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Examining the personal side of change within a collaborative inquiry group: Adopting Problem-Based Learning in primary/elementary science education

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This paper reports on the experiences of a primary/elementary teacher inquiry group consisting of five teachers and a university researcher (the author) as the group planned and implemented a Problem-Based Learning (PBL) science curriculum. Using a change model, the Concerns-Based Adoption Model proposed by Hall and Hord (2006), the author examines the personal side of learning (beliefs and feelings) as members of the inquiry group adopted a new approach to teaching and learning. Outcomes of this one-year collaboration reveal that teachers moved from the awareness stage of concern to the management and consequence stages of concern, although individuals varied in the amount of time and energy devoted to each stage.

INTRODUCTION

Many aspects of the educational system are being targeted for improvement in the current reform movement in science education (American Association for the Advancement of Science [AAAS], 1993; Council of Ministers of Education, 1997; National Research Council, 1996). Supporting teacher learning has been identified as one area that warrants ongoing support and attention. According to the National Research Council (1996), current reform initiatives will require "a substantive change in how science is taught" (p. 56).

Changing how science is taught has implications for the nature of professional development that is available to teachers. To assist teachers in examining their thinking and classroom practice and to broaden their vision of what constitutes optimal learning for students, they will need support and encouragement. Likewise, teacher professional development needs to be embedded in daily classroom practice, to be systematic, and to foster active engagement with new ideas (Cochran-Smith & Lytle, 2001; Darling-Hammond, 1998; Loucks-Horsley, Love, & Styles, 2003). In the context of science education, many primary and elementary teachers feel ill-equipped and ill-prepared to foster student learning through problem- and inquiry-based approaches to teaching and learning. This lack of preparation and confidence in teaching science often results in difficulty with teaching science; adopting conservative, low-risk approaches to teaching; and/or avoiding it altogether in the curriculum (Appleton & Kindt, 2002; Grindrod, Klindworth, Martin, & Tytler, 1991; Mulholland & Wallace, 2001; Tabachnick & Zeichner, 1999).

The adoption of innovations and the manifestation of these innovations in practice may vary, depending upon how the innovation is envisioned and understood. Several change models have been used to

develop an understanding of educational change processes and to facilitate productive change, including Rogers' adoption model (Rogers, 1995), the Technology Acceptance Model (Davis, 1986), the Stockdill and Morehouse Model (Stockdill & Morehouse, 1992), the Instructional and the Transformation Model (Marcinkiewicz, 1994), and the Meaning of Educational Change Model (Fullan & Stiegelbauer, 1991).

In this study, a model of change referred to as the Concerns-Based Adoption Model or CBAM (Hall & Hord, 2006; Hall & Loucks, 1978) was used to examine primary and elementary teachers' concerns, feelings, and perceptions as they designed and implemented Problem-Based Learning (PBL), an inquiry-based approach to teaching and learning. In particular, one aspect of the model was used, stages of concern, to analyze the nature of concerns expressed by the teacher participants at varying points during the adoption process. According to Hall and Hord (2006), these stages follow a quasi-experimental trajectory as the change process unfolds, although the trajectory is not guaranteed and is dependent upon how facilitation occurs and the supports that are in place to enable teacher learning as the innovation is adopted. This study was guided by the following research questions: a) What stages of concern will emerge during the design and implementation of PBL experiences? b) What types of feelings and perceptions will teachers experience at the design phase of the study? and c) What feelings and perceptions will teachers experience during the implementation phase of the study? Before describing the CBAM in detail, the characteristics of PBL are described.

The Nature of Problem-Based Learning

PBL can be traced to the work of Dewey (1944) who emphasized the connections amongst doing, thinking, and learning. According to Dewey, learning "should give students something to do . . . and the doing is of such a nature as to demand thinking or intentional connections" (p. 154). As a new approach to teaching and learning, PBL was developed at McMaster University's medical school by Howard Barrows (1984) to promote student-centred education. In adopting this approach, Barrows hoped to develop medical students' content knowledge and their ability to apply that knowledge in clinical settings (Barrows, 1985). Since that time, PBL has been adopted extensively for use in many faculties and professional schools at the post-secondary level.

Problem-based learning is a curriculum development and instructional approach that places students in situations where they have to solve realistic, ill-structured problems that serve as the impetus for students to enhance their content knowledge, as well as a range of problem-solving and higher-level thinking skills (Barrows, 2000; Hmelo-Silver, 2000). According to Baptist (2003), PBL has been used to change learning cultures and to develop curricular models, programs, courses, and learning modules. Despite these differences in usage, PBL is usually student-centered, with instructors or teachers assuming the role of facilitators or guides, has opened-ended problems or scenarios as the impetus for learning, and new understanding occurs through self-directed learning. PBL should not be confused with project-based learning, which is at times referred to using the same acronym. Project-based learning typically utilizes a production model, where the end product is the focus of the learning. PBL

is open-ended, starting with an ill-structured problem, which students attempt to solve using an inquiry process. In PBL, the problem drives the learning.

While various approaches to PBL may be enacted in primary and elementary classrooms (the context of this study), most PBL experiences are characterized by the following: a) the teacher acts as a facilitator of student learning (e.g. asking probing questions, modelling appropriate collaborative learning skills) as students are introduced to and find feasible solutions to problems; b) students collaborate in small groups (e.g. reporting new ideas, discussing and evaluating options presented within a group), as well as work individually at times (reading resources, recording notes); c) students publicly share solutions to problems; and d) the instructor/teacher uses individual and group assessment of the learning process, skills, and content knowledge.

Barrows and Kelson (1995) highlight five goals of PBL and discuss how each can promote learning. The first goal, constructing flexible knowledge, requires the learner to integrate information across multiple domains, thus enabling the learner to more readily retrieve what has been learned and apply that knowledge in varying contexts. The second goal, effective problem-solving skills, involves selecting and applying appropriate meta-cognitive (e.g. planning problem-solving, monitoring progress, etc.) and reasoning skills. Developing self-directed and lifelong learning skills is the third goal. Learners need to demonstrate an awareness of what they are able to comprehend, be able to identify and set learning goals, take an appropriate course of action to reach their goals, and show evidence of how to reflect upon whether or not their goals have actually been attained (Zimmerman, 2002). The fourth goal, effective collaboration skills, encompasses the development of collaborative, team-building skills such as negotiation, conflict resolution, and consensus-building. The fifth goal, intrinsic motivation, may be achieved when PBL groups are motivated by shared goals, challenges, and interests (Hmelo-Silver, 2004). PBL does not represent a unitary approach to teaching and learning in its conceptualization (Barrows, 1986). Differences in how PBL is designed and implemented may vary according to the educational context, curricular goals and objectives being targeted, student readiness for learning through PBL, and the skills of the teacher.

In the context of K-12 science education, curriculum standards and learning outcomes are being framed through a constructivist lens (Piaget, 1976, 1978; Richardson, 2003) – learning is complex; it is influenced by a learner's prior knowledge; and cognitive change and new understandings develop as learners' prior knowledge and beliefs interact with new knowledge and situations. The characteristics and goals of PBL align with this constructivist lens. PBL is emerging in public schools as a means to foster the development of discipline-specific knowledge, as well as a range of skills such as problem-solving, team-building, communication, decision-making, and self-directed learning.

Although considerable research has been conducted at the post-secondary level about the effectiveness of PBL, the research at the secondary level is only starting to emerge. For example, Gallagher & Stepien (1996) found that students in American studies performed as well on multiple-choice tests as students in a traditional classroom, while Gordon, Rogers, Comfort, Gavula, and McGee (2001)

showed that the use of PBL in a middle school curriculum with minority students resulted in improved behaviour and science achievement. Dods (1997) evaluated PBL in the context of a high school elective biochemistry course. He found that lectures resulted in the coverage of more content, whereas students retained more information and had higher levels of understanding through PBL instruction. Torp and Sage (2002) and Delisle (1997) have also written "how-to" books (K-12) for designing and implementing PBL. This study also contributes to an understanding of the concerns and issues that primary and elementary teachers encounter in the adoption of PBL and provides insight for those who facilitate teacher learning and school-based change.

The Concerns-Based Adoption Model

Hall and Hord (2006), borrowing from earlier work, define a concern as "the composite representation of the feelings, preoccupation, thought, and consideration given to a particular issue or task . . .[and includes] the mental activity composed of questioning, analyzing, re-analyzing, considering alternative actions and reactions, and anticipating consequences (Hall, George, & Rutherford, 1979, p. 5). This conception of a concern is reflected in the CBAM (Hall & Hord, 2006) as a theoretical sequence of stages that individuals or small groups experience as they are asked or volunteer to use an innovation. The model addresses the affective dimension of learning: "[individuals] are not just doing but continually thinking and feeling about how the change is working, how well [they] are doing, and what effects it is having" (Hall & Hord, 2006, p. 143). As an innovation unfolds, the feelings and perceptions of an individual will change. In order to better facilitate the implementation process and to design appropriate interventions and supports, understanding of these stages of concern is necessary.

The CBAM identifies seven specific stages of concern. The first stage, *Unawareness*, occurs when an individual does not indicate any significant interest or involvement in the innovation. Although a teacher may be aware of a new or different teaching approach (e.g. PBL), he/she may have no desire to explore its merit as a pedagogical tool. The second stage, *Informational*, occurs when a person becomes aware of and expresses an interest in learning about the characteristics, aspects, and requirements of the innovation. Continuing with the PBL example, a teacher may become aware of PBL and consider adoption. She may pose questions such as, "What is this approach? How is it alike or different from inquiry, an approach I already use? How should it be structured with students?" During the third *Personal* stage, a person feels uncertain about his or her role in the process of adoption of the innovation. Issues are raised about the potential benefits of adoption and the possible personal and current program conflicts that might arise as a result of adoption. At this stage of concern, a teacher may pose questions about PBL such as, "Will I need additional resources to plan and implement a PBL learning experience? Are we all required to adopt this approach? If we adopt this, will the leadership team be supportive?"

At the fourth stage, *Management,* the individual is focused on the processes and task of using the innovation. In addition, issues related to efficiency, organization, management, scheduling, and time are paramount. At this stage, a teacher may wonder about how long a PBL experience should be and how it might fit with other learning activities and topics in a course. She may also consider how group organization and functioning, a critical aspect of PBL, may be facilitated. The *Consequence* stage, the fifth, occurs when the user evaluates the impact of the change on the client. This includes an examination of the relevance of the innovation to the client and how to improve outcomes for the client. For example, a teacher may formally collect data and use other forms of assessment to determine if students understood concepts targeted within a PBL experience, or if they developed or enhanced skills such as decision-making, presentation, or communications skills. Next, during the *Collaboration* stage, the individual is engaged in communicating and working cooperatively with colleagues when adopting the innovation. Although teachers may work collaboratively at all stages within CBAM, at this sixth stage individuals have become comfortable with the innovation and wish to modify, monitor, and make changes as they simultaneously implement a PBL experience. For example, teachers may agree that students are not good problem-posers and need to introduce additional activities to improve this skill. Or teachers may decide that students need more guidance when finding resources and interpreting text. At the final or *Refocusing* stage, the user considers alternative ways of using the innovation and exploring "the possibility of major changes or replacement [of the innovation] with a more powerful alternative" (Hall & Hord, 2006, p. 140). Once again, like the previous two stages, this stage focuses on improving the impact of the innovation. School-based groups who have adopted PBL successfully may decide to design an entire course using a PBL approach or introduce it into new areas of the curriculum. In the context of science education, the CBAM model has been used to examine the adoption by teachers of computer innovations, new science curriculum programs, and inquiry-based teaching approaches (Butzow, 1988; Loucks & Melle, 1980; Malone, 1984; Sevilla & Marsh, 1992); however, research has not been reported that focuses on the use of the CBAM to understand the adoption of PBL.

Challenges in adopting PBL

In this study, the CBAM was used to explore teachers' concerns and perceptions as they adopted PBL (Barrows, 1984, 1986, 1994). Research on the challenges and concerns associated with developing and implementing PBL in K-12 contexts is starting to emerge in several school disciplines. For example, Clouston and Whitcombe (2005) developed a PBL model that allows users to examine five key issues associated with PBL adoption: the nature of the learning environment in an organization, the role of group dynamics in fostering collaboration, the nature of communication, the nature of knowledge (tentative versus absolute), and student readiness to engage in PBL. Harada and Kim (2003) reported on how library media specialists can support teachers in changing traditional units to problem-based learning units. They suggested that traditional learning experiences be transformed to reflect real world problems; that students be viewed as decision-makers and seekers and creators of knowledge; that real audiences be used for the presentation of problem solutions; and that teachers assume the

role of facilitators in PBL contexts. Achilles and Hoover (1996) worked with middle school and high school teachers in four different schools focusing on teacher training. Teachers identified several challenges and issues associated with the adoption of PBL – student difficulty in working in groups, the extensive time needed in planning for PBL, the need to start with small PBL experiences, and the need for teachers to develop collaborative planning skills. Goodnough and Cashion (2006) worked collaboratively with a high school Biology teacher to develop a PBL module focused on cystic fibrosis. They reported on design and implementation challenges and issues – selecting a PBL topic, determining the level of structure to be incorporated into a PBL experience, selecting appropriate assessment approaches, facilitating groups, and providing optimal student feedback.

CONTEXT OF THE STUDY

Five primary/elementary teachers from various schools within a local school district in Newfoundland and Labrador, Canada participated in the project. These teachers volunteered to be in the study after an invitation was sent to their respective schools principals. Four of the five schools were located in rural areas, while one school was located in an urban centre. Each teacher worked at a different school with the exception of Kayla and Sarah[1], who taught at the same school. The structure of the teachers' schools ranged from K-5 to K-12 configurations. All teachers taught all core subjects in the curriculum, with the exception of French, Music, and Physical Education. Table 1 provides an overview of the teachers' backgrounds and other project demographics. Teachers were recruited through invitations sent to all primary and elementary schools in the district. The study occurred over a 12-month period from January to December 2006. A brief introduction follows of the teachers involved in the study.

Table 1

Teacher Backgrounds and Other Project Demographics

TEACHER	EDUCATIONAL CREDENTIALS	TEACHING EXPERIENCE (YEARS)	CLASSROOM USED IN THE STUDY
Raylen	Bachelor of Arts Bachelor of Special Education Master of Education	**23**	Grade Two (9 girls and 9 boys)
Debby	Bachelor of Arts and Education Master of Education	**23**	Grade Four (8 boys and 14 girls)
Patricia	Bachelor of Arts Bachelor of Education	**2**	Grade Four (9 boys and 9 girls)
Kayla	Bachelor of Arts and Education Master of Education	**15**	Grade Three (12 boys and 12 girls)
Sarah	Bachelor of Education and Graduate Work	18	Grade One (13 boys and 11 girls)

1. All teacher names are pseudonyms.

Raylene worked with a grade 2 class of 18 students (nine girls and nine boys). Four children were following modified programs. Raylene described her students as average or above average in terms of academic ability. Debby implemented PBL with 22 grade 4 students (eight boys and 14 girls). Three children followed modified programs and three children had diagnosed behavioral problems. Overall, Debby described the class as academically weak. Patricia worked with a grade 4 class of 18 students, having an equal number of boys and girls. The class had several strong students; however, one student required a modified program and one student had a diagnosed behavioral disorder. Kayla worked with a grade 3 class of 12 boys and 12 girls. She described her class as weak academically, particularly in reading (50% were below grade level). One student followed a modified program and one student had been diagnosed with dyslexia. Sarah implemented PBL with a grade 1 class of 24 students (13 boys and 11 girls). The class was of mixed ability: four students followed a modified program and one student had a hearing impairment.

In this study, students were presented with an authentic, open-ended problem to solve and the teacher then guided students through the steps of considering the problem; formulating and analyzing the problem by identifying relevant facts; generating hypotheses about possible problem solutions; researching questions or learning issues raised by the problem; applying new knowledge to the hypotheses; and selecting and defending a feasible solution to the problem. The approach was iterative in nature: groups of three to four students evaluated resources (many provided by the teachers) and then returned to the original problem to check their reasoning and understanding of what they learned. Because these were primary and elementary students who had not used PBL in the past, teachers guided this process carefully, ensuring that the open-ended problem was driving learning. Throughout the process, groups were encouraged to construct meaning collaboratively. However, students were also encouraged to apply self-directed learning skills. In the classic medical model of PBL, each PBL group is guided by a tutor. This is usually not possible in K-12 classrooms. Consequently, teachers adopted a floating facilitator model (Duch, Groh, & Allen, 2001), moving from group to group during PBL classes, providing support during problem-solving, and monitoring individual group functioning. Appendices B and C detail the PBL topics and learning outcomes targeted, as well as the assessment and learning activities adopted.

All planning/debriefing meetings occurred at the local school district office, four hours from the author's university and one to three hours from the schools in which the teachers worked. Planning for the study started in January 2006 and continued until June. Because PBL was new for all group members, except the author, the group engaged in intensive reading and examination of PBL resources (e.g., books, videos, journal articles) to develop an understanding of PBL and how it might be implemented in the context of K-4 education. This understanding emerged over time and PBL curriculum materials were developed in the latter part of this six-month period. During implementation of the PBL learning experiences (September to October 2006), group members met virtually to share ongoing insights and to provide each other with support and feedback.

METHODOLOGY

Many current approaches to educational research are re-conceptualizing the relationship between those who are researched and those who are researchers. For example, a wide spectrum of participatory methodologies have emerged that can meet the needs of both practitioners and researchers (Lincoln & Guba, 2005). Many of these methodologies (e.g. action research, teacher research, action science) view researchers and participants as co-learners and co-constructors of knowledge, with relationships reflecting more equity among all participants. Collaborative inquiry (Bray, Lee, Smith, & Yorks, 2000), a participatory methodology inspired by the work of Heron (1981) and Reason (1989), was adopted in this study as a means to foster both adult learning and the generation of knowledge. This approach to human inquiry is "self-directed" rather than "other-directed" and calls upon participants to share in the exploration and development of different forms of knowledge through sustained interaction (Reason, 1989, p. 4). Thus, in this study, group members determined the time and location for planning/debriefing meetings; they generated shared research questions; they conceptualized the PBL approach and the classroom enactment of PBL; and they engaged in ongoing reflection which was both individual and collaborative, thus allowing shared meaning-making to emerge. To obtain a deepened understanding of PBL and the experiences and perceptions of the group members, several data sources and methods were used:

Participant observation

Over the 12-month duration of the study, the group met for over 40 hours both face-to-face and synchronously, on a variety of occasions, to plan and debrief the PBL experience. *Elluminate Live,* a real-time tool that allows users to create a virtual environment for discussion and collaboration, was used to support group functioning. Implementation of the teachers' respective PBL units occurred over a three- to four-week period in September and October 2006. All planning/debriefing meetings were audiotaped and later transcribed. Over 25 hours of audiotapes were transcribed.

Journal entries

During implementation of their respective PBL units, the teacher collaborators recorded reflective entries using the discussion tool of a learning management system. The following sample guiding prompts helped focus their reflection: a) Describe how you implemented your lesson; b) How did students respond to the introduction of the problem? and c) What concerns do you have at this point in the planning process? These entries were both descriptive and interpretive, allowing the author to gain insight into the teachers' thinking, while fostering teacher reflection. All journal entries were compiled and analyzed.

Documents

A range of documents were generated by group members. In the planning stage, group members created concept maps to identify themes and learning outcomes targeted by the PBLs, to brainstorm assessment and learning activities, to anticipate student questions, and to plan a timeline for implementation. During the implementation stage, student work (assignments, projects, etc.) was also examined.

Semi-structured interviews

Each member of the group was interviewed at the end of the study for 60 to 80 minutes, thus facilitating reflection on the overall experience and providing another source of data to inform the study.

Survey

Participants completed a Stages of Concern survey early in the planning stages and then completed the same survey immediately before implementation of their respective PBLs. This survey consists of 35 items that have high reliability and internal consistency (Hall & Hord, 2006). Sample Likert items included: a) I am concerned about students' attitudes toward this innovation; b) I am concerned about not having enough time to organize myself each day; and c) I have very limited knowledge about the innovation. The results of the survey were used in conjunction with other data sets to confirm or refute emerging themes.

Although all group members engaged in data analysis to some extent, the author assumed primary responsibility for the more intensive data analysis. According to Marshall and Rossman (1999), "data analysis is the process of bringing order, structure, and interpretation to the mass of data collected" (p. 150). Data analysis was ongoing throughout the study. This entailed reading and rereading the data from all data sources. During this process, the author engaged in writing analytic memos, and recording notes about developing insights and thoughts. Next, initial basic coding involved assigning labels to units of text from transcripts, journal text, and survey statements. Similar types of concerns (e.g., lack of time) for grouping into the same broader categories were identified.

Next, after categorizing the data, categories were linked to the stages of concern framework. Crabtree and Miller (1992) refer to this as a template strategy: sets of codes are applied to the data, but may change as data analysis proceeds. Ultimately, the author brought meaning to the analyzed data through interpretation, the process of making sense of the findings, offering explanations and generating conclusions (Marshall & Rossman, 2006). Table 2 provides a summary of data collection and data analysis strategies adopted in the study.

Table 2

Data Collection Methods and Analysis Strategies

DATA COLLECTION METHODS AND SOURCES	DATA ANALYSIS TECHNIQUES
Documents Interviews Journal Reflections Participant Observation Survey	Reading and re-reading the data
	Writing analytic memos
	Coding
	Categorizing
	Linking categories
	Interpreting, Offering Explanations, Drawing Conclusions

OUTCOMES

Although the group held shared goals (e.g. understanding how to plan and implement PBL, supporting student learning through PBL) as members engaged in collaborative inquiry, they also posed different research questions. The author's research questions were stated earlier in this paper. The teachers' research questions focused on both their own learning and student learning. Their work was mainly guided by two questions: "How can the adoption of PBL improve my teaching of science?"; and "How can PBL be used to engage all students in learning science?" As previously noted, there were several students in each of the teachers' classes who were following modified learning programs, and the teachers reported that several of these students did not seem interested in learning science. The following two sections focus on the beliefs, feelings, and concerns expressed by collaborative inquiry group members as they planned and implemented PBL experiences. Appendix A provides a summary of the primary concerns expressed by each teacher during the design and implementation phases.

THE DESIGN PHASE

The teacher collaborators joined the project for a variety of reasons. They viewed this as an opportunity to improve student learning in science, and three of the teachers welcomed the challenge of adopting a new instructional approach as is illustrated by the following comment: "I look forward to having my class involved in new learning experiences where both I can grow as a teacher and my students can benefit" (Raylene).

Prior to starting the project, the teachers knew very little about the innovation. In fact, four of the five teachers were unaware of the PBL approach. The first three meetings of the inquiry group were spent in reading about PBL, identifying its salient characteristics, and developing an understanding of how to plan a PBL learning experience. In addition, the group examined how others have implemented PBL in K-12 contexts. The group adopted a nine-step PBL problem design process (Hung, 2006) that is intended to help practitioners adopt a practical approach to problem design.

Early in the planning phase, the author asked group members to share their concerns and feelings about PBL and the project. In addition, the author asked them to complete the "Stages of Concern" survey (Hall & Horde, 2006) and to explicitly discuss some of their concerns and feelings using their responses to the survey. While the group was still very excited about the project, feelings of uncertainty were emerging. In examining the resulting profiles from group members, it became evident that all members had high levels of concern related to the informational, personal, and management stages. Concerns at each of these levels were also expressed during group dialogue and reflection. A description of the types of concerns expressed is provided below.

Informational

By the end of the second planning meeting, teachers had a reasonable understanding of the nature of PBL and the process that would be used to develop a problem. However, they expressed a strong

interest in seeing more information and literature that would include examples of PBLs designed by other teachers in grades 1-4. They also wanted to explore what PBL would look like in their classrooms: "What will this look like in a primary classroom? I think I can envision it, but I really need to see it" (Debby). For the next meeting, the group used a book by Lambros (2002), which focused on K-8 education. Group members reported that the text was very helpful and fostered more insight into how to design and implement PBL for primary children. Another concern related to the nature of PBL arose. Group members wondered if the PBL approach was open-ended inquiry, an important goal in the science curriculum documents used by the teachers. After some discussion about this issue, it was agreed that PBL could range from very structured to open-ended. However, at the primary level and being first-time users (both teachers and students), the teachers felt the PBL experiences needed to be fairly structured to ensure the students received enough scaffolding throughout the learning process.

Personal

The primary personal concern that teachers expressed related to their role in the PBL process. Four of the five teachers questioned how their role would change during PBL. This concern is reflected in comments such as "How do I prepare the classroom groups? If they are not ready, how do I prepare them for collaborative group work?" (Kayla); and "How do I make this open-ended and inquiry-based, yet provide enough scaffolding for students?" (Debby). Although these issues were not resolved immediately, the teachers generated several suggestions that they anticipated would address these concerns. These included engaging students in cooperative learning activities prior to starting the PBL; ensuring groups were given clear directions; constant monitoring of groups during implementation; and requiring regular group meetings through which group members would generate a report about what they accomplished at the end of a class.

Management

Several issues related to management were expressed and these continued to be of concern throughout the design phase. One of these related to time-having enough time to complete readings about PBL and having adequate time to plan and implement the PBL. As Kayla commented, "This is going to be a lot of work, but I am still unsure about the time requirements for this." Several release days were provided for teachers to plan and collaborate. However, with an already demanding schedule and curriculum, time remained an issue. Several teachers raised the issue of resource availability, such as reading materials at the appropriate grade level, computers, and guest speakers. Being pragmatic, they decided that a particular PBL unit could only be planned if appropriate resources were available. Furthermore, they agreed that more energy might need to be devoted to searching for appropriate resources on the Internet. A third issue related to scheduling and when best to implement the PBL units. Patricia suggested, "It might be better to introduce a PBL experience later in the year. In this way, you know your students better."

Teachers were also concerned about the impact this would have on their students. However, concerns related to the impact of the innovation on students (the Consequence stage) were more pronounced later in the project, immediately before and during implementation. During implementation, teachers used a variety of data collection methods and sources to determine the impact the innovation was having on their students, such as informal interviews with students, recorded field notes, and recorded journal entries. Interestingly, four of the five teachers indicated, through their surveys and their discussions during planning, that they were concerned about this innovation and how it would be used in conjunction with others, especially with teachers within the group (the Collaboration stage). This reflects the teachers' strongly felt beliefs that teacher learning should occur within professional communities. These are some of the comments they shared during planning meetings and their interviews: "It is really important to do this together. You are feeding off each other and ideas come together"; "Other teachers in my school are very interested in being part of this project and linking the creation of the garden to their own teaching"; and "This will allow us to share on an ongoing basis and to stay connected." As the teachers became more comfortable with PBL, their informational and personal concerns became less pronounced.

THE IMPLEMENTATION PHASE

In the design of the PBL units, Raylene developed a grade 2 unit that focused on the changes in living things as they grow and develop. This involved the care of butterflies, following their life cycles and tagging adult butterflies before release. Debby and Patricia worked together to develop a grade 4 PBL unit that would allow students to apply their understanding of habitats through the creation and maintenance of a garden area on the school grounds. Sarah and Kayla developed a unit on the basic needs of living things through a study of the life cycle of bats. Although each teacher taught at different grade levels, they modified the outcomes and learning and assessment activities to cater to differences in learning ability and readiness. The teachers introduced their PBLs to their respective classes through an open-ended problem case. The following is one example of a problem case:

> You are entomologists (bug experts) in training. You are called in to help rid Mrs. Batten's garden of very hungry caterpillars that are devouring her plants and flowers. What can you do to help Mrs. Batten without destroying her garden?

Teachers also targeted outcomes from other disciplines, in addition to science, such as language arts, mathematics, and social studies, when designing their PBL science units. They used a variety of learning activities to support their units, including videos, guest speakers, investigations, the creation of models or projects (e.g., a garden), scaffolding charts, role playing, reading and writing stories, recording observations, group presentations, Internet resources, collages, etc. Assessment activities were both formative and summative, such as rubrics, journal writing, teacher observations, student-generated charts ("What do you know? What questions do you need to answer to solve the problem? How will you find answers to your questions?"), self-assessment sheets, and portfolios. For example, at the end of the PBL unit, Raylene asked her students to provide a summary of what the problem was,

what things they did to explore the problem, and what solutions they found to the problem. She also asked students to "complete a reflection activity. It asked them to describe what they enjoyed best, one thing they learned and how it would help them outside of school, and what they disliked about the unit" (Raylene, journal entry). Appendices B and C provide an overview of the topics and learning outcomes targeted in the PBL units, as well as examples of assessment and learning activities adopted in each unit.

At the beginning of and during implementation, teacher concerns focused primarily on management and consequence levels. The Collaboration stage of concern remained high throughout all aspects of the project. In terms of management issues, the teachers were very concerned with the amount of time the innovation would require: "I am concerned about the time factor as a teacher implementing PBL– arranging resource people, managing the day-to-day activities, purchasing materials, etc." (Debby, group planning session). Although the teachers recognized the considerable amount of energy and time that is required at the onset when developing and implementing a PBL unit for the first time, they felt subsequent implementations of and/or the development of new PBL experiences would require less time and energy. As the teachers implemented their PBL units, another prevalent issue focused on the nature of the PBL enacted and on ensuring fidelity between their conceptualization of how PBL should be implemented and the actual implementation. This was shared in an online session by several teachers: "I am very concerned that I run through the PBL in the correct manner, ensuring that the innovation is problem-based and not project-based" (Sarah); "I also want to ensure that experience is driven by the problem" (Raylene); "I want to ensure that the problem is the key feature and that I will not turn it into project-based learning without knowing it" (Patricia).

To address this concern, all teachers introduced the problem and asked students to generate questions that would need to be answered to solve the problem. Teachers continued to return to the student-generated questions as they engaged in learning activities, having student groups add new questions and note when stated questions were answered. One example of this is noted by Patricia in a journal entry: "The students have returned to their learning issues of our scaffolding chart on at least three occasions already and have checked off questions they have answers to."

The impact of the innovation on student learning (Consequence stage) became paramount during implementation. All teachers questioned whether or not the degree of structure in their PBL activities was adequate to provide scaffolding for students. This is reflected in a journal entry by Sarah: "Does my PBL have enough scaffolds in place to allow the students to go off and do some inquiry on their own?" Raylene wondered about the balance needed in a PBL unit between structure and open-endedness, such that optimal learning would occur.

> I'm thinking of an example; our new Math program. They start every unit with the thing called exploration and 90% of the time kids can't do it. They don't have enough background knowledge, and the idea is that you go and explore and then the Math strategies will come out

> of that. That looks really great in theory . . . . So that's where I'm thinking about this - trying then to give enough structure, but yet make it open ended. It will be the challenge for me.

By the end of the implementation phase, the teachers agreed that their PBL experiences did not reflect open inquiry where the students select their own questions and design their own investigations. Rather, they agreed that the PBL offered students opportunities to engage in structured inquiry, where the teacher guided students in selecting and generating questions and finding ways to answer their questions.

Aligned with the issue of the nature of the inquiry within the PBL was a concern about how some students would respond to the innovation: "My main concern now is observing how particular students respond" (Debby); and "We also need to accommodate the special needs children who have learning challenges" (Patricia). Other issues related to student impact were determining the degree of student engagement through PBL learning and ensuring groups worked independently.

One of the main goals of the teachers, in addition to improving their classroom practice and their understanding of that practice, was to determine how PBL could be used to engage all students in learning. By the end of the implementation phase, the teachers, based on classroom observations and informal interviews with students, reported that they witnessed high levels of engagement in their classrooms. Students were on-task, they completed assignments in a timely manner, and there were frequent inquiries about when they would be having science class. Sarah referred to parent feedback as an indicator of student engagement: "To get reports from the parents that their kids are so eager to read about bats was very encouraging. Parents would say they want to read this bat book; they come home and the first thing they do is to take out their book bag and take out their 'bat' books" (group meeting).

The collaborative groups' functioning, according to the teachers, was fairly smooth. However, they did acknowledge that the teacher must be very attentive to the skills of his/her students prior to engaging in PBL:

> You have to consider the skills of your students whether they are used to working in groups. If they are not, then you're going to have to do some group-building exercises before you do the PBL. You are not giving them the information as a teacher when they work in groups. You're guiding them. You are a facilitator. It's purposeful. Children have a purpose for learning. (Patricia, planning meeting)

IMPLICATIONS

According to Hall and Hord (2006), "systems and organizations adopt change, but individuals implement change" (p. 255). Attending to the needs of individuals and supporting them at all stages of adoption needs to be paramount. In this study, a small group of primary/elementary teachers adopted PBL as an instructional approach for the first time. One of the primary structures that provided support for this adoption was the collaborative inquiry group itself. Group members were able to offer each other feedback, listen to concerns, and generate ideas together. As is the case when many innovations are first adopted, self-concerns (informational and personal) were prevalent early in the adoption process (Brzycki & Dudt, 2005; Kelly & Staver, 2005). As a facilitator of the process, the author attempted to be understanding and empathetic, helping group members articulate their concerns, while engaging all groups members in finding ways to alleviate these concerns. Management concerns, such as finding appropriate resources, balancing the time demands of the innovation with other teaching activities and responsibilities, and managing the many demands of PBL during implementation, remained high throughout the adoption process. Moreover, consequence concerns emerged as being more dominant as the group moved into the implementation phase.

The primary challenge in adopting PBL is "making the appropriate adjustments for the developmental level and the learning environment while still holding on to the elements that make PBL successful and worthwhile" (Gallagher, 1997, p. 347). The adoption of PBL places huge demands on many aspects of teachers' pedagogical content knowledge (Shulman, 1986). Teachers need to attend to the interpretation and application curriculum outcomes, how to connect their own beliefs about student learning to the philosophical underpinnings of PBL, how to examine grouping practice and scaffold effective group work, how to assess learning appropriately through PBL, and how to structure the learning context to meet the needs of all students in a regular classroom.

CONCLUSIONS & SUMMARY

The research on PBL in K-12 contexts is starting to grow. As mentioned earlier, design and implementation issues and concerns arise during PBL adoption (Achilles & Hoover, 1996; Clouston & Whitcombe, 1995; Goodnough & Cashion, 2006; Harada & Kim, 2003). This study confirms many previous findings, namely that the adoption of PBL can be challenging and reflect contradictions. In this study, teachers struggled with determining the amount of structure to incorporate into their PBL experiences. They recognized the lack of time for planning and preparation during PBL design and implementation. They were uneasy about not knowing how students would respond to PBL and they acknowledged that students need to be prepared to operate effectively in groups.

There are many questions that still need to be answered that relate to both teacher learning and student learning, such as: What models of PBL are most appropriate for adoption with young students? What types of learning may be promoted by adopting particular approaches to PBL? What types of professional development are most appropriate for helping practitioners adopt PBL as part of their regular teaching practice?

This study focused on teacher learning and the explicit issues and concerns, as they relate to PBL adoption, expressed by teachers during various stages in the adoption process. All teachers in this study were new adopters of PBL. The expressed concerns during early adoption related to the self and moved to concerns related to improving the impact of the innovation on students (Management, Consequence, and Concern stages.) A lack of time to develop and implement PBL experiences was one of the major concerns expressed by all teachers. Other concerns focused on the nature of PBL, the roles of teachers and students, providing appropriate support for student learning during implementation, assessing student learning during PBL, and finding resources to support a PBL experience. Teachers expressed concerns at more than one stage at a time, thus reflecting the complex nature of the adoption process. Operating within a collaborative inquiry group provided a forum for finding ways to resolve the expressed concerns.

The author offers several recommendations for practitioners, researchers, and other educators that need to be considered during the adoption of PBL or any other educational innovation:

1. Collaborative learning communities should be established during the adoption of an innovation, thus offering teachers a supportive context for engaging in shared meaning-making. This was a critical aspect of this study in terms of establishing a learning environment in which individuals could offer and receive ongoing feedback during all stages of the adoption process from colleagues with varied backgrounds and experience.
2. The CBAM may be used as a tool for teachers to reflect explicitly on their beliefs and practice as they engage with an innovation. While the model was introduced to teachers in an explicit manner in this study, it could have been used more systematically and regularly as a collaborative reflective tool.
3. Those who facilitate the adoption of PBL (and other innovations) may use the CBAM framework to inform their choices regarding the types of supports and interventions needed by individuals at each stage of the adoption process. The information garnered from the CBAM framework was used by the author, and to some extent by other group members, to provide different types and levels of support at various stages (e.g. resources, encouragement, critical feedback).

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APPENDIX A

Summary Stages of Concern and the Primary Concerns Expressed at Each Stage by Teachers

Planning Phase of Project			
Stages	*Informational*	*Personal*	*Management*
Raylene	*A B C*	*E*	*G I J*
Debby	*A B C D*	*E F*	*G I*
Patricia	*A B C D*	*E F*	*G I*
Kayla	*A B D*	*E F*	*G J*
Sarah	*B D*	*E F*	*G J*
Implementation Phase of Project			
Stages	*Management*	*Consequence*	*Collaboration*
Raylene	*H L*	*M N O*	*K*
Debby	*H L*	*N O*	*K*
Patricia	*H L*	*N O*	*K*
Kayla	*H L*	*M O*	*K*
Sarah	*L H*	*M*	*K M*

Legend:

Concerns Expressed:

A- Few examples of PBL problems at the K-4 level

B- Nature of inquiry within a PBL

C- Complexity of problems that are appropriate for each grade level

D- Degree of structure within a PBL

E- Role of the teacher

F- Preparedness of students to learn through PBL

G- Lack of time for planning

H- Lack of time for implementation

I- Finding appropriate resources

J- Scheduling

K- Ensuring the work is collaborative and involves group meaning-making

L- Ensuring the learning is driven by the open-ended problem

M- Offering appropriate scaffolding for students during implementation

N- Questioning students' inability to pose questions based on the problem scenario

O- Ascertaining how well special needs students are functioning during a PBL experience

APPENDIX B

Topics and Learning Outcomes Targeted in the PBL units of the Teachers

Unit Topic	Learning Outcomes (examples)
Life Cycles (Grade 2) Teacher: Raylene	• *Knowledge:* - *Observe and describe changes in the appearance and activity of an organism as it goes through its life cycle* - *Identify constant and changing traits in organisms as they grow and develop*
	• *Skills:* - *Ask questions that lead to exploration and investigation.* - *Select and use materials to carry out their own explorations --Propose an answer to an initial question or problem and draw simple conclusions based on observations or research.* - *Identify new questions that arise from what was learned --Communicate procedures and results, using drawings, demonstrations, and written and oral descriptions.* - *Respond to the ideas and actions of others and acknowledge their ideas and contributions.* - *Work with others in exploring and investigating.*
	• *Attitudes* - *Recognize the role and contribution of science in their understanding of the world.* - *Consider their observations and their own ideas when drawing a conclusion.*
Habitats (Grade 4) Teachers: Debby and Patricia	• *Knowledge* - *Use the terms habitat, population, and community in appropriate contexts.* - *Identify questions to investigate about the types of plants and/or animals at a local habitat and the conditions under which they live.* - *Identify various methods for finding answers to questions related to their local habitat and select one that is appropriate.* - *Make observations related to local habitats and their associated populations of plants and animals.* - *Using appropriate terminology, compare the structural features of plants that enable them to thrive in different kinds of places.*
	• *Skills* - *Work collaboratively while exploring and investigating.* - *Compile and display the data collected in the habitat study using tallies, tables and/or bar graphs.* - *Present the procedures and results of their habitat studies.*
	• *Attitudes* - *Appreciate the role and contribution of science and technology in their understanding of the world.* - *Show interest and curiosity about objects and events within different environments.* - *Demonstrate perseverance and a desire to understand.*

Unit Topic	*Learning Outcomes (examples)*
Living Things (Grades 1 and 3) Kayla and Sarah	• *Knowledge* *Grade One* *- Identify and describe common characteristics of humans and other animals, and identify variations that make each person and animal unique.* *- Observe and identify similarities and differences in the needs of living things.* *- Describe different ways that plants and animals meet their needs.* *- Describe the different ways that humans and other living things move to meet their needs.* *- Investigate and describe changes that occur on a daily basis in the characteristics, behaviors, and location of living things.* *Grade Three* *- Investigate and describe how living things affect soil.* *- Investigate and describe how soil affects living things* *- Describe ways in which plants are important to living things and the environment.* *- Identify shapes that are part of natural and human- built structures and describe ways these shapes help provide strength, stability, or balance.* *- Evaluate simple structures to determine if they are effective and safe, if they make efficient use of materials, and if they are appropriate to the user and the environment.*
	• *Skills* *Grade One* *- Ask questions that lead to exploration and investigation.* *- Identify problems to be solved.* *- Make and record relevant observations and measurements, using written language, pictures, and charts.* *- Follow a simple procedure where instructions are given one step at a time.* *- Use appropriate tools for manipulating and observing materials in building simple models.* *- Make and record relevant observations and measurements, using written language, pictures, and charts.* *Grade Three* *- Identify problems to be solved.* *- Make and record relevant observations and measurements, using written language, pictures, and charts.* *- Follow given safety procedures and rules and explain why they are needed.* *- Identify and suggest explanations for patterns and discrepancies in observed objects and events.* *- Propose an answer to an initial question or problem and draw simple conclusions based on observation or research.* *- Communicate questions, ideas, and intentions while conducting exploration.* *- Communicate procedures and results, using drawings, demonstrations, and written and oral descriptions.*

Unit Topic	Learning Outcomes (examples)
	• *Attitudes* *<u>Grade One and Three</u>* *- Recognize the role and contribution of science in their understanding of the world.* *- Show interest in and curiosity about objects and events within the immediate environment.* *- Consider their observations and their own ideas when drawing a conclusion.* *- Be open minded in their exploration.* *- Work with others in exploring and investigating.* *- Be sensitive to the needs of other people, other living things, and local environment.*

APPENDIX C

Examples of Assessment and Learning Activities adopted in Each PBL Unit

Unit Topic	Assessment/Learning Activities (examples)
Life Cycles (Grade 2) *Teacher: Raylene*	*Generating questions based on the PBL scenario* *Presenting solutions to the problem* *Journal writing* *Recording observations of butterfly stages (larva house set up in the classroom)* *Teacher observation checklist* *Visiting websites/reading books*
Habitats (Grade 4) *Teachers: Debby and Patricia*	*Generating questions based on the PBL scenario* *Presenting solutions to the problem* *Planning and creating a garden* *Researching using web sites, books, and magazines* *Recording information* *Using applets (Plant parts)*
Living Things (Grades 1 and 3) *Kayla and Sarah*	*Generating questions based on the PBL scenario* *Building bat houses* *Viewing videos about bats* *Taking pictures* *Compiling portfolios about bats* *Presenting solutions to the problem* *Using a webquest*