Literature Review on Project-Based Learning

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Effective learning is linked to opportunities to "explore, inquire, solve problems, and think critically" (Asghar, Ellington, Rice, Johnson & Prime, 2012). As such, there have been concentrated reform initiatives across many content areas that have integrated authentic and student-driven instructional approaches. Although these initiatives have different names, such as inquiry learning, problem-based learning, and project-based learning, they share the common goal of engaging students through exploring real-world issues and solving practical problems. Specifically, much of the research examining project-based learning (PBL) has focused on student and teacher outcomes in the secondary or postsecondary context, especially in the areas of STEM and technology.

Definition and Influences of PBL

Thomas (2000) draws on two studies (see Jones, Rasmussen & Moffitt, 1997; Thomas, Mergendoller & Michaelson, 1999) to define PBL as:

> Complex tasks, based on challenging questions or problems, that involve students in design, problem-solving, decision making, or investigative activities; give students the opportunity to work relatively autonomously over extended periods of time; and culminate in realistic products or presentations. (p. 1)

In PBL, projects requiring students to apply the knowledge and skills they learn are the focus of the curriculum rather than being added as a supplement at the end of traditional instruction. The entire PBL process is organized around an open-ended driving question that teachers use to connect content to current and relevant issues or problems. Through this process, students develop their own questions to drive learning, study concepts and information that answer those questions, and apply that knowledge to products they develop. In addition, PBL encourages more rigorous learning because it requires students to take an active role in understanding concepts and content, and it enables them to develop 21st-century skills, which foster an enduring curiosity and hunger for knowledge. Since students are able to apply classroom content to real-life phenomena, PBL also facilitates career exploration, technology use, student engagement, community connections, and content relevancy (Blumenfeld, Soloway, Marx, Krajcik, Guzdial, & Palincsar, 1991; The Buck Institute for Education, 2012).

Thomas (2000) cites three "traditions" that have influenced what K-12 educators commonly refer to as PBL. First, PBL educators have drawn from expeditionary learning (EL) in that both approaches have an emphasis on collaboration, "reflection," and "building a connection to the world outside the classroom" (p. 5). However, EL also includes "fieldwork" and "character building," both elements that have not been adopted by most PBL educators. Second, PBL educators have been influenced by problem-based learning, which developed from medical school teaching practices and designs. Solving real-life medical problems was deemed important in developing a medical student's "hypothetico-deductive thinking skills" (p. 5). Thomas notes that during the past 25 years, problem-based learning was applied in K-12 STEM classrooms (see Stepien & Gallagher, 1993). However, problem-based learning activities have often been "prepackaged" by organizations outside of K-12 education, and have failed to engage teachers in the curriculum development process (Thomas, p. 37). Thus, unlike PBL, problem-based learning has not been student-driven at the K-12 level.

The third tradition influencing PBL, according to Thomas (2000), is cognition research, which can be divided into four strands of research on motivation, expertise, contextual factors, and technology. Studies on motivation have found that students who are motivated by content learning and understanding are more likely to stay focused on school-related tasks than students motivated by task completion alone (Ames, 1992). Reward systems that are organized around engagement in a task and cooperative learning also encourage learning. Thomas notes that PBL increases content mastery because it is organized around collaboration, authenticity, and student-driven inquiry. In addition, teachings utilizing PBL have designed and implemented challenging, authentic, and student-centered projects to increase student engagement (Blumenfeld, et al., 1991). Research on experts and novices showed that for young problem solvers to succeed and form the habits of experts, they must be placed in environments where they can investigate content in ways similar to that of experts in the field. The next strand of contextual factors has shown that students learn better through "situated cognition," or when their context for learning is similar to real life situations (Brown, Collins & Duguid, 1989). Additionally, if students are able to apply what they learned in a problem-solving format, they retain that knowledge better. Finally, Thomas discusses how the technology strand has focused on using technology as a "cognitive tool" in making students aware of the knowledge formation processes. Technology also increases authenticity because students can use specific software employed by professionals in the field, collaborate with those outside the classroom, and access information and data.

PBL and Student Outcomes

Multiple studies have reported that students in PBL-taught classrooms demonstrate improved critical-thinking and problem-solving skills (Shepherd, 1998; Tretten & Zachariou, 1995). Researchers have also found that PBL is a successful way of teaching 21st-century skills, and that it increases student engagement and content learning. Further, students show more initiative by utilizing resources and revising work, behaviors that were uncharacteristic of them before they were immersed in the PBL-instructed classes (Barron, Schwartz, Vye, Moore, Petrosino, Zech, Bransford & The Cognition and Technology Group at Vanderbilt, 1998).

Studies have revealed that PBL has a positive effect on the development of higher-order thinking skills in specific groups of students. In particular, students with average to low verbal ability and students with little previous content knowledge learned more in PBL-taught classes than in traditionally-taught classes (Mergendoller, Maxwell & Bellisimo, 2006). Another study demonstrated that PBL positively impacts low-ability students, who increased their use of such critical-thinking skills as synthesizing, evaluating, predicting, and reflecting by 446% as a result of being immersed in PBL-taught classrooms (Horan, Lavaroni & Beldon, 1996). High-ability students increased their use of those skills as well by 76% (Horan, et al.).

Further, PBL has been shown to foster collaboration skills in a variety of students. After working in groups in PBL-taught classes, elementary students learned to understand things from multiple perspectives, as well as conflict resolution skills (ChanLin, 2008); special education students developed social skills such as patience and empathy (Belland, Ertmer & Simons, 2006); and low-ability students demonstrated initiative, management, teamwork, and conscientiousness (Horan, et al., 1996). Students also reported higher enjoyment of their PBL work because it gave them opportunities to interact with their friends and to make new friends through cooperative projects (Belland, et al.; Lightner, Bober & Willi, 2007). Krishnan, Gabb and Vale (2011) found that collaboration skills learned through PBL were essential to positive learning outcomes in their study of first-year engineering students. Groups who adopted a collaborative learning culture emphasized gaining as much knowledge as possible in the team setting. Researchers observed that this group exhibited excellent communication, high levels of participation and mutual respect, and that most students in these teams "used deep learning approaches…[and] focused on finding more than one solution to each program" (Krishnan et al., 2011, 74). Therefore, the researchers considered these groups the most successful in encouraging education for all members, compared to other types of group cultures that were focused on finishing the project or maximizing their grade.

Group- and self-efficacy in PBL were found to depend largely on the quality of the group process (Weng-yi Cheng, Shui-fong & Chung-yan, 2008). For instance, high school students reported that they struggled to work positively in small groups (Achilles & Hoover, 1996). Similarly, in a text analysis of 34 biomedical students' reflections from a problem-based learning module, Sockalingam and Schmidt (2011) found that students believed that "good" problems did not promote teamwork. However, college freshmen who participated in an online collaborative project for six weeks reported gaining a substantial amount of knowledge as a result of collaborating and practicing higher-order thinking skills, such as problem solving, researching independently, and asking for help (Zhang, Peng & Hung, 2009).

Researchers have found high levels of student engagement in PBL classrooms (Belland, et al., 2006; Brush & Saye, 2008) because it places students in a real-world, problem-solving context (Blumenfeld, et al., 1991). A study of one economics class revealed that a PBL unit was successful in engaging both the lowest- and highest-performing students, as well as students who were least interested in economics at the start of the unit (Ravitz & Mergendoller, 2005). Another study reported that PBL had a positive effect on student motivation to learn. According to elementary teachers who reported using 37% of their overall instruction time on PBL, students' work ethic improved as well as their confidence and attitudes towards learning (Tretten & Zachariou, 1995). Similarly, when secondary students from high-need schools participated in an applied shipbuilding project, they were more enthusiastic about marine engineering and physical science (Verma, Dickerson, & McKinney, 2011)

Post-secondary educators have also reported that they believe PBL improves student engagement (Verma, Dickerson & McKinney, 2011). In a postsecondary context, Ocak and Uluyol (2010) found that features of PBL were related to students' intrinsic motivation to learn, which were defined as interest, academic efficacy and cognitive engagement. Researchers uncovered positive, statistically significant relationships between PBL and interest and between PBL and cognitive engagement, but not between PBL and academic efficacy. Therefore, researchers concluded that students enjoyed the course and learned the content as a result of PBL, but that it did not affect their academic efficacy. However, Schaffer, Chen, Zhu, and Oakes (2012) found that PBL did increase college students' level of perceived self-efficacy. The researchers explored how various components of cross-disciplinary team learning influenced changes in college students' perceptions of their efficacy. They concluded that PBL increased self-efficacy for most participants although some students did exhibit self-efficacy changes that "suggest a decrease in confidence and learning" (Schaffer et al., 2012, 91).

PBL has several positive effects on student content knowledge. Students immersed in PBL-taught classrooms emerge with more useful, real-world content knowledge that can be applied to a variety of tasks (Boaler, 1997). An experimental study of 76 teachers who utilized PBL in their classrooms revealed that, compared to the control group of students in traditional classes, their students scored higher on standardized exams, as well as ability tests that measured problem-solving skills and content application to real-world problems (Finkelstein, Hanson, Huang, Hirschman & Huang, 2010). In addition, one study found that students were able to demonstrate specific content area skills after taking part in a PBL unit (Mioduser, et al., 2003). For example, among students utilizing measurement skills to develop blueprints for a geometry project involving architecture and design, 84% developed projects that met architectural building standards (Barron, et al., 1998). Strobel and van Barneveld (2009) conducted a qualitative meta-synthesis of meta-analyses to identify generalizeable findings regarding the effectiveness of PBL in teaching content knowledge. They concluded that traditional instruction produces better outcomes when assessing basic knowledge, but that PBL produces better results when assessing clinical knowledge and skills: "PBL is significantly more effective than traditional instruction to train competent and skilled practitioners and to promote long-term retention of knowledge and skills" (Strobel & van Barneveld, p. 55).

Implementing PBL Instruction

Many teachers perceive PBL as beneficial to their students, thus motivating them to adopt the instructional approach in their classrooms. A national survey of public school teachers revealed that they were most likely to use PBL in their classrooms because they believe it teaches abilities beyond academic content, including such 21st-century skills as collaboration and presentation techniques (Ravitz, 2008). In addition, after interviewing and observing 10 sixth-grade science teachers implementing technology-supplemented PBL, Liu, Wivagg, Geurtz, Lee, and Chang (2012) found that teachers use PBL if they believe that it addresses content standards, aligns with their philosophy of teaching, provides an innovative form of instruction that fosters 21st-century skills, challenges students in an engaging way that meets diverse learning needs, and is supported by building administrators.

Nonetheless, teachers find PBL challenging to implement. Ertmer and Simons (2006) noted three distinct areas of implementation difficulty for teachers: 1) creating a culture of collaboration and teamwork in the classroom, 2) adjusting from a directive to a facilitative role, and 3) scaffolding student learning. Marx, Blumenfeld, Krajcik, and Soloway (1997) also reported barriers to implementation including that project planning is time-consuming, classrooms sometimes feel disorderly, and authentic assessments are difficult to design. Additionally, teachers want to control the flow of information, and find it difficult to balance the need for student independence with providing students support. Finally, teachers struggle to incorporate technology as a cognitive tool (Marx, et al., 1997). These authors found that teachers generally focus on addressing one or two of these barriers at a time and moved back and forth between old habits and new ideas, incorporating the new information gradually and with varied success (Marx, Blumenfeld, Krajcik, Blunk, Crawford, Kelley, & Meyer, 1994; Marx, et al., 1997). Some teachers also struggle to transform their entrenched beliefs. These struggles include letting go of the drive to cover content standards in favor of allowing students to explore their interests, and accepting multiple answers and outcomes rather than providing students with one correct answer (Ladewski, Krajcik, & Harvey, 1991).

Liu, Wivagg, Geurtz, Lee, and Chang (2012) suggest multiple strategies to effectively implement PBL. They recommend that teachers should choose a PBL program that explicitly meets their curricular needs, be proactive with technology access and availability, consider diverse scaffolding techniques, accept that students will need to adjust to the unfamiliar nature of PBL, and realize that implementation takes time. Additionally, school leadership must support PBL implementation through development of a shared vision, coordination of professional development activities, critical evaluation of grading and assessment, and promotion of a "learning-by-doing" approach to pedagogy. The authors concluded that for PBL to be successful, teachers, administrators, instructional materials, and technology must all be aligned. Ertmer and Simons (2006) also suggest that educators must spark student-driven inquiry, maintain engagement, help students understand content, and address misconceptions while encouraging reflection.

PBL and STEM Learning

Some of the research examining PBL has focused on student outcomes in project- or problem-based learning in specific STEM environments. Specifically, high school-level research has examined marine engineering and physical science (Verma, et al., 2011), as well as content knowledge and interest in STEM subjects (Lou, Shih, Diez, & Tseng, 2011). Overall, this body of research has found that students traditionally underrepresented in STEM, such as females and those of minority race/ethnicity status, reported higher levels of engagement and interest in STEM subjects after participating in PBL-instructed classes (Lou et al.; Verma et al.). Other studies have focused on PBL in middle school science classrooms (see Eskrootchi & Oskrochi, 2010; Krajcik, Blumenfeld, Marx, Bass, Fredricks, & Soloway, 1998). Eskrootchi and Oskrochi, (2010) also found that females and those who might not learn effectively in a traditional format can succeed from new technological innovations combined with PBL in STEM areas such as computer technology. Finally, a study of fifth grade science found that PBL was "appropriately efficient and effective" in science learning achievement, science process skills, and analytical thinking for all students (Panasan & Nuangchalerm, 2010, p. 252).

PBL and Technology

There is also a relationship between PBL instruction, technology use, and learning. Eskrootchi and Oskrochi (2010) conducted a quasi-experimental study of PBL instruction in a technology-rich environment to determine their combined impact on students. Eighth-grade students were divided into three groups: a control group, which received traditional, lecture-based instruction; an experimental group that performed a simulation model using only technology (PBS); and an experimental group that learned through PBL while also using technology (PBES). Students were tested on both their conceptual and content knowledge.

Students in the PBES group outperformed the other two groups in subject comprehension, but not content knowledge. Further, the project had a statistically significantly stronger effect on females so that they had higher mean scores in the PBES group than females in the control group. This demonstrates that effectively implementing technology with PBL increases student achievement compared to students using technology alone. The researchers believe this is due to increased student collaboration, authenticity, and the establishment of spaces for more equitable contribution present in PBL-instructed classrooms. They conclude that "students learn best by actively constructing knowledge from a combination of experience, interpretation and structured interactions with peers when using simulation in a PBL setting" (p. 243). Hernandez-Ramos and De La Paz (2009) also examined technology and PBL in the middle school setting, comparing the outcomes of students who participated in a technology-assisted PBL experience to those who received more traditional instruction during a six-week history unit. From an analysis of teacher-created assessments, the researchers determined that students in the PBL-taught class, who learned the material by working in groups, creating multimedia projects, and listening to other groups' projects, learned more than students who received traditional instruction. The researchers also found that students from the PBL classroom performed better on state-administered assessments.

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