Scaffolding Teachers’ Efforts to Implement Problem-Based Learning

Peggy A Ertmer

Krista D. Simons

Purdue University

Abstract

Despite prevalent recommendations for the adoption of problem-based learning (PBL) approaches, the transition to PBL teaching is not easy. Given the general lack of experience most teachers have with open-ended teaching strategies, novice PBL instructors are likely to encounter difficulties in all aspects of instruction: planning, implementing, and assessing. More specifically, researchers have reported that instructors experience frustration with the amount of time it takes to implement problem-based experiences, report difficulty transitioning students into more active roles, and note struggles with effectively assessing student learning.

The importance of supporting teachers during the adoption of innovative teaching methods has been recognized for many years. In this paper we describe the specific challenges teachers face as they plan, implement and evaluate PBL in the classroom and outline effective scaffolds that can be used to support teachers’ efforts in adopting this approach. By structuring the required PBL tasks, scaffolds are thought to enable novice PBL teachers to implement PBL at a higher level than would be possible without them. Furthermore, scaffolds can increase teachers’ ability to implement the tasks independently in the future.

The scaffolds described in this article detail specific ways to structure and simplify the PBL process, thus enabling teachers to take their first successful steps toward PBL implementation. Ultimately, by supporting teachers’ initial and ongoing efforts, it is hoped that we can develop both teachers and students who are flexible thinkers and effective problem solvers.

Acknowledgment

This work was partially supported by *Tech-Know-Build: Indiana Students Building Knowledge with Technology,* a Technology Innovation Challenge Grant awarded to Crawfordsville Community Schools, 2000-2005.

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Over the last few decades, interest in student-centered learning methods (i.e., activities that engage learners in authentic discipline-based problems) has grown significantly (Hannafin, Land, & Oliver, 1999). Represented by a variety of current instructional approaches (e.g., engaged learning, learning by design, authentic instruction, project-based science, problem-based learning), student-centered learning comprises a teaching/learning framework designed to promote deep understanding of subject-matter content in conjunction with the development of higher-order thinking skills (Krajcik, Blumenfeld, Marx, Soloway, 1994; Newmann, Bryk, & Nagaoka, 2001; North Central Regional Educational Laboratory, 2004; Stepien & Gallager, 1993). Kolodner et al. (2003) noted that these types of approaches engage students as researchers; that is, students learn how to ask important questions; design and conduct investigations; collect, analyze, and interpret data; and apply what they have learned to new problems or situations.

Problem-based learning (PBL) is one example of a student-centered approach that engages learners in the investigation of authentic complex problems (Levin, 2001). In PBL, students learn subject-matter content by identifying and solving authentic problems of the discipline (Hallinger, 2005). In general, the PBL process is anchored by a complex, ill-structured problem (i.e., one for which there are many solutions, as well as many different paths to solutions); students proceed through a variety of activities to frame their understanding of the problem, access resources, increase understanding, and recommend solutions (Simons, Klein, & Brush, 2004). In addition, most learning occurs within the context of small groups (Hallinger, 2005). As is true of other student-centered approaches, PBL is thought to help students apply domain-specific knowledge to the solution of problems likely to be encountered in their future careers.

Research suggests that effective use of problem-based learning methods can prepare students to be flexible thinkers who can work productively with others to solve problems (Hmelo-Silver, 2004; Kain, 2003). Moreover, the PBL method has been demonstrated to increase different types of problem-solving skills in students, from describing specific processes needed to address a particular problem, to increasing the depth and breadth of solutions (Stepien, Gallagher, & Workman, 1993, Dochy, Segers, Van de Bossche, & Gijbels, 2003). Research also suggests that PBL can help students develop self-directed learning skills (Hmelo-Silver) and positive attitudes toward learning (Simons et al., 2004).

Despite evidence that PBL is a powerful approach, adoption of this method is not as widespread as might be hoped (Hmelo-Silver, 2004). Like other innovations, PBL poses numerous difficulties for both teachers and students. "The curriculum approach, by itself, cannot do it all" (Kolodner et al., 2003, p. 542). In order to be successful, PBL teachers must make fundamental changes in the way they direct / facilitate student learning in the classroom (Krajcik et al., 1994). According to Brush and Saye (2000), "successfully implementing student-centered learning requires skills and resources that are very different from those required by more traditional, teacher-centered classroom activities" (p. 80).

Given the general lack of experience most teachers have with open-ended teaching strategies (Land, 2000), novice PBL instructors are likely to encounter difficulties in all aspects of PBL instruction: planning, implementing, and assessing. Researchers have reported that instructors experience frustration with the amount of time it takes to plan for and implement problem-based experiences (Simons et al., 2004), report difficulty transitioning students into more active roles (Gallagher, 1997), and note struggles with effectively assessing student learning (Brinkerhoff & Glazewski, 2004).

Left to their own devices, it is unlikely that classroom teachers will readily adopt a PBL approach. According to Joyce and Weil (1996), only 5-10 percent of teachers will even *try* a new teaching strategy unless they are provided with an adequate support system. And "even then, during the first half dozen trials, most teachers found the use of the new teaching strategies, whatever they were, to be extremely uncomfortable" (p. 338). Without adequate support, the adoption of PBL methods is likely to be extremely limited.

In order to increase their chances for success, PBL teachers need support from a wide variety of sources that will enable them to address the diverse challenges they are likely to encounter as they plan, implement, and evaluate the PBL process. For example, teachers will need new tools or strategies that can support them as they adopt new roles, facilitate student inquiry, provide ongoing formative feedback, and implement new types of classroom management strategies. While a number of researchers and educators have described specific methods for scaffolding students' work during the PBL process (Brush & Saye, 2001; Simons et al., 2004), little has been written about specific strategies that can scaffold teachers' change efforts, specifically related to the adoption and implementation of PBL methods in the K-12 classroom.

The purpose of this article is to describe the specific challenges PBL teachers are likely to encounter during each stage of the PBL process (planning, implementation, and assessment) and to outline specific scaffolds that can be used to support teachers' efforts in adopting this new approach. While not a research study, we incorporate evidence and anecdotes from experiences we have had over the last five years helping middle school teachers adopt PBL methods.

Challenges to Teacher Change

Krajcik et al. (1994) and others (Grant & Hill, in press; Murray & Savin-Baden, 2000) have described unique challenges teachers face when implementing project- or problem-based learning in the classroom. For example, Krajcik et al. described challenges at three levels: 1) teacher (beliefs, previous experiences, pedagogical and content knowledge, commitment to the innovation), 2) classroom (resources, support, class size, class schedule), and 3) school/community (curricular and testing policies, community support and involvement). Grant and Hill expanded on specific challenges at the teacher level to identify four factors that influence teachers' adoption and use of project-based learning including: 1) recognition and acceptance of new roles and responsibilities, 2) comfort in the new (physical) environment, 3) tolerance for ambiguity and flexibility in managing the new learning environment, and 4) confidence in integrating appropriate tools and resources, including technology. Grant and Hill's fifth factor (integration of new pedagogies with realities beyond the classroom) acknowledges that teacher change efforts are challenged at many levels--by individual learner needs, by collegial relationships, and by administrative policies, to name a few.

Supporting Teacher Change

The importance of supporting teachers during the adoption of innovative teaching methods has been recognized for many years (Fullen, 1992; Tobin & Dawson, 1992). More specific to student-centered learning, Blumenfeld, Soloway, Marx, Krajcik, Guzdial, and Palinscar (1991) warned that "without adequate attention to ways of supporting students and teachers, learning-by-doing will not be done" (p. 374). Clearly, student-centered teaching approaches are not easy to implement in the classroom. If instructors don't have enough guidance or support, they can easily fall into the trap of thinking that just because these approaches are interesting and engaging, that students are learning the things they need to learn. Unfortunately, teachers may gravitate toward those activities that are most familiar (e.g., finding resources), rather than those that are most productive for learning (e.g., tying information searches to specific questions that need to be answered; Kolodner et al., 2003).

How, then, can we support teachers as they learn to use problem-based learning approaches? Krajcik et al. (1994) noted that it is through collaboration, classroom enactment, and reflection that teacher learning occurs: "… teachers construct their knowledge through social interaction with peers, through applying ideas in practice, and through reflection and modification of ideas" (p. 490). Murray and Savin-Baden (2000) provided additional evidence that PBL facilitators benefit from learning "dialogically," that is, with and through others. What is important to remember, however, is that teachers need access to these types of support *throughout* the adoption and implementation process. As noted by Mergendoller and Thomas (2005): "the overlapping, wide-ranging, and changing demands of PBL management and instruction are difficult to master, and novice PBL teachers frequently experience dilemmas and difficulties" during classroom implementation (p. 35).

Scaffolding Teachers' Adoption and Implementation of PBL

Hogan (1997) defined an instructional scaffold as "a tool for enculturating students into the thinking patterns of experts" (p. 2). Although used initially to describe the specific support that an adult (or more expert individual) provides to a child (or novice) while working on a task (Wood, Bruner, & Ross, 1976), the scaffolding metaphor is now used more broadly to describe additional forms of support and contexts of interaction, such as support that is distributed among multiple participants and artifacts (Tabak, 2004). In this paper, we apply Hogan's definition to teacher, rather than student, learning; that is, we define scaffolds as tools for enculturating novice PBL teachers into the thinking patterns of more experienced, and thus, more expert, PBL facilitators. Based on more recent conceptions of the scaffolding metaphor, scaffolds enable learners, or in this case, teachers, deal with the complexities of a task while simultaneously learning how to accomplish the tasks independently (Hmelo & Guzdial, 1996; Reiser, 2004). Thus, when designing effective scaffolds for novice PBL teachers, it is important to include both those that structure the PBL tasks (i.e., reduce the complexity) and those that increase teachers' ability to implement PBL independently (i.e., promote deeper understanding).

Scaffolding Teachers' PBL Planning Efforts

Designing a PBL unit is not as simple or straightforward as planning a traditional instructional unit (Krajcik et al., 1994). While key content is still targeted, specific learning objectives are not the primary focus. Key tasks to be accomplished during the planning phase include designing or selecting the problem scenario, "trigger," or "driving question;" identifying and possibly gathering relevant resources; and engendering student motivation and ownership in the identified problem. Each of these tasks entails a unique set of challenges, for which specific scaffolds can be designed.

Identifying the "Driving Question"

Problem-based learning units typically revolve around a driving question, as opposed to the presentation of pre-defined content, as outlined in a textbook chapter (Mergendoller & Thomas, 2005). This is not to suggest that the problems are content- or discipline-free. Rather, problems/questions must be relevant to teachers' required curricula, or teachers will not be able to justify the amount of time needed for students to work through them. A good driving question is defined as one that is meaningful to students, includes relevant content, involves authentic problem solving, lends itself to collaboration, and is broad enough to permit students to develop their own questions and investigations (Lehman, Ertmer, Keck, & Steele, 2001). While the importance of the driving question cannot be over-stated, most teachers agree, "crafting an ill-structured problem can be a time-consuming challenge" (Checkley, 1997, p. 111). Murray and Savin-Baden (2000) described the difficulties new PBL instructors encountered while trying to develop triggers for their nursing curricula, noting that "although many staff had devised problem-solving questions for students in former years, few had developed materials in which the problem scenario … enabled students to learn material in the context of resolving or managing a problem" (p. 117).

The inspiration for a problem-based unit can come from a variety of sources. For example, one of the middle school teachers we worked with capitalized on an article that appeared in the local newspaper, "Why should kids care about the cost of gas?" to develop a PBL unit for her mathematics class. Other possible sources include journal articles, radio broadcasts, recent legal cases, current community issues, ongoing policy debates, film plots, curriculum guides, and even teachers' previous units. Teachers should consider beginning the process of problem identification by paying close attention to their current teaching materials, which may already have complex issues, conflicts, puzzles, or controversial decisions embedded within them.

To structure or simply the problem-selection task, a checklist could be used to help teachers remember the various characteristics of a good problem. In addition, templates, or a series of prompts, could be used to guide teachers during the development or selection process. For example, Stepien (1997) recommended that teachers ask themselves four questions to determine the suitability of a potential problem:

- Would my students run across significant content working on this situation?
- Would the content fit my curricular responsibilities?
- Would the content be appropriate for my students?
- Can a PBL unit be built around this situation? (p. 67)

To increase teachers' understanding of how these various characteristics are applied to a specific question/problem, a chart could be used to highlight the differences between good and bad problems, using specific examples (Bradbeer, 2003; Quebec English School Network, 2005). Finally, illustrating how lists of possible topics are transformed into good questions can help teachers understand how to complete this process on their own.

Locating/Gathering Resources

In addition to the characteristics noted above, a good question must be feasible. That is, it must be developed with an awareness of both available resources and students' current skills. If there are limited resources available, or if available resources are beyond students' reading or comprehension levels, the question, no matter how authentic or interesting, will not inspire deep thinking. For example, when a group of social studies teachers created a unit revolving around the question, "How has your home town changed in the last 100 years?" students were unable to locate enough Internet resources to help them answer the question. Because the teachers had not pre-arranged to have materials from the city library available, most of the relevant resources were checked out, leaving students with few resources to consult.

Ward and Lee (2002) noted that the lack of prepared materials for classroom instruction creates barriers to the implementation of PBL. Yet, by starting with a unit that has been previously taught, albeit in a different format, teachers need not be overwhelmed by the need to gather a whole new set of resources. Using a template or checklist, teachers might begin the planning process by visualizing the activities that will take place during the unit, and then identifying resources students will need at specific times. Then, by communicating these specific needs to their school media specialists and local librarians, teachers may be able to off-load some of these initial planning tasks.

Depending on the age of their students, teachers may need to provide a "self-contained" list of appropriate Internet resources. For young students, a WebQuest or a web-resource page can be used to limit students' searching needs. Although this requires additional planning time upfront, it can help avoid problems during implementation. In addition, templates are available that make the task of creating a WebQuest amazingly simple (for more information, see http://webquest.sdsu.edu/LessonTemplate.html). For older students, teachers should consider teaching information literacy skills as part of the first PBL unit so that students learn how to search for, and evaluate, the information they find themselves, whether it be on the Web, in a library book, magazine, or newspaper article. For example, one teacher consistently reminds her students that research is about finding answers to questions. Students are taught to use note cards in a purposeful, systematic manner; as a "header" for each card, students must write the question that the subsequent notes answer. This serves to focus their research and determine the relevance of facts and information.

Finally, when planning PBL activities, it is important to consider students' technology needs. Certainly, PBL units can be completed without the use of technology. However, involving students in authentic discipline-based inquiry typically requires the use of technology tools and processes. Teachers need to consider whether the technology truly is integral to the students' work or whether it is supplemental. If integral, plans need to be made regarding how the resources will be managed and shared by the students, as well as how activities will be completed if the technology is not accessible when needed.

Creating Student Ownership in the Problem

If a "good" question is developed (e.g., one that is meaningful to students, involves authentic problem solving), creating student ownership is probably a moot point. Still, teachers can introduce the problem in ways that capitalize on, and increase, this natural motivation. For example, experienced PBL teachers (as described in Mergendoller & Thomas, 2005) recommend getting students thinking about the project / problem before the unit begins, planting seeds of curiosity weeks in advance. Stepien (1997) suggests that teachers "hook" students through the use of an engaging opening scenario, including the assignment of specific student roles. The use of concrete activities (field trips, videos, fictionalized memos) can quickly engage students' interest in the problem. When evaluating the appropriateness of the driving question, it is impossible to place too much emphasis on its relevance to students' interests: "The greater students' involvement in an issue, the greater their investment in its solution and the harder they will work" (Delisle, 1997, p. 24).

If students are unfamiliar with a PBL approach, posthole activities might be used to ease students into their new roles and responsibilities. Postholes are typically short problems used to introduce students to the problem-based method, including how to work productively in small groups. As "practice" or "mini" PBL units, postholes provide both teachers and students with time and opportunity to adjust to the PBL approach (Stepien & Gallager, 1993).

If the topic/problem is completely new to students, additional measures may be needed to help students start thinking about the problem. Kolodner and her colleagues (2003) created "messing about" activities that helped students understand the specific sub-issues embedded within an overarching design problem. Given the opportunity to "get their hands dirty," students were then able to identify additional questions or issues that needed to be resolved to solve the bigger problem. Similarly, when teachers in a local school corporation wanted their 6th grade students to identify and research potential problems related to rainforest deforestation, they provided them with a list of eight "belief statements" as an entry point into the topic (e.g., "The tropical rain forest is home to many rare animals and plants. Destroying tropical rain forests could make these species extinct." "The tropical rain forest is home to different peoples. No one has the right to destroy these peoples' homes and ways of life."). Students began by individually rank ordering the statements and then coming to consensus with fellow group members on their top two beliefs. Rather than starting "cold" by researching an unfamiliar topic, this activity quickly engaged students in a variety of important issues related to rainforest deforestation and gave them reasons to search for additional evidence to support their beliefs (see http://research.soe.purdue.edu/challenge/PBL/2003_2004/rainforest/activity.htm for more information).

Scaffolding Teachers' PBL Implementation Efforts

Successful implementation of PBL methods requires teachers to assume a guiding role and to simultaneously attend to many different aspects of the classroom (Brush & Saye, 2000). "The result is that teachers in learner-centered classrooms tend to have a broader set of management responsibilities than do teachers in more traditional classrooms" (Mergendoller & Thomas, 2005, p. 40). Implementation challenges relate to creating a culture of collaboration and interdependence, adjusting to changing teacher and student roles, and managing students' engagement during individual and group work.

Creating a Collaborative Classroom Culture

"In a culture of collaboration and interdependence, every member of the community feels responsibility towards helping others learn, and every member of the community knows that he or she can depend on others for help when needed" (Kolodner et al., 2003, p. 512). One of the basic tenets of a collaborative classroom culture is the expectation that the teacher will assume a facilitative, rather than directive, role. Success, according to Kolodner et al., depends on the willingness and ability of teachers to change the way they control the class. Obviously, this is not an easy transition to make; Grant and Hill (in press) noted that, in order to be successful, teachers have to change both "how," as well as "what," they teach.

While it is unclear exactly how teachers (and students) make this transition, Kolodner et al. (2003) described specific scaffolds for supporting teachers through the process. Specifically, they described the use of "rituals," that is, classroom scripts for specific activities (e.g., designing an experiment, preparing for a poster session) that helped teachers and students know what practices were appropriate at different times in the project sequence. By their very nature, rituals help make specific behaviors automatic. In the case of PBL, rituals can help teachers feel comfortable in their roles as facilitators by providing them with specific cues and procedures for managing and carrying out the macro phases of the process.

Additional scaffolds can be used to increase teachers' understanding of the facilitative role such as giving them opportunities to 1) observe experienced PBL facilitators and 2) practice facilitating a mini or posthole unit. Abbreviated units, conducted by groups of teachers with a limited number of students, offer another way to initiate teachers into their new role. For example, to introduce our local teachers to the PBL process, we asked each teacher to bring along a student participant and then engaged everyone in a 2-day mini PBL unit ("What's in our water?"). In this way, teachers and students assumed new roles simultaneously; teachers had the opportunity to witness, first-hand, students' excitement and engagement in the issue and in the approach.

Managing Student Engagement

In PBL environments, very little time is spent on teacher-designed seatwork or whole-class lectures or discussions. Rather, students spend the majority of their time working on their own or in small groups (Mergendoller & Thomas, 2005). Thus, teachers' instructional responsibilities relate primarily to managing student small groups, keeping students focused on important content, and maintaining student motivation.

Collaboration is a key component of PBL learning environments. Yet, specific structures must be in place (e.g., positive interdependence, individual accountability) for students to work together productively (Brush & Saye, 2001). Teachers must scaffold students' efforts so they learn how to establish group goals, divide up project responsibilities, manage deadlines, and address problems related to group dynamics. Posthole units can provide early opportunities for students to practice their collaboration skills. Furthermore, if small group work is followed by whole-class debriefings in which students reflect on the group process itself, students can develop their own strategies for managing problems that occurred within their small groups. By taking advantage of these activities, teachers can ease students into assuming responsibility for their own learning.

According to Hmelo & Guzdial (1997), it is important to provide ongoing opportunities for students to articulate what they are learning in their groups. Teachers accomplish this by asking probing questions, challenging a particular perspective or argument, or offering an alternative hypothesis, thus forcing students to interpret the information they have gathered. By alternating investigative / design work with interpretive or reflective work (Kolodner et al., 2003), students can share what they have learned and benefit from the perspectives of others. Finally, the use of frequent checkpoints and record-keeping devices (e.g., group folders, design diaries, goal charts, etc.) can keep students focused and provide opportunities for reinforcement or redirection. These techniques also serve motivational purposes as they allow students to observe their ongoing progress.

To guard against students becoming more concerned about completing tasks than learning content, it is important to continually help students make links between claims and evidence, questions and information, project design and learning goals. Kolodner et al. (2003) suggested that "scientific reasoning" needs to be established as part of the classroom culture and can be developed through project rituals and the use of classroom "rules of thumb" (design principles that help students connect product design attributes to scientific principles and to consider new investigations based on previous results). Even in disciplines other than science, a culture of "expert" reasoning is important, and can help students become logical thinkers. Posting reminders around the classroom ("Support your claim!" "Present your evidence!") keeps everyone focused on this expectation.

One teacher we worked with accomplished this by taking every opportunity to remind her students of the overarching problem and the specific task at hand. At the top of every graphic organizer or task sheet, she placed two key elements: 1) the driving question ("How can our high school ensure that its students learn and thrive?"), and 2) the description of the task ("Assess the performance of our school. [Be prepared] to offer an unbiased and informed opinion as to what direction school leaders should take to ensure that students learn and thrive."). While each group of students worked on a different element of the problem, the "big picture" was consistently visible to remind students *why* they were working on the activities and to ensure that en-route goals aligned with the driving question.

Scaffolding Teachers' PBL Assessment Efforts

Assessment presents a whole set of challenges that are not present in the traditional classroom. While teachers will want to use measures that realistically reflect what students have accomplished in their groups, they also need to be able to assign individual grades and to determine if students have mastered content-area standards. Thus, in addition to monitoring project progress (noted earlier), additional assessment challenges relate to 1) designing appropriate assessment methods and instruments that address both individual and group accountability and 2) helping students develop the ability to self-assess.

Developing Assessment Methods and Instruments

Assessment strategies in a PBL classroom can be as varied as those in a traditional classroom, although they are likely to lean more toward authentic measures (e.g., problem logs, journals, design diaries) than traditional tests. Still, depending on what the teacher wants to know (e.g., Do the students understand the underlying concept at a sufficiently high level to move on?), quizzes or prepost tests may offer the most effective measure. Kolodner et al. (2003) recommended that teachers use two kinds of homework assignments to determine individual learning progress: 1) nightly assignments that either prepared students for the next day's work or asked them to reflect on what they did that day, and 2) longer reports that asked them to summarize their group experiences.

Experienced PBL teachers often assess group products using rubrics or rating scales, developed collaboratively with their students (Mergendoller & Thomas, 2005). Standards for quality are typically established at the beginning, often using previous students' work or even examples of professional work as the "gold standard." In addition, benchmarks can provide examples of what a novice, advanced, or expert product looks like, thus helping students gauge their progress as they attain each level.

It is important to remember that in a PBL learning environment, evaluation is an ongoing process. According to Delisle (1997), "Assessment of student performance begins the first day a PBL problem is introduced and lasts until the final product is reviewed" (p. 37). Checklists can be developed to help teachers assess students' work during each phase of the problem-solving process: identifying key questions, using available research tools, organizing and synthesizing information, generating possible solutions, working productively with group members, and creating and presenting a final product.

Developing Students' Self-Assessment Skills

One of the primary goals of student-centered instruction is to help students develop the skills needed to regulate their own learning (Brush & Saye, 2001). PBL offers teachers many opportunities to teach students self-directed learning strategies that enable them to set their own goals, monitor their progress, and determine next steps toward goal achievement (Grant & Hill, in press). While it is unlikely that students will possess these skills initially, early efforts can be supported with specific scaffolds. For example, students can fill out daily goal sheets, rate their progress at the end of the day, and then set new goals for the next day. Using problem logs, students can reflect on the strategies used to accomplish specific goals and then rate the effectiveness of those strategies based on how well the goals were met. While the intent of these activities is to help students develop important lifelong learning habits, they also provide teachers with valuable insights into students' specific learning needs. Ultimately, giving students' ownership in their learning leads to significant benefits for both teachers and students.

Conclusion

As Ward and Lee (2002) noted, "The philosophies supporting PBL are well established, but the 'how tos' are in short supply" (p. 21). In this article, we describe some specific "how tos," in the form of scaffolds or strategies, as a first step in helping teachers understand and address the various challenges that occur during each phase of the PBL process. It is our hope that the ideas presented here can structure and simplify the PBL process enough to enable teachers to take their first steps without being "extremely uncomfortable," as portrayed by Joyce and Weil (1996).

It is important for teachers to be realistic as they plan for and implement their first few PBL units in the classroom. In general, it is recommended that they begin by identifying areas in the curriculum that have problems/issues already embedded within them. These curricular areas can offer teachers a reasonably comfortable entry into the process. However, just as we expect students to learn from their mistakes, so too, can teachers benefit by reflecting on their initial attempts and evaluating what worked and what didn't. This includes an assessment of the effectiveness of the problem itself, as well as a critical reflection on one's facilitation skills. In order to assure that teachers experience some early success and thus, gain some initial confidence, it is recommended that they start with small problem units (postholes or mini-PBLs) before attempting more complex or larger units. As Kolodner et al. (2003) noted:

> Teachers cannot always facilitate LBD [Learning by Design] well right away, and many have trouble learning the science, but if they have bought in to what could be in the classroom and if they have help as they are learning to implement the new approach, their classes thrive, and students and teachers learn together (p. 541).

It is our hope that by using some of the strategies and scaffolds recommended here, teachers will be "brought into what could be in the classroom" in a relatively painless manner. By supporting teachers' initial and ongoing efforts, we expect to come closer to realizing our ultimate goal: that of effecting broad dissemination of PBL in teachers' classrooms as a way of developing both teachers and students who are flexible thinkers and effective problem solvers.

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