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A Brief Analysis of Research on Problem-Based Learning

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To be successful in the workplace of the 21st century, individuals must not only have an extensive store of knowledge, but also must know how to keep that knowledge current, apply it to solve novel problems, and function as a member of a team. This modern view of the workplace has compelled many educators to rethink the ways in which students are prepared (Hmelo & Evensen, 2000). Unlike the traditional, objectivist approach to teaching that focuses on identifying the elements that the learner must know, this new, constructivist approach emphasizes the importance of learning in context. That is, it is no longer enough for learners to acquire concepts in isolation; knowledge which often remains inert. Instead, learners must develop and continually modify their understanding of the world as they interact with other learners to solve realistic problems situated in meaningful tasks (Driscoll, 2005).

For many educators, problem-based learning (PBL) represents a particularly useful example of instruction that is consistent with constructivist learning principles. Problem-based learning is an instructional method in which students learn through facilitated problem solving. In PBL, students learn by focusing on a complex problem that does not have a single correct answer, and they work together in collaborative teams to identify what needs to be learned in order to solve the problem. Furthermore, learners "engage in self-directed learning and then apply their new knowledge to the problem and reflect on what they learned and the effectiveness of the strategies employed" (Hemlo-Silver, 2004, p. 235). In theory, learning in PBL environments not only promotes more effective knowledge construction, but results in better learning transfer over time (Bransford, Brown, & Cocking, 2000).

The purpose of this paper is to provide a brief overview and analysis of current research on PBL environments. To achieve this goal, the paper is organized into two main sections: a brief summary of the goals of PBL, and a review of relevant research on the effectiveness of PBL.

Goals of Problem-Based Learning

Problem-based learning was originally developed as a practical solution to faculty dissatisfaction with traditional medical education at McMaster University in the late 1960s (Barrows, 2000). Since its inception, PBL methods have been employed in numerous medical curricula and extended to other professional educational settings. More recently, PBL methods have been employed in K-12 schools to help teach mathematics to young children by situating instruction in “engaging, problem-rich environments that allow sustained exploration by students and teachers” (Cognition and Technology Group at Vanderbilt, 1992, p. 65).

Generally speaking, PBL environments are designed with five foundational goals in mind (Hmelo-Silver, 2004). These learner-centered goals are designed to help students (a) construct extensive, flexible knowledge that transfers to other academic and non-academic settings; (b) develop effective problem-solving skills; (c) develop self-directed, lifelong learning skills; (d) become effective collaborative learners; and (e) become intrinsically motivated to learn.

Empirical Evidence Supporting the Goals of PBL

Much of the empirical evidence supporting the effectiveness of PBL comes from research conducted in medical schools and gifted education. As such, the extent to which this evidence generalizes to other populations and applications has been questioned by some (Hmelo-Silver, 2004). The following section addresses the five goals noted above and provides a brief review of the empirical evidence supporting these purported goals.

Constructing Extensive, Flexible Knowledge

Constructing extensive, flexible knowledge (also known as cognitive flexibility) involves the integration of information across multiple domains. Instead of learning decontextualized facts, students learn information while solving ill-structured problems which possess multiple solutions (Jonassen, 1997). Additionally, the knowledge learned while solving these problems is organized around fundamental principles that often span multiple domains.

According to theory, students who learn by solving complex problems develop extensive, flexible knowledge that is more easily retrieved and applied under varying conditions (i.e., learning transfers to other situations). Research evidence to support this assertion is reasonably consistent. Results from a meta-analysis by Albenese and Mitchell (1993) found that while PBL students scored slightly lower than traditional medical students on multiple-choice tests, they performed slightly better on tasks related to clinical performance and problem solving.

The benefits of PBL on the development of cognitive flexibility have also been confirmed in studies of K-12 students. Researchers in the Cognition and Technology Group at Vanderbilt (CTGV) developed a PBL video series called the Adventures of Jasper Woodbury. Designed to teach math to students in grades five and up, the Jasper series has been researched thoroughly since its inception in the 1980s. In a 1990 study involving 16 schools, the CTGV found that "Jasper students performed as well as or better on standardized tests, even though the Jasper classes had spent three or four weeks less on the regular math curriculum. Jasper students also demonstrated superior performance on one-, two-, and multi-step word problems. Finally, Jasper students scored much higher on planning and sub-goal comprehension problems than their control counterparts" (CTGV, n.d., Data from research, para. 2).

Developing Effective Problem-Solving Skills

Along with learning the specific content required to solve a problem, students engaged in PBL activities purportedly develop general problem-solving skills that are transferable across several domains. These skills include reasoning and decision-making strategies that help students better define the problem and organize their approach to problem solution.

The research supporting the contention that PBL students develop general problem-solving skills, while limited, is fairly consistent. One measure of effective problem-solving skills is the capacity to transfer reasoning strategies to unique problems (Hmelo-Silver, 2004). Patel, Groen, and Norman (1993) found that PBL students were more likely to use hypothesis-driven reasoning when asked to solve novel problems and, as such, developed more coherent solutions than traditional students. Additionally, when faced with new problems to be solved, PBL-trained students tended to be better at defining the problem, a strategy that is particularly important when solving ill-structured problems (Jonassen, 1997).

Developing Self-Directed Learning Skills

Self-directed learners are individuals who implement appropriate self-regulatory strategies when they become aware that certain skills are missing from their learning repertoires (Ertmer & Newby, 1996). These strategies include an awareness of the knowledge and skills they do and do not possess; an ability to set goals and identify what they need to learn in order to solve the problem at hand; and a capacity for monitoring and evaluating implemented plans to determine if goals are being attained (Hmelo-Silver, 2004).

A number of researchers have investigated the extent to which learners in PBL environments develop self-directed learning (SDL) skills. Dolmans and Schmidt (2000) examined what curricular elements might direct SDL. They found that students in PBL curricula reported that problem discussion and course objectives had the greatest positive impact on SDL, while tests and lectures had the least positive influence. In another study comparing behaviors of PBL students to traditional students, Blumberg and Michael (as cited in Hmelo-Silver, 2004) found that “PBL students were more likely to use self-chosen learning resources whereas students in the conventional curriculum used faculty-chosen resources” (p. 256). Finally, Ertmer and Newby (1996) found that students’ approaches to PBL differ qualitatively based on their degree of self-regulation. Specifically, students who were low self-regulated learners (SRL) had a difficult time adjusting to the SDL demands of a PBL curriculum, whereas students who were high SRL tended to more easily direct their own learning. High SRL also valued problem analysis and reflection more so than their low self-regulated counterparts. These results suggest that PBL is not a “one size fits all” proposition when it comes to encouraging SDL. Instead, it appears that low SRL may require more scaffolding in order to develop SDL skills.

Becoming Effective Collaborative Learners

The fourth goal of PBL, becoming an effective collaborator, means working together as a member of a team. In theory, working within a team not only forces students to learn practical skills like conflict resolution, but also improves comprehension. For a team of collaborators, knowledge becomes something that the group constructs together through social negotiation and consensus (Kelson & Distlehort, 2000).

While considerable research has addressed the first three goals of PBL, the empirical evidence supporting the hypothesis that PBL helps students become better collaborators is nominal (Hemlo-Silver, 2004). What has been well established, though, is the idea that students in PBL curriculum work together and provide collaborative solutions (Hmelo-Silver, 2004). At the same time, however, other researchers have found that students do not necessarily participate equally in PBL group discourse, a fact that may lessen the potential benefits inherent to group learning and social negotiation (Duek, 2000). Ultimately, many PBL investigators agree that more research is needed to determine whether these methods do in fact help all learners become better collaborators (Hmelo-Silver, 2004; Norman & Schmidt, 1992).

Becoming Intrinsically Motivated

The final goal of PBL is to help students become intrinsically motivated to learn. “Intrinsic motivation occurs when learners work on a task motivated by their own interests, challenges, or sense of satisfaction” (Hmelo-Silver, 2004, p. 241). Developing an engaging problem is critical to fostering intrinsic motivation and may represent the most difficult aspect of PBL design. When planned effectively, however, high-quality problems support increased student motivation by engaging learners in personally meaningful tasks and providing them with challenging yet tangible goals (Jonassen, 1997).

Problem-based instructional methods assume that encouraging intrinsic motivation can be achieved within the context of the PBL environment. The question remains – are students in fact more intrinsically motivated to learn when engaged in PBL? At this point, the answer to this question is not consistent across multiple academic domains. The results for medical students are, however, reasonably stable – they enjoy PBL and show more intrinsic motivation for learning than their traditional curriculum counterparts (Albanese & Mitchell, 1993; Hmelo & Evensen, 2000). It should be noted, however, that, in general, medical students are highly motivated individuals to begin with and their PBL curricula are fairly well established. The same cannot be said of PBL applications within K-12 schools. In these cases, PBL is usually a single instructional intervention inserted among an entire traditional curriculum. As a result, many students often resist change, do not feel comfortable working in groups, and generally are not as accepting of PBL methods (Hmelo-Silver, 2004). With these limitations in mind, determining PBL's influence on student motivation outside of medical school curricula has been difficult.

Conclusions

As a teaching method, PBL is consistent with many of the principles arising from constructivism. In fact, for many, PBL represents the clearest application of constructivist theory in practice (Jonassen, 1997; Savery & Duffy, 1995). In accordance with the tenants of constructivism, PBL students become active constructors of flexible knowledge; knowledge that is learned in meaningful contexts that are similar to those in which learners will apply that knowledge later. And while the evidence is less extensive, it appears that PBL also facilitates the development of collaborative learning skills and provides for intrinsic learner motivation.

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