often reveal patterns that may not be obvious.	Calculate Mean, median, mode.
Artifacts and art forms convey cultural perspectives and practices.	State the correct terms for the rooms of a house in Spanish.

Learning priorities as understandings...
Educational lingo can sometimes be boggling. Oftentimes, educational researchers have coined somewhat different terms for like ideas. This holds true as we examine the idea of learning priorities. MN' preference is to use the language coined by Grant Wiggins and Jay McTighe; enduring understandings.
A desired understanding is a priority. A student should focus m a small number of transferable big ideas about which understandings are stated—otherwise there really are no priorities. (Grant Wiggins and Jay McTighe, Understanding by Design, 2005 p. 145)

After unpacking standards or reviewing/auditing presently used units-of-study, I suggest teachers synthesize the big ideas into a statement called an enduring understanding. It's simply a statement that unifies more insight into "the why" behind the big ideas that endures the test of time. It's helpful to think of enduring understanding as "the big picture" for what we want our students to be able to visualize and articulate by the end of the unit. Mentally picture all the knowledge/facts/skill as the dots on a connect-the-dots puzzle that once connected, creates a unified and coherent picture-that's the understanding.

Enduring understandings are learning prioritize that we want our students to walk away remembering years after they may have forgotten (gasp!) some c the memorized names and facts. This is sometime likened to the "moral of the story". Think of the Tortoise and the Hare fable-not every minute of the story is likely remembered, but most recall at important lesson that we can apply to other things life. Enduring understandings are concepts/message that have sticking power that oftentimes relate to man things we encounter in life.

Another way of thinking about the importance of learning priorities focused on understanding is found in the infamous Father Guido (priest from classic SNL monologue called "The Five Minute University". Father Guido suggest that he can teach in 5 minutes what most college graduates remember years after graduating from college. Many laugh and share aloud persona examples of how they can relate from their own college experience However, I'll never forget the day when a high school principal challenged his staff to reflect upon what their own students will say 5 years aft leaving their high school; you could hear a deafening silence. Regardless of grade-level, some are challenged to reflect upon this and similar-type questions when thinking of their own classroom. I ask all grade-level teachers to reflect:

What is so special about learning this content that will serve my students well into the future?

If it's not clear to me, how can I expect it to be clear to my students! If it's not clear to my students, how can I expect them to care? Put yourself into your students' shoes. When you're not clear on something are you likely to really care?

Above are some examples of enduring understandings and correlating knowledge components. Consider how the enduring understandings have more long-term impact than the knowledge components.

Courageous Conversations...

One of the most powerful elements that result from this work is not only a prioritized curriculum, but the deeply meaningful professional learning process in getting there.

The level of professional conversation always astounds me: conversation that perhaps might create some dissonance—but dissonant in a positive sense! Experience has taught me that some of the most dysfunctional teams are the quiet ones always nodding and agree in with each other and never challenging ideas because they don't real communicate with each other. Ask your teaching departments/teams these tough questions:

Do we share common learning priorities as a grade-level or content-department? Should we? What's fair to the students in your classroom/ course versus the students in the classroom next door taking the same course? Is it ok to be vastly different? Is it plausible that a child in one classroom could have a completely different idea of the same concept from the child next door?

The responses may not be what we want to hear, but is that a reason not to discuss these things?

These discussions result in compelling and often times the most courageous conversation teachers can have among each other. It's eye-opening. Often, these conversations bring about new and creative ideas that may have been a mystery to the colleague you've taught next door to for the past 5 years. It's interesting to learn what we each hold sacred in what we teach. Sometimes the ideas are similar but just utilizing different terminology; other times vastly different. My assertion is that if we can't make sense of our ideas with each other, how can we expect our students to make sense of what they are learning?

Who's got time for this?

What precious resource do we never have enough of-Time! It is indeed a precious commodity. Yes, this process takes time—to dialogue, discuss and perhaps even debate with your colleagues. However, I've found upon teacher reflection that this time is actually front-loaded in unit development rather than in actual classroom teaching time. Consider the following comments as you think about how your time is spent:

Teacher A: It actually now takes me less time to teach this unit I've always done on X because I'm more focused on what's important. I filtered through all the stuff in my unit file folder that was "nice to know" to being selective on what I choose because of my focus on what is the real learning priority. I ask myself if what I'm doing is really focused on the learning goal or just a cool activity. It seems strange to say this, but knowing the real focus became a relief for me—and as a result, a relief for my students. We are all clear on what the focus is.

Teacher B: Having an enduring understanding focus for me (advanced mathematics teacher) made me realize I didn't have to have my students doing every single problem in the textbook chapter-only the ones that really mattered.

Spending the time upfront on identifying learning priorities to use as a lens for what is being taught in the classroom actually results in a more efficient use of your time in the classroom.

Once an enduring understanding has been determined—it becomes the lens to use as a filter for determining which content really is the priority and then determining how it will be assessed and taught. I've heard some teachers fondly say as they review units they've always taught with this new lens, "Time to filter the fluff!" Sometimes it's hard to say goodbye, but it's amazing how much slimmer some of those file folders become!

Less is more—How?

"Less is more" is counterintuitive to how most might view teaching and learning. Some might believe that the more things they are able to "cover" in class, the more students are learning. The question I pose is what do you value as "learning"— surface-level coverage or deep conceptual understanding? The latter equates to teaching less content with greater depth. So what's better? More content with less understanding OR less content with more understanding?

In our own hectic lives and in the classroom, priority gives one focus and clarity on what really is most important. For the classroom, learning priorities provide laser-like clarity and focus to "what's most important" from "what is nice to know" which is more likely to translate to higher quality learning results for your students. The process of prioritizing your learning priorities has to he the foundational component of am' teaching and learning initiative. Less is more when we equate it to learning that will serve a lifetime.

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Successful Intelligence in the Classroom

(from Sternberg, R. J., and Grigorenko, E. L. (). Successful Intelligence in the Classroom. *Theory Into Practice, 43*(4), 274-280)

Many students could learn more effectively than they do now if they were taught in a way that better matched their patterns of abilities. Teaching for successful intelligence provides a way to create such a match. It involves helping all students capitalize on their strengths and compensate for or correct their weaknesses. It does so by teaching in a way that balances learning for memory, analytical, creative, and practical thinking. This article describes how such teaching is done and provides data supporting the efficacy of the approach.

Many children fail to learn at a level that matches their ability to learn. There can be a number of reasons for this failure. One reason is that the way students are taught and often assessed in school does not enable them to learn and perform in an optimal way. We have developed the theory of successful intelligence in order to understand these children (Sternberg, 1997a, 1999), and a set of methods of teaching for successful intelligence to help these students reach their full potential (Sternberg & Grigorenko, 2000).

The Theory of Successful Intelligence: A Capsule Description

According to the proposed theory, *successful intelligence* is the use of an integrated set of abilities needed to attain success in life, however an individual defines it, within his or her sociocultural context. Thus, there is no one definition of intelligence. People are successfully intelligent by virtue of recognizing their strengths and making the most of them at the same time they recognize their weaknesses and find ways to correct or compensate for them. Both are important. On one hand, students need to learn to correct aspects of their performance in which they are underperforming. On the other hand, they have to recognize that they probably will never be superb at all kinds of performance. It helps to find ways around weaknesses, such as seeking help from others and giving it in return. In other words, people find their own unique path to being intelligent. Successfully intelligent people adapt to, shape, and select environments. In adaptation, they change themselves to fit the environment. For example, a teacher may adapt to the expectations of her principal by teaching in a way she believes the principal will endorse. In shaping, people change the environment to fit them. The teacher may try to persuade the principal to support a new way of teaching different from what the principal has been accustomed to in the past. And in selection, they find a new environment. For example, the teacher may decide to seek a placement in another school if she is unable to convince the principal that her way of teaching is valid and will result in benefits for the students. They accomplish these ends by finding a balance in their use of analytical, creative, and practical abilities (Sternberg, 1997a, 1999). This definition of successful intelligence contains within it several implications for teaching.

Classroom Applications

Teaching for successful intelligence attempts to help teachers reach a larger cross-section of students than more traditional teaching methods that emphasize memory and analytical instruction. In teaching for successful intelligence, a teacher follows a number of fundamental ideas.

There is no one right way of teaching and learning. Moreover, there is no one right way of assessing students' achievement. Teaching and assessment should balance use of analytical, creative, and practical thinking. Fundamentally, teachers need to help students capitalize on individual patterns of strengths and, at the same time, help them correct or compensate for weaknesses. Students, like teachers, need to develop flexibility, giving students multiple and diverse options in assessment.

Because students have different life goals, student success needs to be defined in terms that are meaningful to them as well as to the institution. Students are more likely to see meaning if teachers provide numerous examples of concepts that cover a wide range of applications. Grade student work in a way that preserves the integrity of the course as well as the integrity of the students' varied life goals.

Sometimes teachers are reluctant to teach for successful intelligence because they believe that these techniques may apply to other teachers' students, but not to their own. We would say in response that our research, some of which is described below, has not turned up any groups of students who cannot profit from this form of instruction. The students whose performance improves the most tend to be those who do not profit optimally from conventional instruction. For example, children from out-of-the way areas, such as rural Alaska, have tremendous stores of practical knowledge that can help them learn if only teachers give them the chance to use their knowledge to succeed (Sternberg, Lipka, Newman, Wildfeuer, & Grigorenko, 2003).

We encourage teachers to teach and assess achievement in ways that enable students to analyze, create with, and apply their knowledge. When students think to learn, they also learn to think. And there is an added benefit: Students who are taught analytically, creatively, and practically perform better on assessments, apparently without regard to the form the assessments take. That is, they outperform students instructed in conventional ways, even if the assessments are for straight factual memory (Sternberg, Torff, & Grigorenko, 1998a, 1998b). Moreover, our research shows that these techniques succeed, regardless of subject-matter area. But what, exactly, are the techniques used to teach analytically, creatively, and practically (see Table 1 for a summary)?

Table 1. Assignments for Applying Triarchic Intelligence

Analytical	**Creative**	**Practical**
Analyze	Create	Apply
Critique	Invent	Use
Judge	Discover	Put into practice
Compare/contrast	Imagine if…	Implement
Evaluate	Suppose that…	Employ
Assess	Predict	Render practical

Each of the methods of teaching is described below. For many more examples of each method at grade levels ranging from primary to college, see Sternberg and Grigorenko (2000).

Teaching analytically

Teaching analytically means encouraging students to (a) analyze, (b) critique, (c) judge, (d) compare and contrast, (e) evaluate, and (f) assess. When teachers refer to teaching for "critical thinking," they typically mean teaching for analytical thinking. How does such teaching translate into instructional and assessment activities? Consider various examples across the school curriculum:

- *Analyze* the development of the character of Heathcliff in *Wuthering Heights*. (Literature)

- *Critique* the design of the experiment (just gone over in class or in a reading) showing that certain plants grew better in dim light than in bright sunlight. (Biology)
- *Judge* the artistic merits of Roy Lichtenstein's comic-book art, discussing its strengths as well as its weaknesses as fine art. (Art)
- *Compare and contrast* the respective natures of the American Revolution and the French Revolution, pointing out ways they were similar and ways they were different. (History)
- *Evaluate* the validity of the following solution to a mathematical problem, and discuss weaknesses in the solution, if there are any. (Mathematics)
- *Assess* the strategy used by the winning player in the tennis match you just observed, stating what techniques she used in order to defeat her opponent. (Physical Education)

Teaching creatively

Teaching creatively means encouraging students to (a) create, (b) invent, (c) discover, (d) imagine if..., (e) suppose that..., and (f) predict. Teaching for creativity requires teachers not only to support and encourage creativity, but also to role-model it and reward it when it is displayed (Sternberg & Lubart, 1995; Sternberg & Williams, 1996). In other words, teachers need not only to talk the talk, but also walk the walk. The following examples of instructional or assessment activities encourage students to think creatively:

a) *Create* an alternative ending to the short story you just read that represents a different way things might have gone for the main characters in the story. (Literature)
b) *Invent* a dialogue between an American tourist in Paris and a French man he encounters on the street from whom he is asking directions on how to get to the Rue Pigalle. (French)
c) *Discover* the fundamental physical principle that underlies all of the following problems, each of which differs from the others in the "surface structure" of the problem but not in its "deep structure." (Physics)
d) *Imagine if* the government of China keeps evolving over the course of the next 20 years in much the same way it has been evolving. What do you believe the government of China will be like in 20 years? (Government/Political Science)
e) *Suppose that* you were to design one additional instrument to be played in a symphony orchestra for future compositions. What might that instrument be like, and why? (Music)
f) *Predict* changes that are likely to occur in the vocabulary or grammar of spoken Spanish in the border areas of the Rio Grande over the next 100 years as a result of continuous interactions between Spanish and English speakers. (Linguistics)

Teaching practically

Teaching practically means encouraging students to (a) apply, (b) use, (c) put into practice, (d) implement, (e) employ, and (f) render practical what they know. Such teaching must relate to the real practical needs of the students, not just to what would be practical for other individuals (Sternberg et al., 2000). Consider some examples:

- *Apply* the formula for computing compound interest to a problem people are likely to face when planning for retirement. (Economics, Math)
- *Use* your knowledge of German to greet a new acquaintance in Berlin. (German)

- *Put into practice* what you have learned from teamwork in football to make a classroom team project succeed. (Athletics)
- *Implement* a business plan you have written in a simulated business environment. (Business)
- *Employ* the formula for distance, rate, and time to compute a distance. (Math)
- *Render practical* a proposed design for a new building that will not work in the aesthetic context of the surrounding buildings, all of which are at least 100 years old. (Architecture)

It might seem as though teaching for successful intelligence would require much more classroom time per topic than would teaching in more conventional ways. This is not the case, however. The idea is not to teach each topic three times in three ways. Rather, it is to alternate teaching styles so that some of the time one teaches in a way more geared toward analytical thinking, other times in a way more geared to creative thinking, and still other times in a way more geared to practical thinking. The total time spent in teaching given material is the same as in any other way of teaching the material.

Because teaching for successful intelligence reaches more students' patterns of abilities, the students are more likely to be intrinsically motivated to succeed in their work. Some teachers may be reluctant to do this kind of balanced teaching, because they see their own strengths as being primarily in one of the ways of thinking, such as analytical. But teaching only to one's own strengths deprives students with different patterns of abilities valuable opportunities to learn.

Clearly, it is possible to implement teaching for successful intelligence in a wide variety of academic contexts. But there are potential problems with any new methodology. How do these methods work in practice?

Some Supporting Research

We have sought to test the theory of successful intelligence in the classroom. Our studies extend down to grade 4, and although we believe the methods would apply with younger children, we have not systematically tested their efficacy for them. In a first set of studies, we explored the question of whether conventional education in school systematically discriminates against children with creative and practical strengths (Sternberg & Clinkenbeard, 1995; Sternberg, Ferrari, Clinkenbeard, & Grigorenko, 1996; Sternberg, Grigorenko, Ferrari, & Clinkenbeard, 1999). Motivating this work was the belief that the systems in most schools strongly tend to favor children with strengths in memory and analytical abilities. However, schools can be unbalanced in other areas as well. One school we visited in Russia in 2000 placed a heavy emphasis on the development of creative abilities— much more so than on the development of analytical and practical abilities. While on this trip, we were told of another school—catering to the children of Russian businessman—that strongly emphasized practical abilities. The children who were not practically oriented were told that, eventually, they would be working for their classmates who were.

We used the Sternberg Triarchic Abilities Test, measuring analytical, creative, and practical abilities, in some of our instructional work. The test was administered to 326 children around the United States and in other countries who were identified by their schools as gifted by any standard whatsoever. Children were selected for a summer program in college-level psychology if they fell into one of five ability groupings: high analytical, high creative, high practical, high balanced (high in all three abilities), or low balanced (low in all three abilities).

The students were gifted, but in a broader sense than the term is traditionally used. They were not necessarily in the top few percent, and their gifts were not necessarily analytical in nature. Students who came to Yale were divided into four instructional groups. All four instructional groups used the same introductory psychology textbook and listened to the same psychology lectures. What differed was the type of afternoon discussion section to which they were assigned. They were randomly assigned to an instructional condition that emphasized either memory, analytical, creative, or practical instruction. For example, in the memory condition, they might be asked to describe the main tenets of a major theory of depression. In the analytical condition, they might be asked to compare and contrast two theories of depression. In the creative condition, they might be asked to formulate their own theory of depression. In the practical condition, they might be asked how they could use what they had learned about depression to help a friend who was depressed.

Students in all four instructional conditions were evaluated in terms of their performance on homework, a midterm exam, a final exam, and an independent project. Each type of work was evaluated for memory, analytical, creative, and practical quality. Thus, all students were evaluated in exactly the same way. Our results suggested the utility of the theory of successful intelligence. This utility showed itself in several ways.

First, we observed that the students in the high creative and high practical groups were much more diverse in terms of racial, ethnic, socioeconomic, and educational backgrounds than were the students in the high analytical group. This suggests that correlations of measured intelligence with status variables such as these may be reduced by using a broader conception of intelligence. Thus, the kinds of students identified as strong differed in terms of populations from which they were drawn in comparison with students identified as strong solely by analytical measures. More importantly, just by expanding the range of abilities measured, we discovered intellectual strengths that might not have been apparent through a conventional test.

Second, we found that all three ability tests— analytical, creative, and practical—significantly predicted course performance. When multiple-regression analysis was used, at least two of these ability measures contributed significantly to the prediction of each of the measures of achievement. Perhaps as a reflection of the difficulty of de-emphasizing the analytical way of teaching, one of the significant predictors was always the analytical score. However, in a replication of our study with low-income African-American students from New York, Deborah Coates of the City University of New York found a different pattern of results. Her data indicated that the practical tests were better predictors of course performance than were the analytical measures, suggesting that what ability test predicts what criterion depends on population as well as mode of teaching.

Third, and most importantly, there was an aptitude-treatment interaction where students placed in instructional conditions that better matched their pattern of abilities outperformed students who were mismatched. In other words, when students are taught in a way that fits how they think, they do better in school. Children with creative and practical abilities, who are almost never taught or assessed in a way that matches their pattern of abilities, may be at a disadvantage in course after course, year after year.

A follow-up study (Sternberg, Torff, & Grigorenko, 1998a, 1998b) examined learning of social studies and science by third graders and eighth graders. The 225 third graders were students in a low-income neighborhood in Raleigh, North Carolina. The 142 eighth graders were students who were largely middle- to upper middle-class in Baltimore, Maryland, and Fresno, California. In this study, students were assigned to one of three instructional conditions. In the first condition, they were taught the course that basically they would have learned had there been no intervention. The emphasis in the course was on memory. In a second condition, students were taught in a way that emphasized critical (analytical) thinking. In the third condition, they were taught in a way that emphasized analytical, creative, and practical thinking. All students' performance was assessed for memory learning (through multiple-choice assessments) as well as for analytical, creative, and practical learning (through performance assessments).

As expected, students in the successful-intelligence (analytical, creative, practical) condition outperformed the other students in terms of the performance assessments. One could argue that this result merely reflected the way they were taught. Nevertheless, the result suggested that teaching for these kinds of thinking succeeded. More important, however, was the result that children in the successful-intelligence condition outperformed the other children even on the multiple-choice memory tests. In other words, if the goal is just to maximize children's memory for information, teaching for successful intelligence is still superior. It enables children to capitalize on their strengths and to correct or to compensate for their weaknesses, and it allows children to encode material in a variety of interesting ways.

We have now extended these results to reading curricula at the middle school and the high school level. In a study of 871 middle school students and 432 high school students, we taught reading either triarchically (analytically, creatively, practically) or through the regular curriculum. At the middle school level, reading was taught explicitly. At the high school level, reading was infused into instruction in mathematics, physical sciences, social sciences, English, history, foreign languages, and the arts. In all settings, students who were taught triarchically substantially outperformed students who were taught in standard ways (Grigorenko, Jarvin, & Sternberg, 2002).

Thus the results of three sets of studies suggest that the theory of successful intelligence is valid as a whole. Further, the results suggest that the theory can make a difference not only in laboratory tests, but in school classrooms and even the everyday life of adults as well.

Why Teaching for Successful Intelligence Works

Why should teaching for successful intelligence improve performance relative to standard (or critical-thinking) instruction, even when performance is assessed for straightforward memory- based recall? There are at least four reasons. First, teaching for successful intelligence encourages deeper and more elaborated encoding of material than does traditional teaching, so students learn the material in a way that enhances probability of retrieval at test time. Second, teaching for successful intelligence encourages more diverse forms of encoding material, so there are more retrieval paths to the material and greater likelihood of recall at test time. Third, teaching for successful intelligence enables students to capitalize on strengths and to correct or compensate for weaknesses. Fourth, teaching for successful intelligence is more motivating to both teachers and students, so teachers are likely to teach more effectively and students are likely to learn more. Ideally, of course, exams should *not* assess only static memory learning.

Conclusion

Teachers may wish to consider the option of teaching for successful intelligence. In doing so, they will improve their teaching, improve student learning, and most importantly, modify in a constructive way the entire teaching-learning process. Data collected with thousands of students shows that teaching for successful intelligence works for many students, in many subject-matter areas, at many grade levels. Of course, this form of teaching is not a panacea for the problems of schools, and it most likely will not work for everyone— whether student or teacher. But in our research we have found that the majority of students and teachers benefit from the methods described in this article.

Teaching for successful intelligence obviously relates to other kinds of teaching that emphasize thinking. One example is Bloom's taxonomy, which specifies a set of skills that are arrayed from those at the lowest level of cognition to the highest level of cognition. There are probably three key differences between the present theory and the taxonomy. The first is that the theory of successful intelligence does not array thinking skills hierarchically, but rather, interactively. The second is that there is a more nearly equal balance among analytical, creative, and practical skills than in Bloom's taxonomy. And the third is that the methods of teaching described here are based on a psychological theory rather than a descriptive list of thinking skills.

A second example is Gardner's (1983) theory of multiple intelligences. This theory specifies a number of distinct intelligences, such as linguistic and musical, that can serve as bases for teaching thinking. The present theory is complementary to Gardner's in the sense that any of Gardner's domains, such as the linguistic, can employ analytical, creative, or practical processes (e.g., analyzing a story, writing a story, writing a persuasive essay). But there are differences. One is that the theory of successful intelligence has been subject to many controlled studies seeking empirically to validate it, while Gardner's theory has not. A second difference is that the theory of successful intelligence is more process-oriented: Gardner's theory is more content-oriented. And a third difference is that not all of Gardner's theories fall under the purview of the theory of successful intelligence, such as the candidate "existential intelligence."

A third example is Vygotksy's (1978). Vygotsky suggested that basic to intelligence is *internalization,* which is the internal reconstruction of an external operation. The basic notion is that we observe those in the social environment around us acting in certain ways and we internalize their actions so that they become a part of ourselves.

Vygotsky also proposed the important notion of a *zone of proximal development*, which refers to functions that have not yet matured but are in the process of maturation. The basic idea is to look not only at developed abilities, but also at abilities that are developing. This zone is often measured as the difference between performance before and after instruction. Thus, instruction is given at the time of testing to measure the individual's ability to learn in the testing environment. The research suggests that tests of the zone of proximal development tap abilities not measured by conventional tests. Our conception is wholly consistent with this notion.

The similarities among the various proposed methods of teaching are more salient than the differences, however. All of the methods are designed to help students develop thinking skills that they will be able to use to enhance their academic performance and their lives.

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