Problem-Based Learning in Teacher Education: Trajectories of Change

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Abstract

Teaching is a complex enterprise that requires solving intricate problems and issues in numerous facets of learning and teaching. Problem-based learning (PBL) provides generative contexts for prospective and certified teachers to work together in smallcollaborative groups. Together, they analyze problems, discuss options, and make informed decisions to solve problems based on authentic teaching situations with real, multifaceted challenges. Given the increasing number of classroom implementations of PBL studies, it is timely to extend this body of work to include research that is aimed at teacher education. New and experienced teachers are facing educational reform that requires themto meet the demands of an arduous profession. The discussion in this paper shows that PBL can be instrumental in equipping teachers to meet these demands. Frameworks for implementing PBL that move away from the traditional medical models and better respond to the demands of teacher education are discussed.

Keywords: educational psychology,problem-based learning, teacher education, approaches to implementation

1. Introduction & Aims

Current educational reform movements call for preparing prospective teachers and certified teachers to address the diverse and complex problems that arise in the classroom and in pedagogy (Putnam & Borko, 2000; Zeichner & Conklin, 2005). Problem solving requires that all teachers understand several components: (a) content knowledge of the domain (knowledge of facts, ideas, principles); (b) pedagogical knowledge of the curriculum, (knowledge of learner differences, assessment, and classroom management); and (c) conditional knowledge, knowing when particular knowledge must be retrieved and whenpedagogical tools can be applied; and (d) reflective knowledge(reflecting- in-action and reflecting-on-action) (Hmelo-Silver, 2004; Peterson & Treagust, 1998; Savery, 2006;Schön, 1991).

Teachers are confronted with many complex problems that require collaboration with their colleagues as they frame the issues, consider multiple perspectives, discuss solutions, contemplate consequences, and reflect on decisions (Harrington, 1995; Hmelo-Silver, 2000; Hmelo-Silver & Barrows, 2006; Leinhardt & Steele, 2005; Mayer &Wittrock, 2006). Besides being masters of their content, teacher candidates and teachers are expected to use pedagogical strategies for teaching and learning. They are also expected to work in collaborative contexts with other teachers, students, and parents. Moreover, they are expected to be self-directed learners throughout their professions (Bransford, Darling-Hammond, & LePage, 2005).Furthermore, they are faced with the stresses of standardized testing, the aims of which can often be inconsistent with the goals of the new reform. Current educational reformemphasizes learning as a process reflected in genuine real-life experiences and constructed between the teacher and students and between students with students.

Undoubtedly, teachers have been handed a tall order. However, PBL is a comprehensive pedagogical framework that can support teachers in adapting to this educational reform. The aim ofthis paper is to examine problem-based learning in the context of teacher education. The first partwill define and examine the critical features of PBL and how they relate to teacher education's present mandate. However, becausePBL is comprehensive and requires that all aspects of its pedagogy change based on goals, strategies, curriculum, and assessment, the present discussion also needs to highlight the challenges PBLposes to teaching.

These will be presented in the second part.The last section of this discussion describes ways of implementing PBL so that teachers can be supported to meet the demands of the 21st century, and how these approaches allow researchers to investigate questions that serve both practice and scholarship.

2. Historical Highlights of Problem-Based Learning

Problem-based learning has its origins in medicine at McMaster University, where Barrows pioneered this approach (Barrows & Tamblyn, 1980; Gijbels, Dochy, Van den Bossche, &Segers, 2005). After Barrows'success, PBL has been extensively applied to other fields, such as law, nursing, and business (Walker & Leary, 2009). Since the 1980s, individual teachers most commonly conducted PBL implementations in teacher education. Since then, PBL has become more widespread (Derry, Hmelo-Silver, Nagaran, Chernobilsky, & Beitzel, 2006; Hmelo-Silver, 2000; McPhee, 2002).

Researchers at Rutgers University and theUniversity of Wisconsinhave implemented PBL in their teacher education programs (Derry et al., 2006; Hmelo-Silver et al., 2009). Furthermore, PBL has found applications in teacher professional development (Zhang, Lundeberg, McConnell, Koehler & Eberhardt, 2010).There are smaller, more individual applications of PBL that have been pioneered by the author at her institution. Other applications led by Karen Goodnough (2005) at Memorial University of Newfoundland work with a small group of in-service teachers to implement PBL in the science curriculum. At the University of British Columbia, integrated PBL cohort pre-service teachers study teaching and learning using PBL.

3. Problem-Based Learning Defined

PBL is a learner-centered pedagogical approach that affords learners (including prospective and certified teachers) opportunities to engage in goal-directed inquiry. Learners work collaboratively with others as they analyze complex and ill-defined problems (Barrows, 2000; Hmelo-Silver, 2004). Learners also work independently to collect information they then bring back to the group as they resume their collectiveproblemsolving and subsequent reflection on both the issue at hand and the group's functioning. The teacher's role changes from one of primarily "telling" information to one that facilitates thinking, reflecting, and collaborative inquiry, while content decisions are left up to the students.

Thus, PBL'sgoals consist of conceptual and pedagogical content knowledge construction, collaboration, and self-directed, lifelong learning. These goals are brought to fruition throughlearners' engagement in the PBL tutorial process and three of the process's features: the problem-cases, learning issues, and the facilitator.

4. PBL Experience: Tutorial Process & Features

Problem-based learning has a tutorial process that consists of three features: problem-based cases, learning issues, and a problem-based facilitator.

4.1 Problem-Based Cases

The problem cases in PBL must be authentic and multifaceted problems that are open-ended and have multiple solution paths (Bereiter & Scardamalia, 2006; Hmelo-Silver, 2004; Jonassen & Hung, 2008). Although cases must be complex, they must resonate with learners' prior knowledge; otherwise, the problems in the cases may fail to engage learners and their learning processes. PBL cases can either be in paper-based or in multimedia form, the latter being more interactive and motivating (Derry et al., 2006; Hmelo-Silver, 2004). Both types of cases must represent real-life classroom decisions that provide opportunities toconsider multiple perspectives, warranting solutions, assessing consequences, and reflecting on decisions (Brown, Collins, & Duguid, 1989).

For teachers to develop sound and flexible knowledge, PBL cases must be presented in multiple contexts so they can be revisited from multiple perspectives and for multiple purposes. According to researchers (Spiro, Feltovich, Jacobson, &Coulsen, 1992), providing cases from multiple contexts across the curriculum helps teachers form connections between ideas and seepatterns across problems so they can apply ideas to different contexts.Thus, PBL can help teachers make essential cross-curricular links, satisfying one of the major mandates of the new reformin North American education. For teachers, failure to see patterns and to establish an interrelated body of knowledge results in a fragmented view of the classroom and its manyintricacies. Consequently, problems in the classroom such as managing the classroom, assessing learning, meeting individual differences, and building parent-teacher relationships become insurmountable especially for new teachers.(Shulman, 1987; Spiro, Vispoel, Schmitz, Samarapungavan, & Boerger, 1987; Zeichner, 2005).

4. 2 Learning Issues

Prior to conducting their independent research, teacher candidates discuss the problem cases to"pull out" learning issues, which are the concepts they feel they need to learn more about in order to understand the problems and potential solutions (Hmelo-Silver, 2004). Theydivide the learning issues among themselves, independently research the issues, and then bring their findings to the table; reflecting upon and revising previously proposed hypotheses, perspectives, and information. Thelearning issues aspect of PBL reminds us that instead of solving cases procedurally, PBL requires that learners engage in conceptual analysis (Bereiter & Scardamalia, 2006). In turn, this analysis helps PBL learners to (a) frame and clarify the problem, which is an essential aspect of pedagogical problem solving; and to (b) locate relevant and credible information that is then brought back to the. Teaching requires practical knowledge and the ability to build knowledge, making it an integration of practice, scholarship, and technique (Torpe and Sage, 2002).

4.3 Problem-Based Facilitator

Good PBL problems are essential for learning; however, the type of learning derived from these problems is a function of PBL facilitators. In the traditional PBL model, facilitators are course instructors whose focus is not on the content, but on the PBL process. They serve as expert learners, modeling good learning and thinking strategies. Alternatively, PBL facilitators can be more skilledstudents. More specifically, the PBL facilitator guides the development of higher-order thinking skills through the use of open-ended and complex questions. The facilitator encourages all group members to justify their thinking andguides them to discuss each other's ideas (Hmelo-Silver & Barrows, 2006; Hmelo-Silver, Chernobilsky, & Jordan, 2008; Koschmann et al., 1994). Facilitators provide less support as students assume more responsibility for their collaborative learning (Collins, 2006; Hmelo-Silver & Barrows, 2006).

However, other models of PBL, such as those adapted by Hmelo-Silver (2000; 2004),contend that providing learners with the needed content support is in keeping with the new reform. Such supports are essential to enhancing student success while minimizing anxiety and providing learners with a positive learning experience. For example, when learners come to a crossroads regarding content, the facilitator may haltthe PBL processes to conduct a mini-lesson on concepts that are vague to the class and will support ensuing discussion. Alternatively, the PBL model may build in benchmark lessons that review key ideas. For example, in Hmelo-Silver's Educational Psychology course for students expecting to enter the teacher education program, received 6 lectures out of 30 classes in a semester on the topics of instructional planning, the constructive nature of knowledge, and the social nature of learning and cognitive transfer.

5. The Goals of PBL and Their Representation in Teacher Education

A well-selected case and a facilitator are vital to PBL. According to the literature, the PBL facilitator's goals is to foster four outcomes in learners: (a) conceptual knowledge and problemsolving, (b) collaboration, (c) self-directed and lifelong learning, and (d) intrinsic motivation (Hmelo-Silver &Author, 2013). These learning goals are at the crux of new educational reform and, therefore, an essential part of teacher training and development. In the next section, these goals and their relationship to teacher education are discussed.

5.1 Conceptual and Pedagogical Problem Solving Goals

The first goal of PBL is for teachers to understand the content in questionandhow it relates to their discipline. Effective teachers know how to use knowledge of pedagogy, curriculum, and learning in a relatable and flexible manner to address the complexities they encounter in the classroom (Bransford et al., 2005; Harrington, 1995).

According to Spiro et al. (1987; 1992), flexible knowledge involves integrating information across multiple domains, drawing upon relevant prior knowledge, and organizing around the central ideas of a subject area. As such, knowledge can be flexibly retrieved, applied, and extended as learners engage in effective problem solving. Researchers such as Murray-Harvey, Curtis, Cattley, andSlee(2005) and vanEsandSherin(2002)have demonstrated that teachers with well-developed, flexible knowledge about content, learning strategies, curriculum, and teaching were more effective at resolving pedagogical challenges than those teachers who did not possess these knowledge basis and skills.

Teachers are constantly asked to engage in problem solving as they deal with classroom practice, make instructional decisions for the class as a whole, and address the needs of individual students. This makes the goal of pedagogical problem solving particularly germane in teacher education. Research demonstrates that, in comparison to a control group of pre-service teachers in a standard curriculum, pre-service teachers in aPBL group were significantly better able to work through diagnosis-solution pedagogical problems (Author, 2008; 2009). These studies showed that pre-service teachers in the PBL group were able to (a) provide feasible solutions while being sensitive to the needs of learners and teachers described in the case; to (b) evaluate the solutions, weighing pros and cons with respect to both short-term and long-term conditions; and to (c) use educational concepts as support for their analyses of the pedagogical situation.

The transfer of problemsolving skills and concepts is a pivotal area of learning; without it, knowledge is inert. A three-year study by Derry, Hmelo-Silver, Nagarajan, Chernobilsky, and Beitzel (2006) and Hmelo-Silver, Derry, Bitterman, and Hatrak (2009) compared a hybrid, online version of PBL with a face-to-face educational psychology course. The hybrid PBL consisted of multimedia cases, an electronic notebook, and an online whiteboard to highlight important issues and to serve as a springboard for discussion. The educational psychology course consisted of lectures and face-to-face interactions. Repeatedly, the results demonstrated that learners using the hybrid PBL approach were better able to transfer their learning sciences concepts, to analyze a novel video case, and to use such information to generate recommendations for improvements to instructional methods than those learners who were taught using the traditional approach (Hmelo-Silver et al., 2009).

5.2 Collaboration Goals

The second goal of PBL is collaborative learning. In PBL, collaborative learning is a learner-centeredprocess withthe objectiveof PBL members engaging in thoughtful analysis and synthesis of the issue at hand. PBL is a way for teachers to think about individual learner issues as well as broader systematic issues, such as assessment and evaluation. This is different from cooperative learning approaches, which are much more teacher-directed with respect to what the learning issues are and the procedures for resolving them. Moreover, in cooperative learning, the group members' goal is to achieve a shared understanding of the task and content by holding each other accountable and ensuring that all members of the group have mastered the content (Johnson & Johnson, 1994). Some cooperative learning techniques, such as Student Teams Achievement Division (STAD) and Teams-Game-Tournament (TGT), have reward structures to motivate learners to reach their goals (Slavin, 2009).

The new reform in education placesemphasis on the importance of collaboration in training prospective teachers.The new generation of teachers is expected to work in teams, to engage in collaborative teaching of intricate learning and teaching issues, and to manage an increasingly diverse student population (O'Donnell, 2006). Collaborative inquiry supportsteacher development by helping teachersbecome acculturated into their profession. As prospective teachers come together with new and expert teachers, they have opportunities for dialogue that equips them to understand the language and knowledge of the profession.Moreover, theyare trained to communicate and to use knowledge flexibly to solve problems that arise in the profession(Lave & Wenger, 1998). Chernobilsky, DaCosta, and Hmelo-Silver (2004) found that pre-service teachers who worked through problems in PBL groups increased their professional vocabulary and became more careful about their explanations using discipline appropriate terms and limiting their explanations to the information and resources they had available as their semesters progressed. In PBL, group members verbalize what they already know and what they still need to learn, which aids them in the development and flexible application of knowledge when solving problems. In turn, this fuels collaboration in communities of practice, creating a forum for teachers to fruitfully addressproblems and engage in dialogue (Lave & Wenger, 1991; Askell-Williams, Murray-Harvey, & Lawson, 2007).

Collaboration is a multifarious skill that must be learned. In fact, Ertmer and Simons (2006) and Schmidt, Loyens, van Gog, and Pass (2007) contendthat collaborative inquiry does not occur spontaneously. Rather, in the domain of PBL, it needs to be facilitated by PBL mentors who are proficient in thecontent and in communication skills. This facilitation can take the form of having groups work on smaller PBL tasks so that emerging problems with collaborative engagement can be more easily managed. Additionally, Zhang, Lundenberg, McConnell, Koehler, and Eberhardt (2010) found that asking questions assists teachers in the development of collaborative inquiry. Gressick and Derry's (2010) research shows that asking questions that require clarification, elaboration, and application lead to a better understanding of the teachers' knowledge domain.

Being sensitive to group dynamics and helping groups resolve interpersonal issues are both essential in the promotion of collaborative inquiry in PBL (Schmidt & Moust, 2000). Facilitators can give timely and relevant feedback to individuals and groups to scaffold collaboration (Connolly, 2009).

5.3 Self-Regulated Learning, Self-Directed Learning, and Lifelong Learning

The third goal of PBL is to foster lifelong learning skills. In current educational reform, teachers are mandated to be lifelong learners; thus, becoming a teacher is based on a continuum of learning experiences throughout a teacher's career. Lifelong learning is dynamic, and it requires self-direction and self-regulation (Evensen, 2000; Evensen, Salisbury-Glennon, & Glenn, 2001; Zimmerman, 2008). These two terms are often used interchangeably; however, the term "self-directed learning" has its roots in adult education, and it refers to a design feature in the learning environment (Candy, 1991; Knowles, 1975). However, self-regulated learning (SRL) is usually described as a favorable learner characteristic—that is, a process that encompasses learners'"own thoughts, feelings, strategies, and behaviors, which are oriented towards the attainment of goals" (Schunk& Zimmerman, 1998, p. viii).

In this paper, the term "self-regulated learner"will be used because the focus is on how PBL can support the internal management of teachers' thoughts, feelings, and behaviors during pedagogical problemsolving. For example, Jeong and Hmelo-Silver (2010) examined how pre-service teachers used resources to address problems in educational psychology. These resources, such as books, computers, and maps, helped teachers locate information, make sense of it, and reflect upon it. To be competent in their subject areas and in pedagogy, teachers must know what resources are available and how, why, and when they should be used. This proficiency helps them to make informed choices and to direct subsequent courses of action; in other words, their use of resources affects their skill and their will to direct themselves (Hmelo-Silver, 2004; Hoffman & Ritchie, 1997; Nesbit &Winne, 2003).

Jeong and Hmelo-Silver (2010) found great variability in how pre-service teachers used resources in a PBL virtual environment. High-achieving pre-service teachers used a range of resources to jointly work through and solve a given problem. They used resources both those which were most relevant to the course objectives, and those that were not directly relevant but might have some value to the problem at hand, that would help them frame and work through the problem and arrive at a sound solution.In contrast, low-achieving pre-service teachers tended to use a limited and rigid set of resources studying them in a superficial manner. This approach impeded their understanding of the problem and limited their ability to make effective pedagogicaldecisions.

Teachers must work collaboratively and by themselves to effectively and efficiently meet the needs of their learners. To do so, they must engage in effective self-regulatory thinking and actions to address complex problems. Problem solving requires them to define the problem, to select and to evaluate critical and relevant resources, and to consult with other teachers, professionals, school administrators, and parents. At the same time, teachers must monitor the decisions they make individually and collectively to resolve an issue at hand. Failing to orchestrate the elements needed to solve a problem or to explain what is going on, orfailing to take responsibilityor to think in a discerning manner, will gravely impact the success of the plan and can have dire consequences for learners (Evensen et al., 2001).

5.4 Intrinsic Motivation

The fourth goal of PBL is to help learners become intrinsically motivated. Intrinsic motivation occurs when learners work on a task that ismotivated by their own interests,choices, and agency, and by the learning gained by doing so (Ames,1990). Gijselaers and Schmidt (1990) and Van Berkel and Schmidt (2000) found that the quality of aproblem case had a major influence on the time learners spent engaged with the case and how interesting it was to them. When looking at problems related to teaching, one would expect them by their very nature to be intrinsically motivating for teachers; most teachers enter the teaching profession because they are inherently committed to pedagogy (Lampert& Ball, 1998). There are several aspects of PBL that foster intrinsic motivation, such as dealing with issues which are personally and professionally relevant (authentic) and optimally complex without being overwhelming (Hung, 2006). Lambe's (2007) study on the implementation of PBL in teacher education indicates that when learners address real-life problems within their educational interests, they are increasingly motivated to investigate such issues further.

They also develop critical reflection skills in their collaborative interactions. Moreover, intrinsically interesting problems spur dialogue and negotiation (elements of collaboration) among PBL group members as they assume responsibility to frame the problem, decide on the key learning issues, and select, collect, and assess information and ideas (Hung, 2006).The more committed teachers are to an issue, the more they will take ownership and follow through until it is resolved (Bandura, 1997; Dweck, 1991; Hmelo-Silver, 2004).

6. PBL Challenges

A discussion of PBL would not be complete or accurate without an examination f some of its implementation challenges. The next section will discuss two such aspects: the resource-intensive nature of PBL; and the implementation dip.

6.1 Resource Intensiveness

PBL requires major changes in planning, curriculum, and assessment. Curriculum changes must be integrative; they cannot not just be "academic frills" or tokenisms tacked on as afterthoughts (Villegas & Lucas, 2002). This process would involve the construction and/or selection of cases, the alignment of cases with teacher education content, and the assessment and evaluation of cases. With the help of one research assistant, the first author of this paper devoted three months, five days a week, to the design and implementation of her first PBL course. Moreover, when PBL is done in large classes, extra resources are required. Basedon the first author's initial experience, it is recommended that the instructor be trained in both the practice of PBL andin its scholarship. Ertmer and Simon (2006)offer several suggestions for implementing PBL in teacher education classes.These include having students take on the role of the facilitator andreducing the number of topics. While these strategies require significantplanning, the authors contend that they also require a certain degree of facility with PBL—something that students are unlikely to fully acquire, given the constraints of their degree requirements.

Hmelo-Silver and her colleagues have turned to technology-supported PBL. There are setup and maintenance costs to be considered, but through technology groups, teachers can receive expert PBL support and offer one another support in implementing this strategy. For example, the STELLAR project—developed by Derry, Hmelo-Silver, and colleagues (2006)—used hybrid courses in educational psychology and the learning sciences to train pre-service teachers in PBL. STELLAR includes a knowledge web (a library of cases and online PBL tools) to help pre-service teachers analyze cases and redesign lessons based on learning principles. Approaches like STELLAR can be used to train pre-service teachers in cutting-edge pedagogy across institutions. It also helps them to conceptualize, implement, and assess current knowledge where communities of educators and schools take on an integrated and systemic approach to PBL. However, the challenges of long-term system upkeep and of the logistics of sharing approaches like STELLAR across institutions remain and, especially during the first five years of implementation.

6.2 Implementation Dip

Often, when people try something new and grapple with the demands of a new process, situations get worse before they get better (Fullan, 1992; 2001). Fullan calls this the "implementation dip." The implementation dip is a drop in performance and confidence as usersencounter an innovation that requires new skills and new understanding. For example, Edwards and Hammer (2006) found that when PBL was introduced in a child development course, the initial reactions from pre-service teachers wereas follows:"needing more direction about how to approach a task, difficulties in working with group members, difficulties understanding the roles of other members in the PBL team, and difficulties in understanding expectations" (p. 470). These kinds of challenges are not particular to Edwards and Hammer. As an implementer of PBL, I have experienced PBL challenges that have been echoed by the researchers Ertmer and Simons (2006).

According to Fullan (2001;2008), all successful schools experience "implementation dips" as they move forward. He observes that it is often assumed that, once an educational change has been implemented, the outcomes will be what was intended or articulated at the outset. But innovations, once implemented, need longevity to createlasting effects; it is only after an innovation hasproduced proven results that it can be acknowledged as successful. Institutionalized success is not only measured in terms of staff's technical capacity or revised institutional arrangements; it must bring measurable benefits to students.

Moreover, the teacher's role in PBL changesfrom being the "owner" and dispenser of the information, responsible for assessment, to being a facilitator of learning, supporting student agency (Hmelo-Silver & Barrows, 2006; 2008). The PBL facilitator, as seen earlier, must adapt to many roles and must learn new ones. This process will require time and faculty professional development. Any difficulties the teacher and student both experience with these changes beyond the initial period of the PBL should be addressed.

7. Choosing Appropriate PBL Implementations: Implications for Research and Practice

Two things are clear from the discussion thus far: (1) PBL has many benefits, with the potential to guide teachers to meet the mandate of new reform with respect to problemsolving, collaboration, and self-directed learning;
(2) at the same time, PBL presents many challenges with respect to necessary resources anddemands made on teachers, learners, and faculty. Therefore, the decision to adopt PBL is one that requires careful consideration of its short-and long-term trajectory.

There are large and small ways of implementing PBL depending on the needs of the stakeholders—teachers, students, and faculty. In this section, I will(a) describe a number of approaches to PBL implementations; to (b) outline the research questions that emerge from these approaches to PBL implementation; and to (c) relate them to teacher education reform.

7.1 Faculty-Wide Implementation

Faculty-wide implementations of PBL are typically characteristic of the medicalschool model of PBL, as described at the outset. According to Fullan (2008a), "[i]mplementation occurs when teachers interact with and support each other as they try out new practices, cope with difficulties, and develop new skills. Early implementation is fraught with difficulties and the institution, more than any other level, can provide the kind of environment necessary to address the inevitable implementation problems" (p.78).For example, the state of Tennessee has begun to implement PBL across its teacher education program (Short, Hill-Clarke, & Short, 2010). They have created a faculty-wide version of PBL wherein teacher candidates use the principles and approaches of PBL when confronted with pedagogical issues reflecting the types of issues they will subsequently face in their practice and the teaching profession. Moreover, faculty-wide approaches benefitfromshared resources.

Faculty-wide implementationsafford us the opportunity to address research questions such as the effectiveness of the strategy across multiple sections in a domain, provided we control forteacher effects. Furthermore, questions about cognitive transfer are possible within the faculty-wide approach. For example, does PBL prepare teacher candidates for their future courses in their teacher education programs? Does PBL improve their ability to integrate issues from different content areas and to solve problems? More importantly, does it prepare them for their future practice?The ability of teacher candidates to integrate knowledge and skills is a lifelong quality that requires the facility to apply their knowledge and skills throughout their careers. A failure to do so means frustration and anxiety for teachers and students alike (Beck &Kosnik, 2006; Schneider & Stern, 2010).

7.2 The Cohort Implementation of PBL

In teacher education, a cohort is made up of pre-service teachers and a core faculty group that are focused around a theme (e.g., global and peace education). The University of British Columbia, which has framed its elementary teacher education program around cohorts, uses PBL as one of them. In this model, teacher candidates become knowledgeable about PBL and apply that knowledge to their own study of teaching, learning, and the broader teaching profession. Therefore, like the faculty-wide implementations of PBL described above, cohort approaches encourage teachers to share resourcesandexpertise, as well as challenges and ways of overcoming them.

Inan example of cohort implementation, both UBC faculty members and key members of the Richmond School District teach the PBL cohort. Teacher candidates are trained as facilitators to expertly guide other teacher candidates to develop inquiries into pedagogy, curriculum, learning, and the profession of teaching. One of the unique features of the program is itsfocus on identifying and engaging problems through collaborative and networked inquiry. Teacher candidates spend one full day a week at their practicum schools throughout the 12-month program.

The cohort approach would allow researchers to address the longer-term trajectory of PBL from the university classroom into the schools where teacher candidates apply PBLconcepts. Collaborating with teachers and administrators in schools could set the stage for teacher candidates to use what they havelearned about PBL in the authenticity of the classroom.

Beck and Kosnick(2003) contend that schools often lag behind pedagogically, yet in universities, candidates are exposed to many contemporary teaching methods. Teacher candidates' experiences during internships in public schools focus on "what works" while revealing little or no understanding of why it works. Consequently, teacher candidates often learn how to apply routinized procedures to intricate pedagogical situations, but relinquish links to discernment, reflection, and collaborative problem solving.

Teachers' education goes beyond what they learn in their university classes. Practitioners and educational researchers are also preoccupied with the links between what happens in university classes and what happens in practica. This brings us to the need for university and K–12 schools to integrate so that approaches such as PBL can go beyond the university context to be used where actual practitioners need them.

Research questions such as the following might arise from university and school partnerships: Would the knowledge and skills acquired during teacher candidates experience with PBL translate into better teacher preparation, teacher success, and their own students' learning? What internal and contextual factors might influence teachers'application of PBL in their classrooms? Furthermore, how can school experiences translate into more informed teacher education? For example, how can teachers and university professors design more relevant courses and other ways of helping teacher candidates become more strategic teachers in the way they use the surrounding resources.

7.3 Cross-Institutional Implementation

According to Fullan (2001), there are multiple advantages to this model:the motivation gained from working with a group of other teachers, the possibility of "de-centering" from one's surroundings, and a greater wealth of ideas and expertise. Working within this approach, teams of people can work on different projects and problems by sharing resources, which may be a better design than relying only on the intra-institutional model.

We see a cross-institutional model in the extended partnership between the collaboration of Hmelo-Silver and Derry in their conceptualization, implementation, and re-thinking of PBL in light of learning theories and pedagogy (Derry et al., 2006; Hmelo-Silver et al., 2009). This partnership allows for the collaborative development of technology, video cases, and problem materials, creating a synergy in the expertise of the collaborators.

These kinds of partnerships are central when dealing with PBL or other major pedagogies. As mentioned earlier, the development and design of PBL cases alone takes much thought and revision. Each case must be authentic, experiential, and collaborative; learners working on a PBL case must see the relevance of the case to what they will do in their classrooms. They must have some prior experience with or knowledge of the elements of the case to feel they can contribute their knowledge to the case. The case must be sufficiently complex that learning and thinking processes (e.g., planning, generating hypotheses, gathering evidence, and weighing such evidence) are engaged. If the case warrants collaborative inquiry, new insights can be gained.

Sharing resources is essential to PBL implementations because it allows teachers to unite, to share information, and to offer support as part of a community of scholars. Failure to do so results in duplication of resources and effort, contributing to implementation challenges and frustration on the part of implementers (teachers) and learners (Fullan, 1992; 2008a). When people are frustrated, they are likely to revert to more familiar instructional strategies (Ertmer & Simons, 2006). This is not only an important practical consideration, it is also an important research consideration concerning the factors that affect teachers' continued use of major pedagogical approaches like PBL. Embarking on cross-institutional partnerships would allow us to seewhether PBL is stable and consistent across contexts. For example, when all things are relatively equal (discipline, teachers, and resources), are learners from different institutions using PBL better able to collaborate, self-direct, and solve problems than learners using otherapproaches? Most importantly, are these results consistent across institutional contexts? If not, then what factors contribute to these differences?

The cross-institutional model also allows us to study any transformations it instigates. Teachers, both individually and collectively, must learn to manage change continuously (Fullan,1992; Hopkins, 2001a, b). Moreover, this is required by many contemporary educational reforms. However, it takes several cycles of trial and error and collective reflection to develop the skill to manage the technical and the social-emotional aspects of change and to grow accustomed to the pace of change. Using the cross-institutional approach to implementing PBL would meanbeing able to assess change happening at different paces in the two or more institutions.

Providing a dedicated facilitator and appropriate resources would encourage students' motivation and active engagement. Therefore, making PBL easier for individuals and groups to receive content and process guidance from the facilitator (Hmelo-Silver & Barrows, 2006).

7.4 Individual or Small Scale Implementation Approach

Widespread involvement at the start of implementations generally, and PBL,in particular, is not always feasible or successful (Fullan, 1992; Poikela& Moore, 2010).When educational changes require some impetus to get started, it is more likely that small groups of people will embark on a change first.If they are successful, the process is more likely to build momentum.

For example, classes in medical school tend to be small (around 10). In contrast, the larger teacher education classes could extend to as many as fifty students per class making dedicated facilitation with one instructor an arduous task (Author, 2008; 2009).In this case, PBL was adapted for training large teacher education classes byusing a wandering facilitation model. This approach allows for facilitators to move from group to group according to the groups' needs. However, the use of one facilitator (the teacher or instructor) has its limits. Thus, to supplement the wandering facilitator approach, peers (teacher candidates) were selected on the basis of the following several criteria. These were the quality of their assignments; their class engagement as shown by their bringing in illustrative learning and teaching examples; their questions about readings; and their participation in the school community. These teacher candidates also had the potential to be sensitive listeners to the group, to allow for equitable distribution of resources, and to encourage all members of the group to speak. Eight such teacher-candidates were identifiedand placed each in a group of five or six teacher candidates, yielding eight groups. The eight peers were given basic training in the PBL mission, its procedures, thechallenges they might encounter, and how to problem-solve with the group. The facilitator/instructor (myself) monitored the members and their groups regularly.APBL and content facilitator and peer facilitators make it easier for individuals and groups to intrinsically engage with the content and PBL process (Hmelo-Silver & Barrows, 2006).

8. Conclusion

We began a discussion of the status of problem-based learning in teacher education in North America. The research presented here clearly showsthat PBL is a pedagogical approach that affords teacher educators opportunities to meet the demands of 21st-century educational reform. Teachers are expected to have solid content and disciplined knowledge and to engage in framing, analyzing, and problem solving. Equally important, they will be expected to work with other teachers, parents, and their students to jointly address learner and pedagogical issues; to work as team members and collaborators; and to develop themselves as self-reflective, self-directedand lifelong pedagogues.

The way, in which PBL is implemented, from single implementations to more systematic and integrative ones, will certainly affect the type of PBL research and practice that follows. From a research perspective, different PBL approaches lend themselves to different questions, from action-oriented self-study questions to questions of generalizability and theory building. PBL is a comprehensive approach, and the scope to which it is implemented depends on a variety of individual, social, and institutional factors. It is pivotal that as researchers, educators, and administrators, we address some of these questions:

- What kinds of changes to the educational system are needed to bring PBL (and other inquiry approaches) more broadly into teacher education?
- What additional capabilities would be needed for schools of education to implement PBL?
- How can cross-institutional and university-school partnerships be developed to support resource sharing and professional development?
- In what ways can technology be used to leverage existing resources to create new opportunities for PBL in teacher education?
- How would these changes be compatible with standards for teaching certification?
- How would these changes be reflected in student outcomes?

These are initial questions that must be part of a research agenda for PBL in teacher education. I am encouraged by the potential benefits of PBL for teacher education, but there are many questions yet to answer. Iexpect that this discussion provide an impetus for the investigationto continue.

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