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Jumping the PBL Implementation Hurdle: Supporting the Efforts of K–12 Teachers

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Abstract

While problem-based learning (PBL) has a relatively long history of successful use in medical and pre-professional schools, it has yet to be widely adopted by K–12 teachers. This may be due, in part, to the numerous challenges teachers experience when implementing PBL. In this paper, we describe specific hurdles that teachers are likely to encounter during the implementation process and provide specific suggestions for supporting teachers' classroom efforts. Implementation challenges relate to 1) creating a culture of collaboration and interdependence, 2) adjusting to changing roles, and 3) scaffolding student learning and performance. By supporting teachers' initial and ongoing efforts, we anticipate that more teachers will recognize the potential of PBL as an effective instructional approach for developing learners who are flexible thinkers and successful problem solvers.
Keywords: problem-based learning, implementation, scaffolding, inservice teachers

Introduction

Problem-based learning (PBL) is currently advocated as a powerful means for facilitating students' attainment of the high-level competencies and transferable skills increasingly being demanded by government, commerce, and industry (Murray & Savin-Baden, 2000). PBL, as defined by Barrows and Tamblyn (1980), refers to "the learning that results from the process of working toward the understanding or resolution of a problem" (p. 18). In general, the goals in problem-based learning are two-fold: 1) to promote deep understanding of subject matter content while 2) simultaneously developing students' higher-order thinking. While PBL can come in a variety of forms, depending on the discipline under study and the goals of the curriculum (see Savery, this issue), it tends to include features such as learner autonomy, active learning, cooperation and collaboration, authentic activities, and reflection and transfer (Grant & Hill, in press).

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In PBL, students' work is organized around solving a complex, ill-structured problem that encompasses authentic, discipline-based content. Because students are introduced to the problem before they have learned the required content knowledge, they work together to identify their learning needs and to locate relevant information to address those needs. Throughout the process, the teacher monitors and guides students' progress by overseeing the management of small student groups, keeping students focused on important content, and providing ongoing formative feedback. Finally, as a way to help students both deepen and strengthen their understanding of the concepts and skills acquired, students engage in ongoing reflective activities such as journaling, self-evaluation, and group debriefings.

Despite a relatively long history of successful use in medical schools (Barrows & Tamblyn, 1980), and some encouraging reports of effective use in the K–12 sector (Brush & Saye, 2000; Pedersen & Liu, 2002-2003), problem-based learning has yet to be widely adopted by K–12 teachers (Hmelo-Silver, 2004). Like other student-centered innovations, PBL poses numerous difficulties for both teachers and students who are likely to be unfamiliar, as well as uncomfortable, with the new roles and responsibilities required by this type of open-ended learning environment (Land, 2000). For example, researchers have reported that instructors experience frustration with the amount of time it takes to plan for and implement problem-based experiences (Simons, Klein, & Brush, 2004), report difficulty transitioning students into more active roles (Gallagher, 1997), and note struggles with effectively assessing student learning (Brinkerhoff & Glazewski, 2004). 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). Furthermore, when considering these challenges in the highly charged climate of No Child Left Behind (U. S. Department of Education, 2001), teachers may be reluctant to adopt an unfamiliar teaching approach, especially one that is perceived as being more time-consuming than the traditional method (Brinkerhoff & Glazewski, 2004).

In order to increase the likelihood that PBL will be effectively integrated within K–12 contexts, a variety of resources is needed to support both teachers' and students' efforts. For example, teachers will need guidance as they adopt new roles, facilitate student inquiry, provide constructive feedback, and apply new types of classroom management strategies. Students, too, will need to be supported as they learn to develop and implement their own strategies for addressing complex problems and for working with diverse others to negotiate solutions in a collaborative manner (Hannafin, Hill, & Land, 1997).

The purpose of this paper is to describe the specific challenges teachers are likely to encounter during the PBL implementation process and to outline specific means to support their efforts. While we acknowledge that planning and assessment tasks are also critical to the success of PBL, we focus primarily on implementation challenges, as these tend to involve both teachers and students. In fact, two of the primary challenges teachers face as they introduce and facilitate a PBL unit relate to managing student engagement and ensuring meaningful student learning. Thus, our efforts to support teachers must, by necessity, include specific recommendations for supporting students' efforts during the learning process.

PBL Implementation Challenges

Krajcik, Blumenfeld, Marx, and Soloway (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, Grant and Hill identified five 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, 4) confidence in integrating appropriate tools and resources, including technology, and 5) integration of new pedagogies with realities beyond the classroom, including the ability to balance the unique needs of individual learners, teaching colleagues, and administrators, to name a few.

Clearly, student-centered teaching approaches are not easy to implement in the classroom. If instructors do not have enough guidance or support, they can easily fall into the trap of thinking that just because these approaches are interesting and engaging, 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; Brush & Saye, 2000, 2001; Brinkerhoff & Glazewski, 2004).

Successful implementation of PBL methods requires teachers to assume a guiding role and to simultaneously attend to many different aspects of the learning environment (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). Specifically, implementation challenges relate to 1) creating a culture of collaboration and interdependence, 2) adjusting to changing roles, and 3) scaffolding student learning and performance. We discuss each of these challenges and provide specific suggestions and considerations for supporting teachers. While we recognize that each of these challenges is important, we focus the majority of our discussion on methods for scaffolding student performance, since the bulk of teachers' time will be spent initiating student inquiry and ensuring content learning. Finally, in order to illustrate and clarify our recommendations, we incorporate evidence and anecdotes from the literature as well as from experiences we have had over the last five years helping middle school teachers adopt PBL methods.

Creating a Collaborative Classroom Culture

Collaboration is a key component of PBL learning environments, as it allows students to draw on each other's perspectives and talents in order to more effectively devise solutions for the problem(s) at hand. Yet, specific structures must be in place (e.g., positive interdependence, individual accountability) for students to work productively together (Brush & Saye, 2001). For example, teachers must support students as they learn how to establish group goals, divide up project responsibilities, manage deadlines, and address problems related to group dynamics.

One strategy teachers have used to help students adjust to the collaborative nature of PBL is the use of "posthole" units (Stepien & Gallagher, 1993). In general, postholes are 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 give students the time and opportunity needed to practice collaboration skills. That is, prior to asking students to work on a multi-week or whole-semester unit, a shorter lesson (e.g., 2-3 days) is used to introduce students to the problem-solving process. For example, Stepien and Gallagher described developing posthole units from the student edition of the Wall Street Journal, based on topics such as the spotted owl controversy or the plight of the mentally ill living in homeless shelters. As another example, teachers at a local middle school asked their students to consider the question, "What makes a good friend?" as an initial problem-based lesson, prior to tackling the bigger issue/unit related to, "What can we do to improve the quality of life in our city?" After participating in a set of smaller problem-based activities, students seem more prepared to deal with the complexities of a larger unit.

Another strategy teachers can use to develop a classroom culture of collaboration is to conduct whole-class debriefings, after small-group work is completed, so that students can reflect on the group process itself. Through these group reflections, students can develop their own strategies for managing problems that occurred within their small groups and thus move closer to assuming greater responsibility for their own learning. In addition, the use of learning contracts or daily worksheets that include a place for students to record group goals and related activities can help students adopt a collaborative mindset.

Adjusting to Changing Roles

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 Kracjik et al. (1994), 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 suggestions 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. For example, two university PBL instructors required their preservice teachers to develop a series of three artifacts to represent their understandings of different aspects of technology integration. While each artifact was distinct, the process, or ritual, students employed to develop each artifact was similar: brainstorm ideas, narrow the focus, represent priorities in an authentic manner, obtain instructor feedback, and revise for final submission. According to the Learning by Design (LBD) researchers (Kolodner et al., 2003), rituals ". . . [make] the expectations for any activity clear and succinct . . ." so that students and teacher can effortlessly engage in them (p. 513).

Teachers might enhance their understanding of the facilitative role further by taking advantage of opportunities to 1) observe experienced PBL facilitators (either in person or virtually through video cases) and 2) practice facilitating a mini or posthole unit. Teachers we have worked with have often come on board in pairs or in teams, thus building their own local support systems. This has the added advantage of initiating the development of a social network of PBL-using teachers, one of the first steps in creating the type of learning community needed to sustain innovative teaching practices (Ertmer, 2005).

While there is evidence to support the idea that shifting learning responsibilities from the teacher to the students promotes the development of students' critical thinking and problem-solving skills (Brush & Saye, 2001), this shift does not occur naturally or easily. Students particularly can become disoriented or frustrated if they do not receive the support or guidance needed to be successful. Teachers, in response to this frustration, may be tempted to revert back to their teacher-directed strategies (e.g., telling the students what to do or providing answers). Supporting, or scaffolding, student learning becomes a key component of the teacher's role as a facilitator.

Scaffolding Student Learning and Performance

Scaffolds represent one means of supporting learners in complex or unfamiliar environments. As such, instructional scaffolds refer to the tools, strategies, or guides that enable learners to reach higher levels of understanding and performance than would be possible without them (Wood, Bruner, & Ross, 1976). "By controlling those elements of the task that are initially beyond the learner's capability" (Wood et al., 1976, p. 9), scaffolds enable learners to deal with the complexities of a task while simultaneously learning how to work independently in the domain (Hmelo & Guzdial, 1996; Reiser, 2004). Given the complexity of initiating and sustaining PBL inquiry in the K–12 classroom, novice PBL teachers and their students can benefit from scaffolds that structure the required PBL tasks (i.e., reduce the complexity) while increasing their ability to complete PBL tasks independently.

Scaffolds may assume multiple forms depending on the learning environment, the content, the instructor, and the learners. In this paper we use the term to encompass both "soft" and "hard" scaffolds. Saye and Brush (2002) conceptualized soft scaffolds as "dynamic," which includes the timely support teachers provide as they "continuously diagnose the understandings of learners" (p. 82). For example, one middle school teacher provided soft scaffolds by conferencing with at least one group of students during every class session, gauging their progress, and providing guidance as needed.

In contrast, hard scaffolds are defined as "static supports that can be anticipated and planned in advance based on typical student difficulties with a task" (p. 82). For example, two sixth-grade teachers provided scaffolds in the form of handouts during various stages of inquiry. These scaffolds helped students perform a variety of inquiry-related tasks: searching for relevant information, providing details in their writing, brainstorming with their groups, and the like. In other words, hard scaffolds provide support at various stages known to be difficult, thus freeing the teacher, or expert, to perform additional soft scaffolding. According to Saye and Brush (2002), both hard and soft scaffolds are critical components in the successful completion of student-centered learning activities.

Within problem-based learning, teachers can use scaffolds to accomplish four important goals: 1) initiating students' inquiry; 2) maintaining students' engagement; 3) aiding learners with concept integration and addressing misconceptions; and 4) promoting reflective thinking. In the remainder of this paper we explore how scaffolds can support each of these purposes, and present examples that might assist teachers during implementation.

Initiating Student Inquiry

Research has shown that novice PBL learners tend to have difficulty during the initial stages of inquiry (Brush & Saye, 2000; Land, 2000; Simons et al., 2004). This pattern appears consistent across multiple levels of students, from primary to post-secondary (Abrandt Dahlgren & Dahlgren, 2002; Simons & Klein, in press). Successful implementation appears to hinge on initial student engagement with the problem. One approach to engaging the learners is to formally "recruit" learners, which Wood et al. (1976) described as a twofold process of enlisting the learners' interests and presenting the requirements of the task. For example, in Learning by Design (Kolodner et al., 2003) middle school learners begin exploring a design problem with a "messing about" activity in which they construct an initial model or device without formal guidance. Students record their observations and collaboratively generate ideas and questions. These are captured on a whiteboard and used to frame subsequent activities.

Similarly, Baumgartner and Reiser (1998) incorporated "staging activities." For example, the teacher might show an example project from a previous year or demonstrate a scientific principle. In a unit entitled Composites Module, the teacher demonstrated the effect of reinforcing ice with shredded toilet paper to show that this composite was stronger than either of the materials alone. The common goal among these approaches involves sparking learners' interest at the beginning of the inquiry process, thereby prompting them to ask questions, predict outcomes, and make observations.

In addition to sparking learners' interests, many designers advocate narrowing or constraining the task to make it more manageable (Hannafin, Land, & Oliver, 1999). For example, one multimedia PBL unit for middle-school students, Up, Up & Away! contained a "Hints" section that aligned with the two project requirements—designing a balloon that could circumnavigate the earth and planning a travel route (Brinkerhoff & Glazewski, 2004). Each hint began with a question and guide to help students get started, such as "If I've never designed a balloon before, where do I start?"

Teachers with whom we have worked have employed a variety of techniques in order to constrain the task, including distributing the grading rubric in advance, collaborating with students to create the grading rubric, presenting a series of interim deadlines, and providing graphic organizers. Once students are involved and engaged in the inquiry process, a significant barrier has been addressed. The next consideration involves maintaining students' engagement throughout the problem-solving process.

Maintaining Students' Engagement

In a PBL environment the majority of students' time is spent working on their own or in small groups (Mergendoller & Thomas, 2005). While students typically enjoy group work, group time is not always used productively, and teachers need to enlist strategies to ensure that relevant content is being addressed. Hmelo and Guzdial (1996) suggested that teachers provide opportunities for students to articulate what they are learning in their groups. This can be accomplished 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. Finally, the use of frequent checkpoints and record-keeping devices (e.g., group folders, design diaries, goal charts) 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, and project design and learning goals. Kolodner et al. (2003) suggested that scientific reasoning needs to comprise part of the classroom culture and can be developed through the establishment of project rituals, which students then use to frame their investigative and reflective work. 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!") can keep 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 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 always visible to remind students why they were working on the activities and to ensure that en-route goals aligned with the driving question.

Initiating and maintaining student engagement are clearly two key components in PBL; however, it is possible for learners to immerse themselves in the tasks of PBL (such as due dates, project timelines, and the like) without actually developing a deep understanding of the content. Thus, teachers must incorporate ways of promoting and enhancing concept integration.

Aiding with Concept Integration and Addressing Misconceptions

It is important to remember one of the foundational goals of PBL—to help learners gain a deeper understanding of content through the process of doing. However, progress toward this goal has led to mixed results. While research findings tend to favor PBL over traditional environments when it comes to student outcomes such as motivation (Albanese & Mitchell, 1993; Norman & Schmidt, 1992; Rideout et al., 2002), problem-solving, and self-directed learning (Blumberg, 2000; Gallagher, Stepien, & Rosenthal, 1992; Stepien, Gallagher, & Workman, 1993), the findings tend to favor more traditional environments when it comes to measures of content knowledge (Albanese & Mitchell, 1993; Vernon & Blake, 1993). To date, this appears to be one of the most significant shortcomings of PBL.

One way of facilitating concept integration is to incorporate more systematic ways of helping students make the connection between their inquiry activities and the content. The developers of WISE (Web-based Inquiry Science Environments) employ the term "making thinking visible" in reference to strategies that reveal what and how students are thinking within a specific content domain (Linn, Clark, & Slotta, 2003). For example, as part of the WISE approach, students post online responses at various stages in their inquiry, which are saved for future accessibility by the student or the teacher. Following this, prompts are used to help students connect their ideas to project topics, such as, "How do we use all of this information to solve the problem?" (Linn et al., p. 528). However, it is important to note that these types of scaffolding strategies do not necessarily have to be technological; one middle-school teacher used sticky notes to elicit students' thinking during PBL activities. At the end of each class period, students posted responses and additional questions. The teacher gathered these, organized them, and responded to them the following day. These and similar strategies help reveal what students are thinking.

A second way to aid with concept integration is to directly reinforce the content and learning goals. The LBD group accomplishes this through the use of "rules of thumb," which are student-generated rules used to explain their observations (Kolodner et al., 2003). Rules are posted, tested, and refined throughout the inquiry process, based on students' findings and new observations. The teacher guides the discussion and challenges students to support their theories with evidence, but refrains from correcting assumptions until students have had the opportunity to test their rules. At that time, the teacher might engage in what Schwartz and Bransford (1998) called a "time for telling," which involves directly telling the rule through the use of a lecture or mini-lesson. While lecturing is not a commonly endorsed practice in PBL, at times it reflects the best and most efficient manner to reinforce content.

Finally, once it is clear what and how students are thinking, it is important to elicit and address student misconceptions or biases (Land, 2000). Linn, Shear, Bell, and Slotta (1999) suggested this might be accomplished by asking students to articulate their beliefs about a phenomenon and then highlighting inconsistencies in their thinking. For example, Linn et al. (1999) noted that students naively tended to hold beliefs based on intuition or bias, such as believing that items that "felt" hotter must have a correspondingly higher temperature (e.g., metal vs. plastic); their explanations did not account for properties of conduction on insulation, which could be modified through inquiry experiences.

Although deep content learning is one of the key reasons for employing a PBL approach, it is relatively easy for both teachers and students to lose sight of this goal and to focus, instead, on the interesting activities that need to be completed. The strategies described above can assist both teachers and students in their efforts to connect these engaging activities to the relevant content that is being addressed. Furthermore, reflective activities, which require students to articulate what they are learning, can play an important role in concept integration. Because reflection serves other important roles as well, it is described in a separate section below.

Promoting Reflective Thinking

According to Rowland (1992), "Reflection is critical to understanding experiences and to developing skills. Students must engage in reflective conversations with themselves and with others in order to make sense of experience and deepen their understanding" (p. 38). However, most learners are not automatically reflective and therefore require guidance and support (Land & Zembal-Saul, 2003). That is, learners have a tendency to focus on the task, experiment, or project rather than on conceptual understanding of the key principles (Reiser, 2004). In addition, learners often find it difficult to manage their inquiry activities and do not necessarily devote sufficient attention to reflection. As Krajcik and his colleagues (1998) asserted, "The concern with completing school work makes students hesitant about devoting time to revisiting ideas and improving their work. [This] suggests that class time be allocated for sharing ideas and for revision and that teachers need to work with students so that they appreciate the importance of both" (p. 343).

Researchers have found that the simple act of prompting students to reflect can enhance the transferability of content and problem-solving skills (Davis, 2003). Prompting reflective thinking can take a variety of forms. One successful approach is as simple as facilitating class discussions and capturing students' thoughts on whiteboards. Another strategy incorporates structured diaries or guided prompts (Davis, 2003; Hmelo-Silver, 2004). However, teachers might not want to be too directive with their prompts: Davis found that students actually incorporated more ideas, evidence, and scientific principles in their reflections when "generic" prompts were used (e.g., "Right now, we're thinking . . .") rather than more "directed" prompts (e.g., "To do a good job on this project, we need to . . ."). She speculated that students who received the directed prompts may not have been able to interpret thoroughly what was needed or they may have been superficially completing the task. Nevertheless, whether they take the form of less formal discussions or more formal written activities, the use of prompts appears to enhance students' reflective thinking.

A second approach involves modeling the completion of a task, investigation, or approach. The goals for modeling are primarily twofold: to incorporate the language of the discipline and to prompt students to compare their own processes with those of an expert or another student (Collins, Brown, & Newman, 1989). The practical application of this approach can be live, in a small-group or whole-class context, or videotaped for just-in-time access. For example, Alien Rescue (Pedersen & Liu, 2002-2003), a multimedia-based PBL program, contains a feature that allows students to view video advice from an expert at various stages during the process. The expert verbally describes his problem-solving strategies, such as how he selects relevant information and why he chooses to ignore other information. The authors found that students transferred these expert strategies to different problem-solving domains, and speculated that enhancing students' thinking during PBL helped them participate more effectively in the environment that then enhanced their problem solving in the transfer situation.

Reflection plays a key role in problem-based learning, and the strategies for enhancing reflective thinking are found in some of our most conventional classroom activities—discussions, prompts, and modeling. By scaffolding reflective thinking, students are better prepared to remember content, transfer skills, and use the language of the discipline.

Summary

While scaffolding is an important component in any learning environment, it appears especially important in problem-based environments. Students have been found to perform better, achieve more, and transfer problem-solving strategies more effectively when their inquiry is supported through scaffolding (Land & Zembal-Saul, 2003; Linn et al., 1999; Pedersen & Liu, 2002-2003; Reiser, 2004). Given that students are unlikely, at least at first, to initiate and engage in their own inquiry, understand or integrate new content, or think reflectively, scaffolds appear to increase the potential for successful implementation and completion of the PBL learning process.

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 empowering teachers to address the various challenges that occur during implementation of the PBL process given some of the constraints of K–12 environments. 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 did not. 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.

Furthermore, it is common for teachers to face a number of difficulties when it comes to engaging students and scaffolding their learning. For example, soft scaffolding depends on a highly skilled teacher knowing when and how to support students. Hard scaffolding depends on students' ability to recognize the support as helpful or useful, and not just another task to be completed or as "extra work" (Oliver & Hannafin, 2000; Simons & Klein, in press). In addition, scaffolding introduces a number of tensions that teachers must weigh. One of the biggest tensions reflects the need to constrain students' efforts, but not control them to the point that the environment is no longer open-ended (Reiser, 2004). We want students to take responsibility and conduct independent investigations, and constraining them may prohibit their independence.

Another strong tension relates to the need to simplify components of the problem and content without making them superficial (Brush & Simons, 2004; Reiser, 2004). In other words, within some contexts, scaffolds may render the task more challenging, namely in content domains where students tend be satisfied with shallow solutions (Reiser). Our overall goal is for students to understand the complexity of a given domain, to weigh trade-offs, and to understand principles of cause and effect. At some point, teachers must consider whether they have simplified a domain to the point that it is no longer accurately represented.

Still, it is our hope that by using some of the strategies and scaffolds recommended here, teachers will realize the potential of what PBL could be in the classroom. By supporting teachers' initial and ongoing efforts, we expect to come closer to achieving our ultimate goal: that of effecting broad dissemination of PBL in teachers' classrooms in order to develop both students and teachers who are flexible thinkers and effective problem solvers.

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