FACILITATORS' PERCEPTIONS OF FACILITATION

IN THE PROBLEM-BASED LEARNING

MATHEMATICS CLASSROOM

by

SHELIA MCGEE INGRAM

B. JOYCE STALLWORTH, CHAIR
JAMIE D. MILLS, CO-CHAIR

M. JENICE GOLDSTON
ROXANNE MITCHELL
TOMMY SMITH
ELIZABETH K. WILSON

A DISSERTATION

Submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy in
the Department of Curriculum and
Instruction in the Graduate School
of The University of Alabama

TUSCALOOSA, ALABAMA

2013

ABSTRACT

Despite the significant amount of research on problem-based learning (PBL) in medical education and gifted education, there is only a scarce amount of research on this instructional approach in secondary mathematics education. The purpose of this study was to examine the perceptions of secondary school mathematics PBL facilitators on their facilitator training, classroom experiences, roles, skills, and implementation challenges. Survey data were collected from a sample of 41 facilitators who received PBL training from the Problem-based Learning Network (PBLN) of the Illinois Mathematics and Science Academy (IMSA). The findings revealed that a strong majority of participants indicated that their PBL training was effective at helping them understand the PBL philosophy, and the training provided them with sufficient insight into how they should manage the small group learning process. One major result indicated no statistically significant difference between mean *roles* scores and no statistically significant difference between mean *skills* scores based on level of facilitation experience. Qualitative findings indicated various challenges and difficulties facilitators perceived they faced while they planned for and implemented PBL into their classroom, including time constraints and curricular constraints. The qualitative results also indicated the majority of respondents found one or more roles of a PBL facilitator difficult or challenging, including managing the small group learning process. The results revealed that a small percentage of participants who received PBL facilitation training did not implement the instructional approach into their classroom while the implication from this finding suggested the need for additional training, professional development, and additional support from school administrators. Limitations

related to the findings are reported and discussed, which includes the small sample size and the small number of problems scenarios some participants had facilitated.

ACKNOWLEDGEMENTS

I have been blessed to experience the guidance of caring individuals who recognized the importance of helping others reach their goals. Since no one achieves a goal alone, I have a dissertation committee, a team of family and friends, including my mentors, who supported me in my passion for learning. I also fully recognize the sacrifice and devotion of my husband and the support of my children (Ashley, Rodrick, and Aaron).

I would like to express my gratitude to my dissertation chairperson, Dr. B. J. Stallworth, for her unwavering support during the pursuit of my doctoral degree. I truly appreciate the time and guidance you have given me. I would like to thank my co-chair Dr. Jamie Mills. Your guidance and expertise have been invaluable during this process. I would also like to thank my committee members, Dr. Elizabeth Wilson, Dr. Roxanne Mitchell, Dr. Jenice Goldston, and Dr. Tommy Smith for their feedback and service while pursuing my research.

I dedicate this dissertation to my wonderful husband, thank you for your understanding and sacrifice as I spent many a day and night working on this dissertation.

CONTENTS

APPENDICES

LIST OF TABLES

LIST OF FIGURES

CHAPTER I:

INTRODUCTION

Background

Problem-based learning (PBL) originated in the late 1960s in medical education because of students' unsatisfactory clinical performance related to traditionally taught courses (Barrows, 1996; Barrows & Tamblyn, 1980). Medical students needed effective clinical problem-solving and lifelong learning skills, but studies concluded that the traditional teaching approaches were inadequate in equipping the students with these skills (Albanese & Mitchell, 1993; Barrows, 1996). Therefore, faculty at McMaster University developed a student-centered, problem-based, interdisciplinary approach to learning (PBL) that they believed would better prepare students for their clinical experience and as future doctors. Educators in higher education and medical schools have used PBL successfully for many years (Savery, 2006), and more recently some teachers in K-12 education have adapted and used the model (Hemlo-Silver, 2004).

PBL has become an increasingly popular instructional approach as evidenced by the numerous publications (e.g., Delisle, 1997; Lambros, 2004) and web sites dedicated to its implementation. Also, research has consistently shown that PBL as a pedagogical approach, aid students in constructing an extensive, flexible knowledge base, developing effective problem-solving skills, and developing self-directed lifelong learning skills (e.g., Gallagher, Rosenthal, & Stepien, 1992; Gallagher & Stepien, 1996). Such skills are vital K-12 learning goals.

However, instructional practices over the years in mathematics classrooms have not varied significantly. In addition, they have not adequately aided students in developing a deep understanding of mathematical ideas. Ronis (2008) has suggested traditional instructional practices usually do not help students make real-world connections that would better prepare them for college or the workforce. Consequently, as students enter college and the workforce, many find they lack critical thinking, problem-solving, communication, and collaboration skills (Hemlo & Evensen, 2000; Partnership for 21st Century Skills/AACTE, 2010). Students also need flexible thinking and lifelong learning skills, which have become the focus of discussions regarding classroom improvement in an effort to prepare them to succeed in school and beyond (Bransford, Brown, & Cocking, 2000; Greeno, Collins, & Resnick, 1996).

Therefore, mathematics education stakeholders continue to seek a methodology that will best educate learners of the 21^{st} century since many students in the mathematics classroom are lacking in their ability to understand, communicate, and apply key concepts in mathematics (O'Brien, 1999; 2004). In an attempt to meet the needs of today's diverse learners, some national organizations are urging classroom teachers to use innovative methods of instruction that aid students in demonstrating comprehensive learning and apply it to real world settings (e.g., National Council of Teachers of Mathematics (NCTM), 2000; National Science Foundation, 2006). Richardson (2003) has explained that education stakeholders are now placing an emphasis on the student's ability to understand and use information, not just merely possess it. According to researchers and practitioners, PBL is a viable instructional approach for teaching mathematics that holds the promise of aiding teachers in supporting students in meeting these learning goals when effectively implemented (e.g., Erickson, 1999; Lubienski, 1999; Ronis, 2008).

Statement of the Problem

Since traditional instructional practices usually do not help students make real-world connections, many educators have moved from using more traditional instructional approaches to teaching students with a focus on understanding by implementing PBL into their mathematics classroom (Ronis, 2008; Schoen & Charles, 2003). However, the problem is that even when teachers desire to implement PBL into the classroom they often face internal and external challenges (Delisle, 1997; Torp & Sage, 2002). Effectively implementing PBL is a complex task for both novice and veteran teachers (Lewellen &Mikusa, 1999). Moreover, Torp and Sage (2002) have explained that when implementing PBL, many teachers have to rethink the entire idea of teaching and learning, and they may at times feel overwhelmed. They take on increased responsibilities beyond presenting mathematical information to students. They also must assist students in learning various mathematical procedures and skills linked to communication, representation, modeling, and reasoning (Erickson, 1999; Lubienski, 1999; Smith, 1998).

Another problem is that there is a scarce amount of empirical research on implementation challenges PBL mathematics facilitators often encounter. This study fills that gap in the research literature. PBL facilitators are teachers who use PBL as a classroom instructional approach and are referred to as facilitators in this study (Hemlo-Silver & Barrows, 2006). However, within that scarce amount of research, researchers rarely indicate the professional development, training, and support facilitators perceived as useful in aiding them in effectively planning for and implementing PBL in to the classroom (e.g., Cerezo, 2004; Gallagher et al., 1992). Such knowledge would be directly helpful to PBL facilitators, to school administrators, to teacher educators, and to others considering implementing PBL. Consequently, the researcher's rationale for this study is to add to the scarce amount of research on PBL in secondary mathematics education and develop a better understanding of the facilitation processes and challenges based on the viewpoints of those who have been trained on the approach. Thus, allowing the researcher and others to make more informed decisions in reference to implementing the approach or sustaining its implementation.

Purpose of the Study

A major purpose of this study was to examine facilitators' perceptions of implementing PBL in the secondary (grades 6-12) mathematics classroom. These are facilitators (classroom coaches) who have previously participated in PBL professional development. In addition, this study investigated how teachers previously trained in PBL perceived their roles and duties in the tutorial process (learning process). This study explored facilitators' perceptions of the skills needed to implement PBL, and it examined the facilitators' perceptions of the challenges they encounter while planning for and implementing PBL.

Research Questions

The following questions guided this study:

1. What are the perceptions of secondary school mathematics PBL facilitators of facilitator training and facilitator experiences, as measured by the Facilitator Perception Survey-Revised;
2. Are there any differences in the perceptions of roles and responsibilities among secondary mathematics PBL facilitators with different levels of facilitation experience (i.e., novice, intermediate, advanced, and expert) as measured by the Facilitator Perception Survey-Revised;
3. Are there any differences in the perceptions of the skills needed for effective implementation of PBL among secondary mathematics PBL facilitators with

different levels of facilitation experience (i.e., novice, intermediate, advanced, and expert) as measured by the Facilitator Perception Survey-Revised; and

4. What challenges do secondary school mathematics, PBL facilitators perceive they encounter while they are planning for and implementing PBL into the classroom as measured by the Facilitator Perception Survey-Revised?

Overview of Research Design

In order to examine the research questions, a survey research methodology was used in this study with an online questionnaire for data collection. According to Creswell (2005), survey research is a quantitative research method in which the researcher administers a survey to a sample or an entire population of participants in order to describe the attitudes, perceptions, behaviors, or characteristics of the population. The target population in this study was secondary mathematics teachers who had completed a PBL professional development workshop. A non-random purposeful convenience sample was used to select participants for this study. The sample for this study consisted of teachers who were members of the Problem-based Learning Network (PBLN) at the Illinois Mathematics and Science Academy (IMSA). PBLN provides professional development to PBL facilitators, who range in experience from novice to expert, on inquiry-based teaching strategies and skill. The participants in the study were selected based on the following criteria: 1) participants must have previously participated in PBL professional development; and 2) participants must have taught mathematics in grades 6-12.

Definitions and Terms

For the purpose of this study, the following terms are significant.

Novice Facilitator–A novice facilitator is a teacher who has been trained as a PBL facilitator, but has only been a PBL facilitator for less than three years (or facilitated less than three problem scenarios).

Intermediate Facilitator – An intermediate facilitator is a facilitator who has been a PBL facilitator for 3 to 6 years (or facilitated 3 to 6 problem scenarios)

Advanced Facilitator – An advanced facilitator is a facilitator who has been a PBL facilitator for 7 to 10 years (or facilitated 7 to 10 problem scenarios)

Basic PBL Training – Basic PBL training is a four-day institute that provides participants with experience as PBL learners engaged in a problem. The participants analyze the key elements of IMSA's PBL model and design a problem scenario to be used in their own classrooms. They identify learning objectives linked to state and national standards and benchmarks and design assessment opportunities.

Advanced PBL Training – Advanced PBL training is a four-day institute. Completions of basic PBL training and classroom experience with PBL are prerequisites for participating in advanced PBL training. Advanced training allows participants to improve their PBL ideas and strategies in a collaborative environment. Participants' bring work that is already in progress; they test out problem scenarios, research resources, develop a questioning plan and authentic assessment plan for their unit, and brainstorm problem ideas for curriculum.

Expert Facilitator – An expert facilitator is a facilitator who has been a PBL facilitator for more than 10 years (or facilitated more than 10 problem scenarios).

Cognitive/Metacognitive Coaches – Cognitive coaches guide students in reflecting on their thinking (i.e. thinking about thinking). In other words, they guide students in acquiring knowledge about cognitive processes (thinking processes), knowledge that can be used to control cognitive processes.

Experienced Facilitator – An experienced facilitator is a teacher who has been trained as a PBL facilitator and has been a PBL practitioner for three years or more.

PBL Curriculum – A PBL curriculum consists of carefully selected and designed problems that demand from the learner acquisition of critical knowledge, problem-solving proficiency, self-directed learning strategies, and team participation skills.

Learning Issues – Learning issues are what students identify they "need to know," but "do not know."

Metacognition – Metacognition is the ability to control one's cognitive processes.

PBL Tutorial – A PBL tutorial is a small group learning process used in problem-based learning.

PBL Unit – A PBL unit is not always interdisciplinary (e.g., consist of math, science, and history), but it is always integrative (e.g., consist of multiple subjects, domains or topics in the same discipline such as algebra, geometry and calculus).

Professional Development – Professional development is the training that a teacher receives towards the goals of developing new skills, knowledge, and competencies.

Secondary School – Grades 6-12

Self-directed Learning – Self-directed students take the initiative and responsibility for their own learning. They select, manage, and assess their own learning activities. In PBL, teachers emphasize and support students in acquiring self-directed learning (SDL) skills.

Student-centered Classroom – This is a classroom where the focus is not on the teacher teaching, but rather, the focus is on students' learning where the students are active and involved in learning.

Facilitator or Classroom Coach or Tutor – A facilitator in this study is a teacher who uses PBL as a classroom instructional approach (Hemlo-Silver & Barrows, 2006). The facilitator's role is to guide or coach students during the tutorial (learning process).

Organization of the Study

This study is divided into five chapters. Chapter I provides an introduction to the study. Chapter II provides a review of relevant literature related to facilitators' implementation of PBL into the secondary mathematics classroom. Chapter III explains the study's methodology and research design. Chapter IV discusses the results of the study. In conclusion, Chapter V discusses the implications of the findings and recommendations for future research.

CHAPTER II:

LITERATURE REVIEW

Overview

PBL scholars and practitioners commonly refer to a PBL teacher as a facilitator or classroom coach or tutor (e.g., Hemlo-Silver, 2004; Hemlo-Silver & Barrows, 2006; Savery, 2006). A facilitator in this study is a teacher who uses PBL as a classroom instructional approach (Hemlo-Silver & Barrows, 2006). However, this chapter reviews the literature relevant to this study. It begins with an overview of constructivism, which is the theoretical framework of PBL. Research studies on PBL are included next, followed by relevant literature on the roles of a facilitator. Next, this chapter includes relevant literature on the design of professional development, which is a central component in teaching and effective implementation of reform mathematics curricular and instructional approaches in the classroom. The chapter concludes with relevant literature on factors related to implementation of PBL and the effects the implementation procedures may have on research outcomes**.**

Theoretical Framework

Problem-based learning has its roots in constructivism, but many of these views date back to John Dewey (1938). While PBL has a foundational framework in medical education, it is consistent with the principles of constructivism (Torp & Sage, 2002). Moreover, Brooks and Brooks (1999) stated that constructivist views encourage a learning environment where students explore their world, discover knowledge, reflect, and think critically. Furthermore, constructivism put emphasis on the significance of the teaching context, learners' prior knowledge, and active interaction between the student and the content to be learned.

Constructivism characterizes how individuals solve real-life, challenging problems in society by working with others. In constructivism people make thoughtful decisions and take the initiative to solving problems. In classrooms using problem-based learning, teachers address these principles of constructivism, and Savery and Duffy (1995) have argued that PBL learning environments may be one of the best examples of a constructivist learning environment.

A constructivist perceives learning as a process of knowledge construction, with concept development and comprehensive understanding as the objectives (Brooks & Brooks, 1999; Fosnot, 1996). Savery and Duffy (1995) have posited that learners construct their own knowledge, and the motivation for learning is "puzzlement" which is some experience of cognitive conflict. Equally important, learning is an active effort by learners interested in resolving issues and should be organized around their interest. As explained by von Glasersfeld (1989), cognitive change and learning take place when a learner's way of thinking or scheme leads to a cognitive conflict instead of producing what the learner expects. When this cognitive conflict or puzzlement happens, students engage in accommodation (cognitive change) and gain a new sense of balance. Cognitive change is facilitated through the interaction with others who may hold different understandings. According to Savery and Duffy, learners bring their own beliefs to learning experiences based on what fits their experiences, but social interactions may challenge their current views as well as allow them to test their current understandings. PBL, therefore, exemplifies the constructivist approach to teaching.

Research on PBL

Many scholars have posited problem-based learning (PBL) as an effective method to prepare students to become lifelong learners because of its emphasis on self-directed learning (SDL). Its proponents also claim that it will help students become effective collaborators and intrinsically motivated to learn (Cerezo, 2004; Hemlo-Silver & Barrows, 2006; Schmidt & Moust, 2000). Furthermore, they believe PBL will boost students' problem solving skills, and help them to construct a broad and flexible knowledge base (e.g., Gallagher et al., 1992) Educators have long attempted to empower their students with effective learning skills, yet the processes of attaining these goals have varied over time. Moreover, some education stakeholders have largely accused today's generation of teachers of inadequately preparing students in acquiring these skills (e.g., Ronis, 2008; Schoen & Charles, 2003). It is problematic for students when they do not acquire these essential skills because they need them to be successful in school, the workforce, and their personal lives. Many researches support PBL as a viable teaching alternative to traditional approaches of teaching (e.g., Hiebert et al., 1996; Mergendoller, Maxwell, & Bellisimo, 2006) that can support students in attaining necessary skills to be successful in the 21st century. Furthermore, according to Lambros (2004), numerous schools nationwide have embraced PBL within the past ten years with several other schools considering adopting a PBL approach.

However, there is a large amount of variations in the research findings on the effectiveness of PBL (Walker & Leary, 2009), and much of this research is in medical education (e.g., Albanese & Mitchell, 1993; Dochy, Segers, Van den Bossche, & Gijbels, 2003). For example, a synthesis of medical education inquiries indicated that PBL was more effective in attaining the students' interest and motivation than traditional teaching approaches (Vernon & Blake, 1993). Though, with the rigor and high expectation of medical school curriculum, the understanding is that medical students are inherently more prone to be motivated than the average student with lower aptitudes for learning. Thus, it is arguable whether one can generalize the findings from PBL research inquiries, which researchers conducted on medical students, on the average student (Berkson, 1993 cited in Mergendoller, et al., 2006). Consequently, this literature review focuses on research on PBL at the secondary school level.

Secondary School Research Studies

The researcher defined PBL, collectively from studies that focused on secondary school students. These studies together define PBL, as an instructional approach in which the teacher poses a complex problem to students, and ask them to reason, question, research, and think critically to resolve the problem (Cerezo, 2004; Gallagher et al., 1992; Mergendoller et al., 2006). In alliance with this definition, Gallagher et al. (1992) examined the effects of a high school version of the medical school model of PBL in a study on students' academic achievement and problem-solving skills. PBL, which educators previously used at the college level, had not been tested with secondary school students. In the researchers' study, the experimental class enrolled in an interdisciplinary, problem-based course that consisted of gifted mathematics and science students. The comparison group who were not taught using PBL also consisted of gifted students. Furthermore, the researchers presented the students with two "ill-structured" (open ended, complex problems) problems. Results showed some significant changes for the PBL class that were not observed in the comparison class. For instance, they observed a significant improvement in the problem solving schemes of the students in the problem-based class, but this improvement was not evident in the students in the comparison class.

Moreover, Lubienski, (2000) examined 7th graders experiences using PBL, focusing on the socio-economic status (SES) differences in their reactions to mathematics through PBL. The researcher found that the higher SES learners were more likely to demonstrate confidence and solve problems while focusing on the intended mathematical ideas. However, the lower SES students preferred additional external direction and at times approached problem scenarios in a way that caused them to miss their intended mathematical ideas.

Cerezo (2004) conducted a qualitative study to examine how middle school math and science students who had been taught using PBL perceived the changes in their learning process. Additionally, the researcher wanted to know if there were any changes in their self-efficacy and how the students described these changes. In other words, the purpose of this study was to examine PBL, and how students in middle school math and science classes perceived its effectiveness. This case study consisted of 14 at-risk female students incorporating nine classes (math and science) of various levels (i.e., sixth, seventh, and eighth grade classes) from three middle schools in one school district in the southeast part of the United States. Each school consisted of about 40% of minority students, and the teachers selected female students at-risk of failing a math or science course to participate in the study.

The staff development program at the Center for Educational Research and Teacher Learning trained the teachers in PBL. Furthermore, the researcher provided a comprehensive definition of at-risk to the teachers, and the teachers identified students as at-risk for several reasons (e.g., students with learning disabilities, students with self-esteem problems, and students with low grades in math or science). They taught the students during the school year by using the PBL approach. In addition, the focus of the researcher's study examined students and self-efficacy via interviews. The researcher used the structured interviews to understand the perceived changes in students' learning process and self-efficacy.

Cezero (2004), through careful analysis of qualitative data, examined the perceptions of students learning processes and their self-efficacy. However, limitations to the study were the small sample size and lack of random selection of students. Furthermore, major findings from this study indicated a positive correlation between self-efficacy and PBL and an increase in self-motivation. Data revealed that PBL helped increase the students' confidence in taking control of their learning. Moreover, students' attitude towards mathematics improved, and results indicated all students benefited from PBL in one way or another (e.g., increased self-efficacy, increased confidence). However, there are other qualitative studies that reveal that not all students believe they benefited from PBL (e.g., Lubienski, 2000).

In another study in which students taught using PBL showed increased confidence, Clarke et al. (2004) examined the perceptions of students of the effectiveness of PBL. The researchers addressed students' mathematics beliefs and perceptions outcome. They found that students who participated in the problem-based program appeared to be more confident than their peers in the traditional classes. These students also valued communication in mathematics learning more than students in the traditional classes. Moreover, the problem-based students were more likely to see a mathematical component in everyday activity. These outcomes occurred while the problem-based students' performance levels on the mathematics portion of the SAT were sustained at or above those of their peers (in traditional classes).

In a quantitative study, Mergendoller et al. (2006) hypothesized that there would be no difference in learning achievements between students in the PBL and traditional instructional environments. Mergendoller et al. proposed that, with the scarcity of research on PBL in high schools, that there is a need for more research before it is plausible to accept the claims that PBL is more effective for lower achieving students than traditional instruction. However, given this research and their own observations of problem-based environments, the intent of the study was to compare and contrast students' preference to learning in groups and their perceptions of competency to problem solve in PBL learning environments.

Mergendoller and colleagues (2006) selected a sample from all the high schools located in a large metropolitan area in northern California. They collected data from a sample of 346 twelfth-grade students in 11 classes and five veteran teachers from four different high schools. For the data analysis, an independent sample t-test was used to examine whether students in the PBL and traditional classes showed statistically significant difference ($p < .05$) in their verbal ability. At the start of the semester, students in both the experimental and control classes completed the aptitude measures (academic ability, attitude towards economics, preference for group work, and problem-solving efficacy). The researchers based the data analysis on data gathered from the pre and post-macroeconomics knowledge instrument and the verbal ability measure.

Moreover, the researchers used the verbal ability as a proxy for general academic ability and they measured it using the Quick Word Test: Level 1 (Borgatta, 1964). They developed an instrument to measure students' interest in learning economics. The questions on the instruments allowed the students to respond on a scale ranging from 1(very interested) to 5 (not interested). They also designed similar instruments to measures students "preference for group work" and "problem-solving efficacy" with scales ranging from 1 to 5. The data led the researchers to reject the first hypothesis. The first hypothesis specified that the PBL method was more effective than the traditional method in aiding students in learning basic macroeconomic concepts.

Mergendoller and colleagues (2006) also tested whether there was a difference in gains, in macroeconomics knowledge between students with different aptitude levels, in PBL and traditional classes. Their data analysis allowed them to accept their second hypothesis of no difference in pretest-posttest change, in macroeconomics knowledge between students with different levels of verbal ability in PBL and traditional classes. The data also led them to reject their third hypothesis, indicating a difference in pretest-posttest change, in macroeconomics knowledge among students with different levels of the following aptitudes: interest in learning economics, preference for group work, and, problem solving efficacy.

A key limitation of Mergendoller and colleagues (2006) study was the lack of in-depth information about what exactly, teachers were doing in the PBL classes that distinguished them from the traditional classes, and how they associated these differences with increased student learning. Last, Mergendoller et al. (2006) and Cerezo (2004) have emphasized the importance of more studies with at-risk students, those who do not typically succeed in school. Furthermore, there are other studies in which researchers report the outcome of the goals of a PBL model, though some without including appropriate data (e.g., Gordon, Rogers, Comfort, Gavula, & McGee, 2001). These opinion articles were excluded from this discussion.

Teaching mathematics using PBL has received some criticism in the literature. For example, several researchers (Kirschner, Sweller, & Clark 2006; Mayer, 2004; Winn, 2003) emphasized that, despite the claimed advantages of problem-based environments to help students construct meaning from learning experiences, cognitive load theory suggests that the unguided exploration of a highly complex environment may generate a heavy working memory load. Moreover, this heavy working memory load is harmful to learning, which can be more detrimental for those students new to problem-based learning environments that do not have appropriate schemas to integrate the new information with their prior knowledge skills. Also, Lubienski (1999) in her study has suggested that another criticism of PBL is that it results in teachers covering a limited amount of mathematics content (the coverage issue). In other words, some teachers believe if they implement PBL into the mathematics classroom, they will not have time to cover all the objectives in the curriculum because of the extended time some complex problem scenarios take to resolve.

Role and Skills of the PBL Facilitator

Before facilitators embrace facilitation, it is essential for them to understand and accept the philosophy that supports PBL. Each educator must, therefore, believe in the benefits of active, constructive learning and be able to give up some teaching control, which is inherent in traditional teaching approaches (Torp & Sage, 2002; Ronis, 2008). However, for many teachers, PBL as an educational philosophy, questions many of the theories of knowledge embedded in their previously designed student activities, in a traditional classroom. Therefore, PBL may be met with some resistance (Schoen & Charles, 2003).

However, the facilitator’s roles are critical to the success of the small group tutorial (learning process), which is a key element of PBL. The facilitator has numerous roles, but the facilitators’ primary role is to ensure student learning and interaction during the small group sessions. Student learning is dependent on the facilitator’s understanding of and motivation to embrace his or her responsibilities in the tutorial (Torp & Sage, 2002). The facilitator must insure that the students’ construction of knowledge is meaningful, which is a pivotal and challenging role. The facilitator must develop a “mathematical discourse community” of learners. In this community, the students problematize mathematics. In other words, they wonder why things are, they inquire, they search for resolutions, and they resolve incongruences, and the teacher also shares in searching for resolutions (Hiebert et al, 1996).

A mathematical discourse community is a community in which the facilitator uses students' thoughts and ideas as the foundation for class discussions while also making sure that the discussions are productive mathematically (Sherin, 2002a). Developing mathematical discourse communities which support interactive mathematical discussions is challenging for many teachers and their students. It is likely challenging because they might not have formerly been exposed to learning and teaching in such classrooms (Hunter, 2009). However, one of the PBL instructional objectives is that learners are involved in a learning community in which each participant has an opportunity to take part in productive mathematical dialogue (Manoucheri & St John, 2006).

The facilitator must also select and present problems that engage students in reflective inquiry that stimulates meaningful learning (Clarke, 1997; Hiebert et al, 1996). Furthermore, motivation and perseverance are particularly vital elements in successful problem solving. Equally important, the facilitator should make sure that the problem solving task is not altered after the students begin working. In other words, the facilitator must also keep the cognitive demands of high-level problems from diminishing (Erickson, 1999).

To keep learners from becoming discouraged or unmotivated, teachers should share pertinent information with them if it will not inhibit them from problematizing the subject. The learners will likely make extremely slow progress if they have to rediscover everything on their own. Schoenfeld (1992) added that because conflict is an essential part of learning, the facilitator should also reveal conflicts between different interpretations or solutions. The facilitator must aid students in examining one another's suggestions and critically reflecting on them by anticipating disagreement among groups and group members.

Effectively implementing PBL is not an easy task for a facilitator, predominantly because students are expected to develop their own strategies for solving problems. Facilitators must support students in developing these informal strategies into formal strategies, which can be applied in other situations (Wubbels, Korthagen, & Broekman 1997). Also, facilitators need sound pedagogical content knowledge, which is mathematics content knowledge and knowledge of how students learn mathematics. Facilitators who understand how students learn are able to provide students with varied opportunities to construct knowledge. They can easily adapt their teaching styles or approaches to accommodate the different learning styles of students.

Another important aspect of the PBL facilitator's roles is the selection of an appropriate problem or task to present to the class. These problems should enable learners to see the usefulness of mathematics in their everyday lives. These problems can be solved using many different strategies (e.g., table, guess and check, equations, etc.). In selecting tasks, the teacher should draw on the knowledge of the subject and learners own thinking (Hiebert et al., 1996). Knowledge of the subject encourages learners to be exposed to key ideas. Knowledge of students thinking allows the teacher to select tasks linked to students experiences so students can see the relevance of ideas and skills they already posse. Erickson (1999) has indicated that the problems teachers choose should be interesting and challenging for students. They should have multiple solution strategies, multiple representations, and multiple solutions. However, the researcher warns that although the problems chosen should be challenging; they should be of reasonable difficulty level so as not to discourage learners (zone of proximal development).

The selection and ordering of tasks are also critical roles of facilitators. Consequently, the facilitators must be mindful of the students' prior knowledge. Murray and colleagues (1998) have cautioned that sequencing of task, studying special or extremely simple problems initially does not make the development of concepts and skills easier. The researchers have suggested that there is no hierarchy or order that best describes the sequence or structure of every student's knowledge acquisition. Cangelosize (1996) added that the integration of topics is extremely important. The scholar has indicated that integration of topic is crucial because when topics are isolated (e.g., geometry from algebra, linear equations from quadratic equations) learners may find it difficult to see the connection or relationship between many concepts.

In conclusion, the facilitator has numerous vital roles in the PBL process, and one may say that a facilitator should not be a transmitter of knowledge but a facilitator of knowledge. Furthermore, they must be co-learners with the students while sustaining a classroom environment that is conducive to learning (Boaler, 1999; Hiebert, 1996). More importantly, the values of mathematics as sense-making should be reflected in everyday activities, and the facilitator must make every effort to assure that the classroom is a safe place for students to express their thoughts and ideas without fear of ridicule or embarrassment (Schoenfeld, 1989a). Instructional materials alone do not determine the ability of a teacher to implement an instructional approach effectively, but rather, an interaction among various factors such as teachers' beliefs and teachers' professional development experiences as suggested by an increasing body of research (Roth, 1995; NCTM, 2000; Stein et al., 2000; McCaffrey et al., 2001; Boaler, 2002; Schoen et al., 2003). The transition from teacher to facilitator requires teachers to develop numerous nontraditional teaching skills in PBL facilitation. Thus, it is evident that teachers will need training and professional development to fulfill such challenging roles.

Professional Development

Professional development, according to Loucks-Horlsey et al. (1998), refers to the opportunities accessible to educators to cultivate new knowledge, skills, methods, and dispositions to advance their effectiveness in their classrooms and organizations. The scholars differentiate between in-service education, staff development, and training since professional implies a commitment to continuous learning. Professional development in this age of reform, according to Darling-Hammond and McLaughlin (1995), means providing instances for teachers to reflect critically on their practice and to acquire new knowledge and beliefs about content, teaching, and learners. Much of the current literature on professional development has emphasized a need to rethink the structure of professional development experiences for teachers.

Loucks-Horsley et al. (1998) have suggested that there is a paradigm shift in professional development, one in which there is less emphasis on transmission of knowledge and more on learning through experience, which supports constructivism. What is known is that many teachers were trained to teach in a style that put emphasis on memorizing facts, with not as much of an emphasis on a deep understanding of the subject matter (Darling-Hammond & McLaughlin, 1995). Consequently, traditional professional development efforts have been criticized for the previously mentioned and other numerous reasons. For example, professional development efforts that take place out of context are viewed as less than ideal. Professional development efforts that are not related to teachers' experiences and are short-term are also criticized. In addition, those in which teachers are just passive participants that consist of disjointed activities, and do not provide chances for collaboration are not regarded as effective professional development methods. Moreover, Elmore (2002) and Speck and Knipe (2005) have suggested that professional development should be designed with support for teachers to grow, change, and reflect on their practices.

As mentioned earlier, teaching using PBL requires a transition for most teachers. Since teachers were not taught or trained to teach in this innovative way, some teachers are likely uncertain about how to teach using this opposing teaching approach. Elmore (2002) has explained that professional development designed for the outcome of substantial changes in practice should center clearly on the domains of knowledge. It should also engage teachers in self-evaluation of their practice. Professional development should provide opportunities for teachers to observe experts and to be observed by and to be given feedback from experts. Other researchers also have argued that professional development should consist of opportunities for teachers to reflect on their practice within the context of their daily classroom experiences (Hawley & Valli, 1999; Putnam & Borko, 2000; Wilson & Berne, 1999).

Darling-Hammond (1998) has maintained that attaining high levels of student understanding requires supporting teachers' continuous learning. Before teachers can aid students in increasing their level of understanding, the teacher must have a deep and flexible understanding of their subject matter. She further added that teachers need to be able to understand how concepts link across fields and that this type of knowledge is the foundation for the pedagogical content knowledge. Equally important, in order to help teachers teach according to education reform initiatives, effective professional development in which teachers assume both the role of teacher and learner are required (Darling-Hammond & McLaughlin, 1995). All of this means that passive participation in professional development for teaching is not likely to result in changed practice. In other words, professional development undertakings, in which teachers are lectured to by an expert or panel of expert teachers, are no longer viewed as effective. Consequently, it seems to be a consensus that just telling teachers what to do differently in their classrooms will not work when transitioning to teaching using a reform instructional approach (PBL).

In order for teachers, to use a teaching approach so different from what they experienced as a student and in their teaching practice, opportunities for them to learn what the new practice consist of must be presented by more than only talking about new pedagogical techniques (Darling-Hammond, 1998; Darling-Hammond & McLaughlin, 1995). This is equally the case when adapting to PBL. Major changes in practice are difficult for many teachers. However, research indicates that there is still much to learn about what types of professional development models help teachers most. What is explicit, as indicated by research and PBLN, is that while implementing PBL into the classroom administrators and school systems should think about the support and professional development mechanism their teachers will need to aid in the effective implementation of PBL. Consequently, according to PBLN (2008), IMSA developed a PBL model for K-12 educators, and since the early 1990s PBLN has provided professional development in PBL to teachers in over 30 states and 7 countries. However, research continues to show that many facilitators still struggle to implement PBL effectively in the classroom (e.g., Gallagher, 1997; Grants & Hill, 2006).

Implementation of PBL

Calls for changes in mathematics teaching and learning (e.g., NCTM, 1989, 1991, 2000) have generated significant interest in how teachers implement problem-based approaches to instruction. In a study of teaching practices in Germany, Japan and the United States, Stigler and Hiebert (1999) found that teachers in the US have a tradition of presenting mathematics as a collection of terms and procedures. A typical United States mathematics lesson consists of the teacher leading the class in checking homework, followed by a quick-paced question and answer session with the teacher demonstrating solution methods and asking students to work several similar problems, and then closing the class with the teacher assigning new homework. Thus, for most United States teachers, as well as teachers from many other countries, problem-based approaches to teaching represent a substantial shift in practice (Boaler, 2002), which likely contributes to the resistance to and difficultly in implementing PBL into the mathematics classroom.

Furthermore, not all researchers consider the effect of facilitators' training and professional development on implementation of a curricular or instructional approach. When this factor is not considered, studies that conclude that the students' perceptions are to the actual instructional approach instead of to its inadequate implementation would be a mistake. However, many research studies have documented that variations in implementation exist or that their studies conclusions are presented even though they failed to consider implementation consistency (Huntley et al., 2000; Star, Smith, & Jansen, 2008; Tarr et al., 2008). Reys et al. (2003) explained that teachers even within the same school may vary in their implementation of a curricula or instructional approach. Senk and Thomposn (2008) added that variations in implementation exist in instruction, even when teachers teach the same lessons.

Examining issues of implementation is vital because they will have an effect on the study's results. According to Mergendllor et al. (2006), attending to some implementation issues can be addressed by all teachers receiving implementation training as opposed to professional development training. The facilitators in their study had participated in at least a one-week training workshop to prepare them to implement the PBL unit in their classes. All instructional resources essential to teach the PBL lessons were provided, as well as a carefully prepared curriculum guide and instructions and strategies for guiding students through the problems. Discussions with teachers as they taught the lessons and at debriefings when they had concluded the unit suggested that the PBL and traditional approaches were implemented as intended. In conclusion, results have suggested that given the variations in teachers' implementation of the same instructional approach one could argue that students taught using the same approach could have entirely different learning outcomes. Consequently, variations in implementation consistency may explain some of the contradictory results in PBL studies.

Summary

While research has documented the positive effects of problem-based learning (e.g., Albanese & Mitchell, 1993; Cerezo, 2004; Dochy, Segers, Van den Bossche, & Gijbels, 2003), less is known about it effects in secondary education. Based on the review of the literature, there appears to be a significant amount of research in medical education and gifted education pertaining to PBL, however, the research base of PBL in secondary mathematics education is scarce and, therefore, need further investigation.

This chapter began by examining constructivism, the theoretical framework of PBL. It also synthesized PBL studies in secondary education and identified roles of a facilitator and facilitation skills needed for effective PBL implementation. It explored characteristics of training and professional development relevant for PBL's effective implementation. Last, the chapter provided an overview of concerns on the variations in the implementation process.

Chapter III presents the methodology of this study. The chapter identifies the research design, participants, instrumentation, and procedures of data collection and analysis.

CHAPTER III:

METHODOLOGY

Overview

This chapter provides an overview of the methodology of this study. The first section describes the research design and discusses why an online survey research method was utilized. The following sections include the Sample, Instrument, Procedure, and the chapter concludes with the analysis of data.

The purpose of this study was to investigate the perceptions of PBL facilitators who received professional development on how to implement effectively PBL into the classroom. More specifically, the study addressed the following questions:

1. What are the perceptions of secondary school mathematics PBL facilitators of facilitator training and facilitator experiences, as measured by the Facilitator Perception Survey-Revised;
2. Are there any differences in the perceptions of roles and responsibilities among secondary mathematics PBL facilitators with different levels of facilitation experience (i.e., novice, intermediate, advanced, and expert) as measured by the Facilitator Perception Survey-Revised;
3. Are there any differences in the perceptions of the skills needed for effective implementation of PBL among secondary mathematics PBL facilitators with different levels of facilitation experience (i.e., novice, intermediate, advanced, and expert) as measured by the Facilitator Perception Survey-Revised; and

4. What challenges do secondary school mathematics, PBL facilitators perceive they encounter while they are planning for and implementing PBL into the classroom as measured by the Facilitator Perception Survey-Revised?

Survey Research Design

An online survey approach was chosen as a low-cost method to collect the survey data from geographically disbursed individuals in a way that allowed them ample time to reflect on a complex topic (i.e., problem-based learning). Another advantage of the online survey was that it insured anonymity, confidentiality, and convenience. Moreover, it allowed respondents to complete the survey online when it was convenient for them increasing the chance of a high response rate. For these reasons, the investigator used a survey research design for this study in order to ascertain the current perceptions and opinions of PBL facilitators. This survey used a cross sectional design to collect data about current attitudes, perceptions, or beliefs at one point in time. Consequently, the data that was collected did not allow for cause-and-effect explanations as in experimental research (Creswell, 2005).

Sample

The target population in this study was secondary mathematics teachers who had completed a PBL professional development workshop. The sample participants were purposefully selected based on this criterion. Moreover, this sample consisted of teachers who were members of the Problem-based Learning Network (PBLN) at the Illinois Mathematics and Science Academy (IMSA). PBLN provides professional development to PBL facilitators, who range in experience from novice to expert, on inquiry-based teaching strategies and skills. For this study, a facilitators' experience was described in years or number of problem scenarios facilitated (i.e., novice = facilitated < 3 yrs or facilitated < 3 problem scenarios; intermediated =

facilitated 3 to 6 years or facilitated 3 to 6 problem scenarios; advanced = facilitated 7 to 10 years or facilitated 7 to 10 problem scenarios; expert = facilitated > 10 years or facilitated > 10 problem scenarios). The training normally ranges from a one-day session to a two-week summer session. The facilitators participate as learners (or students) engaged in a problem scenario. Therefore, they have the opportunity to experience PBL in a way that is similar to how their students will experience it. They also engage in the stages of designing a PBL scenario for their classrooms and collaboratively develop strategies to implement them effectively into their classrooms. They gain first-hand experience in facilitating or coaching strategies while identifying learning objectives linked to state and national standards and benchmarks. There were 75 secondary mathematics teachers who had gone through the PBLN training. The researcher's goal was to survey all 75 teachers. All PBLN participants that responded to the survey were included in this study.

An Example Problem Scenario

The following problem scenario represents an example of a typical scenario for a 9^{th} grade geometry class.

You have just won a ticket from the local radio station to see one of your favorite bands that will be performing at a nearby auditorium. The auditorium has a triangular seating chart in which your seat will be at floor level. The seats are positioned around the perimeter of the triangular floor plan, and the stage is positioned in the center. The radio station has promised you one of the best views in the auditorium. They will mail you your ticket in a couple of weeks, but you are anxious to know where you might be sitting. How can you and your group members choose a seat for you on the seating chart in such a way that would give you one of the best views to see the performance? Develop support for and prove the chosen seating position is reasonably accurate. Methods and resolutions will be discussed during group presentations.

Instrument

The *Facilitator Perception Survey-Revised* was the instrument that was used to collect the data for this study (see Appendix A). The survey measured the perceptions of PBL facilitators who were previously trained by a professional development program, and included questions that assessed participants' demographic characteristics as well as questions that related to participants' perceptions of the facilitator's roles, skills, training, classroom experiences, and implementation challenges.

Demographic information. The demographic information requested on the survey included gender, state of residence, and age. It also included the highest level of education attained, years of mathematics teaching experience, type of PBL training, previously implemented PBL in a classroom (yes or no), and number of PBL units facilitated.

Facilitator roles perceptions. There were nine questions on the survey that measured perceptions of the facilitator's roles. Sample questions include (a) a role of a facilitator is to ensure that the small group process runs smoothly, (b) a role of a facilitator is to ensure that all students participate equally in the group, and (c) a role of a facilitator is to assess individual students in the group. For each question, participants were asked to respond using a five point continuum scale where 1 = strongly disagree, 2 = disagree, 3 = not sure, 4 = agree, and 5 = strongly agree.

Facilitator skills perception. There were 13 questions on the survey that measured perceptions of the facilitator's implementation skills. Sample questions include (a) what is your perception of your ability to ask probing questions to get students to think about issues relating to the posed problem or scenario, (b) what is your perception of your ability to encourage all group members to contribute, and (c) what is your perception of your ability to support each member of the group? For each question, participants were asked to respond using a continuum scale where 1 = effective, 2 = weak, 3 = satisfactory, 4 = good, and 5 = excellent.

Facilitator training perception. There were three questions on the survey that measured perceptions of the facilitator's training. Sample questions include (a) prior to PBL training, how would you rate your knowledge/understanding of the PBL philosophy, (b) after PBL training, how would you rate your knowledge/understanding of the PBL philosophy? For these questions, participants were asked to respond using a five-point continuum scale where 1 = none, 2 = scant, 3 = reasonable/average, 4 = good, and 5 = excellent.

Facilitator experiences perceptions. There were 11 questions on the survey that measured perceptions of the facilitator's experiences. Sample questions include (a) did you ever find that a tutorial group was difficult to control in terms of your understanding of how a small group should function, (b) did any student in one of your groups not participate in the discussions, and (c) after facilitating 1 theme, did your opinion of PBL being beneficial in terms of student learning change? For these questions, participants were asked to respond using a five-point continuum scale where 1 = strongly disagree, 2 = disagree, 3 = not sure, 4 = agree, and 5 = strongly agree.

Open-ended questions. There were six open-ended questions on the survey that assess the facilitator's perception of PBL. Sample questions include (a) what motivated (or prompted) you to implement PBL in your classroom (e.g., believed in the PBL philosophy, my head of Department/School asked me to implement PBL); (b) based upon your facilitation experience, describe the strengths and weaknesses of the PBL approach to teaching; (c) describe any challenges and/or frustrations you have experienced in the PBL facilitation process; (d) describe any aspects of the PBL facilitation process that you enjoy; and (e) how could your school system or administration best provide ongoing support for PBL facilitators?

Instrument reliability and validity. All Likert scale questions were adapted from a survey used in a study by McLean (2003) in which he categorized items under four key facilitation competencies (i.e. facilitation skills, curriculum knowledge, personal qualities, and subject-matter expertise). This is an open access study in which the author grants in advance one the right to use the research article in its entirety or in part, provided the study is properly cited. However, McLean did not report the results on the instrument's reliability and validity. Both are vital for evaluating the suitability of a measuring instrument. This instrument was also used in an unpublished study by Justine Slattery and Jacinta Douglas (2011). For the present study, revisions were made to the instrument, which was based on a review of the literature on PBL in secondary education by the researcher, and validity and reliability results were reported.

Validity refers to the degree that an instrument or method measures what it is supposed to measure. A valid instrument is always reliable, but a reliable instrument is not always valid (Gay, Mills & Airasian, 2006). Consequently, PBL experts at PBLN of IMSA (director of PBLN and colleagues) reviewed the survey items before it was administered to ensure that the questions adequately measured and addressed the various areas related to PBL. The reviewers examined the completeness of the content in the survey to determine its content validity (Gay, Mills & Airasian, 2006). The review was also used to alert the researcher of any difficulties that were not previously anticipated. That is it provided feedback on the survey's wording, clarity, and whether the survey was appropriate for the sample. The researcher and an assessment and statistical expert also reviewed and made recommended changes to the survey as needed before it was administered. All of these steps helped to establish the content validity of the revised instrument in order to ensure that it served as a useful measurement (Crocker & Algina, 1986, p. 218).

Reliability is another important characteristic of any measurement procedure. It is essential to indicate reliability estimates for each administration of an instrument. Reliability is mainly concerned, not with what one measures but with how well it is being measured (De Vos, 2002). It refers to the degree of consistency of the scores over repeated administrations (Crocker & Algina, 1986). Internal consistency reliability is the extent to which items in a particular instrument are consistent among themselves and with the instrument as a whole. It is acquired through three different methods: split-half, Kuder-Richardson, or Cronbach's Alpha (Gay, Mills & Airasian, 2006).

In this study, the reliability of the revised instrument was estimated using Cronbach's alpha, an index of internal consistency that provides information on how consistently the participants performed across the survey items. Cronbach's alpha overall for the *Facilitator Perception Survey-Revised* was .89. The training subscale consisted of 3 items (alpha = .35), the facilitator experiences subscale consisted of 11 items (alpha =. 93), the roles subscale consisted of 9 items (alpha =.27), and the skills subscale consisted of 13 items (alpha = .95).

In addition, four of the six open-ended questions were taken from the unpublished survey research study by Justine Slattery and Jacinta Douglas with their permission. The research study was presented at a national PBL conference. The study focused on the perceptions of participants of their roles and the competencies required to facilitate in a PBL context. Slattery and Douglas (2011) presentation was titled *Exploring novice and experienced PBL facilitators' perceptions of their roles and skills. Does experience matter?*

Sample Size. The *Facilitator Perception Survey-Revised* was created using *SurveyMonkey*. The PBLN list was the representative sampling frame of the population. It was from this list that the actual sample was drawn and potential respondents were invited to participate in this study. According to Fink (2009), high response rates are desirable; however, a response rate of 70% may be adequate. A power analysis was estimated to determine the minimum size of the sample required to detect group differences. This estimate takes into consideration the number of groups involved, the probability of rejecting the null hypothesis when the null hypothesis is false (i.e., power = $1 - \beta$), and an estimate of the treatment effects.

For research questions 2 and 3, the estimated minimum sample size per group was estimated based on a power of .80 for a medium effect size ($d = .5$) at the .05 level of significance. According to Maxwell & Delaney (2004), the minimum sample size for 3 groups is 79, for a total of N = 237.

Procedure

Following IRB approval (see Appendix G), the items on the *Facilitator Perception Survey-Revised* were entered into *SurveyMonkey,* which is one online format for collecting survey data. Once completed, the survey was activated. This generated a unique Uniform Resource Locator (URL), address for the survey. This URL was emailed to the director of PBLN along with a cover letter (see Appendix C) explaining the identity of the researcher and the purpose of the survey. On April 09, 2013 the director of PBLN sent an email (see Appendix D) indicating PBLN's support for the research study and encouraging the teachers to participate. The URL to access the survey was placed in the email and cover letter, and individuals who voluntarily consented to participate in this study were directed to link to the online survey electronically through *SurveyMonkey*.

The cover letter explained the identity of the researcher and the purpose of the survey. It also included an assurance of confidentiality of the information, how the data would be used, the deadline for taking and submitting the survey, and the directions for navigating through the survey. The cover letter explained that the participants had the right to withdraw from the study and the risk associated with participating in the research. It was estimated that it would take the participant approximately 30 minutes to complete the survey. In addition, the survey's "Thank You" page (see Appendix E) was included, expressing gratitude to the respondents for their participation. A response deadline of April 30, 2013 was indicated, and the PBLN director sent three reminder emails to the teachers. The emails reminded them that if they had not already completed the survey, then please complete it (see Appendix F). These reminder emails were sent on April 16, 2013 and April 23, 2013 and April 28, 2013 to aid in increasing the response rate. Each time the PBLN director sent a reminder email, she sent the research an email indicating the reminder email had been sent. This allowed the researcher to verify that the reminder emails were sent to the PBLN.

The respondents' data compiled from the survey was electronically assembled automatically as an excel file by the data collection program. Moreover, the data management processes included saving the data file each time a change was made using the file name and date as the file label. All data analysis was saved as an output file and similarly labeled. Also, the researcher maintained a research log documenting all work undertaken on the data. Furthermore, the survey data was securely stored in a locked file cabinet, in the researcher's home.

Data Analysis

The following data management table describes the data analysis.

Table 1

Data Management

Research Questions	Measure	Independent or Grouping Variable(s) (include levels of each variable)	Dependent Variable(s)	Analysis
1	Facilitator Perception Survey-Revised			Descriptive Statistics
2	Facilitator Perception Survey-Revised	Level of Facilitation Experience (novice and advanced)	Facilitator Role Scale	Analysis of Variance
3	Facilitator Perception Survey-Revised	Level of Facilitation Experience (novice and advanced)	Facilitator Skill Scale	Analysis of Variance
4	Facilitator Perception Survey-Revised			Qualitative/ Description

CHAPTER IV:

RESULTS

The purpose of this study was to determine what secondary school mathematics, problem-based learning (PBL) facilitators perceived as the roles of a facilitator and their perception of their skill and ability level on specific facilitation tasks. The data were analyzed using SPSS, version 21. In addition, an objective of this study was to examine PBL facilitators' perception of their facilitation training, classroom experiences, and challenges. This was determined by collecting data through a survey administered to secondary school mathematics PBL facilitators who had received their PBL facilitation training from the Problem-based Learning Network (PBLN) of the Illinois Mathematics and Science Academy (IMSA). This chapter presents the findings that emerged from the *Facilitator Perception Survey-Revised* (see Appendix A), which was guided by the following research questions:

1. What are the perceptions of secondary school mathematics PBL facilitators of facilitator training and facilitator experiences, as measured by the *Facilitator Perception Survey-Revised*;
2. Are there any differences in the perceptions of roles and responsibilities among secondary mathematics PBL facilitators with different levels of facilitation experience (i.e., novice, intermediate, advanced, and expert) as measured by the *Facilitator Perception Survey-Revised*;
3. Are there any differences in the perceptions of the skills needed for effective implementation of PBL among secondary mathematics PBL facilitators with

different levels of facilitation experience (i.e., novice, intermediate, advanced, and expert) as measured by the *Facilitator Perception Survey-Revised*; and

4. What challenges do secondary school mathematics, PBL facilitators perceive they encounter while they are planning for and implementing PBL into the classroom as measured by the *Facilitator Perception Survey-Revised*?

Demographics

The sample consisted of 75 secondary school mathematics PBL facilitators, which revealed a 55 % (*n* = 41) response rate. All participants completed the standard demographic information (i.e., gender, age, in what state do you live, highest level of education, number of years teaching mathematic). The representation from the 30 states and 7 countries the PBL Network covers came from only five states: 44% (*n* = 18) live in Illinois, 42% (*n* = 17) live in Ohio, 2% (*n* = 1) live in each Oklahoma and Washington, and 10% (*n* = 4) live in Wisconsin. There were almost twice as many females (*n* = 27) as male (*n* = 14) respondents. The survey respondents ages were mixed and ranged across all three groups: 32 % (*n* = 13) were less than 40 years old, 54 % (*n* = 22) were 40-50 years old, and 14% (*n* = 6) were over 50 years old. Almost two thirds (61%) of the facilitators were over 40 years old (*n* = 25). The majority, 83% (*n* = 34) of the respondents had master's degrees and 2% (*n* = 1) had an education specialists degree while 15% (*n* = 6) had bachelor's degrees.

In terms of facilitator preparation, almost all respondents indicated that they had participated in formal facilitator training: 95% (*n* = 39) participated in a basic training workshop, but 5% (*n* = 2) of the survey participants did not respond to this question. Twenty-six percent (*n* = 10) had also participated in an advanced training workshop while a small percentage (5%) had facilitated training workshops (*n* = 2). Both teaching and facilitation experience varied (see

Figure 1). Teaching experience varied from 1 year to 28 years. More than half (54%) of the sample had over 10 years of teaching experience (*n* = 22) while the remaining participants had been teaching between 6-9 years (29%) and 1-5 years (10%). Facilitation experience was measured using the following two variables: time facilitating in years and number of problem scenarios facilitated. The majority (78%) of the respondents had been facilitating for less than three years (*n* = 32). Only 2% (*n* = 1) of the participants had facilitated over 10 years while 13% (*n* = 5) of the participants had facilitated 4-6 years. Seven percent (*n = 3*) of the participants did not respond when asked how many years they had been a PBL facilitator.

Far from the norm within this sample, one participant had facilitated over 50 problems. Another participant had facilitated nine problems and similarly another participant had facilitated eight problems. Five percent (*n* = 2) of the participants had facilitated five problems and likewise five percent (*n* = 2) had facilitated four problems. Almost half (45%) of the participants had only facilitated one or two problems (n = 18). One participant did not respond when asked how many PBL cases (or problem scenarios) they had facilitated. However, one fourth (25%) of the participants indicated they had not yet facilitated a PBL problem (*n* = 10).

Over half (54%) of the participants described the socioeconomic status of the majority of the students, they taught as “poor” (*n* = 22). Twenty five percent (*n* = 10) described their students’ status as “medium,” 17% (*n* = 7) described their students’ status as high, and while 5% (*n* = 2) indicated there was no dominant socioeconomic status among the students whom they taught. In summary, as illustrated in Table 2 a demographic profile emerged from the survey sample indicating a heterogeneous sample in a number of categories (e.g., age, gender, education, teaching experience, and facilitator training). A summary of all demographic statistics is reported in Table 2.

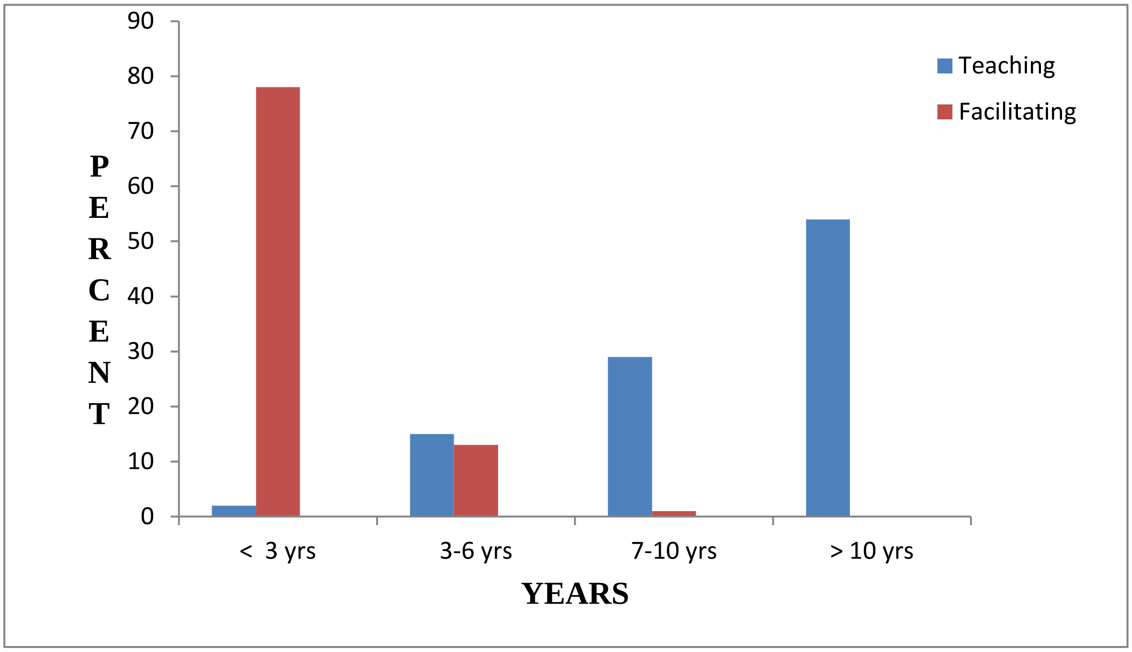

Figure 1. Teaching and Facilitation Experience of PBL Teachers

Table 2

Survey Participants Demographics

Survey Item	Response	n	Percent
Teaching Experience	>10 years	22	54
	7-10 years	12	29
	3-6 years	6	15
	< 3 years	1	2
Facilitator Experience	>10 years	0	0
	7-10 years	1	3
	3-6 years	5	12
	<3 years	32	78
	Missing	3	7
Number of Problem Facilitated	< 2	19	48
	2-5	16	40
	>5	5	12
	Missing	1	3
Highest Level of Education	Bachelor’s Degree	6	15
	Master’s Degree	34	83
	Education Specialist Degree	1	2
Age	<40	13	32
	41-50	22	54
	>50	6	14
Gender	Female	27	66
	Male	14	34

Research Question 1

The first research question was "What are the perceptions of secondary school mathematics PBL facilitators of facilitator training and facilitator experiences, as measured by the *Facilitator Perception Survey-Revised*?" The results for this question will be discussed considering the participants' PBL training, their facilitating experiences, facilitators' roles, and facilitation skills.

PBL Training

Questions 14, 15, and 16 focused on participants' perceptions of their PBL training. Question 14 asked participants to rate their knowledge or understanding of the PBL philosophy, prior to PBL training. The responses to this question indicated that before PBL training, 7.5% (n = 3) of the respondents rated their knowledge or understanding of the PBL philosophy as good or excellent. On the other hand, when asked to rate their knowledge or understanding of the PBL philosophy after PBL training, 80.7% (n = 32) of the respondents rated it as good or excellent. When asked if PBL training provided them with sufficient insight into how a facilitator should manage a small PBL group, 82.5% (n = 33) of the respondents agreed or strongly agreed that the training provided them with sufficient insight into how they should manage the small group learning process. Forty-four percent (n = 17) agreed or strongly agreed with the statement: "I feel/felt confident before facilitating my first session," but an equal percentage (44%) of participants (n = 17) were not sure or disagreed with this statement. Also, two participants chose not to respond to this statement.

Facilitators' Experiences

Survey questions 17, 18, 19, 20, 21, and 22 were used to gather responses on participants' perceptions on their classroom experiences while they plan for and implement PBL into their classrooms. Only 5% (n = 2) of the respondents reported that a facilitator does not need to facilitate more than one problem scenario to become effective. In contrast, the majority (88%) of the respondents (*n* = 35) agreed that facilitators need to facilitate more than one problem to become more effective; though, a few respondents (*n* = 3) were not sure (8%). The responses varied on whether facilitators preferred to implement PBL into their classroom rather than direct instruction or lecture approach. Sixty percent (*n* = 24) of the respondents reported that they would prefer to implement PBL. Fifteen percent (*n* = 6) reported they would prefer to implement direct instruction or lecture approach, but one fourth (25%) was indecisive (*n* = 10). Less than half (47.5%) of the participants (*n* = 19) agreed that their first experience facilitating was a success, and an equal percentage (47.5%) of participants (*n* = 19) felt confident after their first facilitation experience. Once the participants facilitated one theme, 65% (*n* = 26) agreed or strongly agreed that the PBL training made more sense in terms of understanding the role of the facilitator in small group learning sessions, and only 5% disagreed (*n* = 2). Nevertheless, a surprising 25% (*n* = 10) of the participants indicated that they had not yet facilitated.

Approximately 24.4% (*n* = 9) of the participants' opinion did not change about PBL being beneficial in terms of student learning after facilitating their first problem or scenario, but 46% (*n* = 17) of the participants opinion did change. In terms of learning mathematics, participants reported diverse responses on how they felt about the PBL process promoting learning in mathematics. Half (50%) of the participants (*n* = 20) perceived that the PBL process promoted learning mathematics, but 2.5% (*n* = 1) perceived it was ineffective, 10% (*n* = 4) perceived it as being barely effective, and 17.5% (*n* = 7) of the participants indicated that they were not sure about its effectiveness. As it relates to classroom management experiences, 36% (*n* = 14) of the participants agreed that one or more tutorial groups were difficult to control, and 38% (*n* = 15) agreed that they had one or more students in one of the groups who disrupted the group process. Moreover, over half (54%) of the participants (*n* = 21) specified they had one or more students in the groups who did not participate in the discussions.

Facilitator's Roles

Forty participants completed the nine items on survey question 23 concerning the facilitator's roles. The mean (*M*), standard deviation (*SD*), and frequency percentages were calculated. A presentation of these data appear in Appendix H: Survey Roles Items - Relative Frequencies and Count, Table 3. These items revealed a high percentage of participants agreed or strongly agreed with four of the nine items. For instance, a strong majority (89.74%) of participants (*n* = 35) reported that a facilitator should serve as a role model for learners, and 87.50% (*n* = 35) reported that a role of a facilitator is to ensure that the small group process runs smoothly. Seventy-eight percent (*n* = 31) of participants' agreed or strongly agreed that a role of a facilitator is to ask the students probing questions to ensure that the groups achieve their learning goals. Seventy-three percent (*n* = 29) of participants agreed or strongly agreed that a role of a facilitator is to ensure all students participate equally in the group. The high percentage of agreement showed the majority of facilitators could identify the roles of a PBL facilitator. In addition, the data indicated that many facilitators were in agreement with each other on these items.

Furthermore, almost sixty percent (57.5%) of the participants (*n* = 23) agreed or strongly agreed that being a mentor is a role of a facilitator and 8% (*n*=3) disagreed, but 35% (*n* = 14) of the participants reported they were not sure if a facilitator should be a mentor for learners (e.g., someone students can confide). Sixty five percent (*n* = 26) of the participants' agreed or strongly agreed that a role of a facilitator is to assess individual students in the group and 10% (*n* = 4) disagreed, but 25% (*n* = 10) reported they were not sure if a facilitator should assess individual students in the group. The responses varied on the items concerning a role of a facilitator are to provide expert knowledge. Thirty-three percent (*n* = 13) of participants perceived providing expert knowledge to students as a role of a facilitator and 50% (*n* = 20) disagreed or strongly disagreed, but 18% (*n* = 7) of participants were not sure if a facilitator should provide expert knowledge to students. However, only half (50%) of the participants (*n* = 20) reported that a facilitator should treat learners in small group sessions as colleagues.

An initial impression of what facilitators perceived as their roles was obtained by examining mean scores. Item responses varied (*M* = 2.38, *SD* = .77 to *M* = 4.15, *SD* = .81) (see Appendix H). Four items with high means (*M* > 3.5) included: item 1 (ensure small group runs smoothly), item 2 (ensure all students participate), item 4 (ensure groups achieve learning goals), and item 8 (serve as a role model). Examination of item responses with low means (*M* < 3) revealed two items; item 3 (NOT to assess individual students) and item 7 (should not become a mentor).

Facilitator's Skills

Forty participants also responded to the thirteen items on survey question 24 concerning facilitator's skills and abilities. The mean, standard deviation, and frequency percentages were calculated. A presentation of these data appears in Appendix I: Survey Skills Items-Relative Frequencies and Count, Table 4 and Table 5. These items revealed that more than half of the participants rated their ability as good or excellent on four PBL facilitation skills. For instance, almost 63 % (*n* = 25) of participants rated their ability as good or excellent on pointing out inconsistencies in students' explanations. Sixty percent (*n* = 24) of the participants rated their ability as good or excellent on encouraging students to examine new ideas. Furthermore, exactly half (*n* = 20) of the participants rated their abilities on the following tasks as good or excellent: (a) ensure everyone has a chance to contribute, (b) encourage students to extend themselves, (c) support each member of the group, (d) encourage students to utilize their prior experiences to benefit the group, and (e) summarize the progress of the group.

When participants were asked to rate their ability to ask students probing questions (i.e., What is your perception of your ability to ask probing questions to get students to think about issues related to the posed problem scenario?) and to encourage students to expand their reading (i.e., What is your perception of your ability to encourage students to read widely?), twenty-five percent of the participants ($n = 10$) rated their ability to perform these tasks as ineffective or weak. Furthermore, these two tasks were selected more frequently than any other task as areas in which facilitators perceived they were ineffective or weak.

An initial impression of facilitators' perceptions of their ability with task items was also obtained by examining mean scores. Item responses varied ($M = 3.13$, $SD = .88$ to $M = 3.70$, $SD = .69$) (see Appendix I). Five items with high means ($M > 3.5$) included: item 3 (encourage students to examine new ideas), item 4 (point out inconsistencies in students' explanations to perform certain tasks), item 8 (support each member of the group), item 9 (ensure that everyone has a chance to contribute), and item 10 (encourage students to extend themselves beyond the learning objectives). Examination of item responses with low means ($M < 3$) did not reveal any items. However, three items had slightly low means ($M < 3.25$): item 1 (ask probing questions), item 5 (get students to effectively brainstorm hypotheses), and item 12 (encourage students to read widely).

Research Question 2

Research question two addressed whether there were any differences in the perceptions of roles and responsibilities among secondary mathematics PBL facilitators with different levels of facilitation experience (i.e., novice, intermediate, advanced, and expert) as measured by the *Facilitator Perception Survey-Revised*. Forty participants completed question 23 on the survey that measured the roles of a facilitator. However, the low response rate obtained from the participants created some challenges. First, the original research question involved comparisons among the four groups: novice, intermediate, advanced, and expert. Because inadequate sample sizes were obtained among these categories (novice facilitators n = 28, intermediate facilitators n = 7, advanced facilitators n = 4, and expert facilitators n = 1), the groups were collapsed into two categories. They were collapsed into novice facilitators (n = 19) and advanced facilitators (n = 21). Participants' who had facilitated less than three problem scenarios were included in the novice category, and participants' who had facilitated three or more problem scenarios were included in the advanced category.

Analysis of Covariance Assumptions

The analysis of covariance (ANCOVA) was proposed to answer this research question. The assumptions for this analysis, in order to make inferences back to the population require that: (1) the subjects are independent of one another, (2) the scores are normally distributed in the population, (3) the variances are equal across groups, (4) homogeneity of regression slopes, and (5) there is a linear relationship between the dependent variable and the covariate (Huitema, 1980; Rutherford, 2011). Considering the ANCOVA design, the tenacity of the assumptions were evaluated first. First, the assumption of independence was satisfied due to the lack of dependence or relationship among the participants. Second, the statistical tests of normality assume that the dependent variable (*roles*) is normally distributed in the population. A visual check of the histogram was assessed for normality. The mean and median of the dependent variable (M = 3.37 and Mdn = 3.33) were approximately equal, which indicates that the distribution is approximately normally distributed. Normality was also examined based on the criteria that the skewness and kurtosis of the dependent variable fell within the range from -1.0 to

+1.0 (Lomax, 2001). Both of these test supported the assumption of normality for the roles variable.

Another assumption is that the variances between the two groups are the same. Levene's test revealed $F(1, 38) = .47$, $p = .50$). Because the observed p-value is greater than an alpha of .10 for this test, the assumption of homogeneity of variances was also met. These findings support equal variances between the two groups.

The assumption of homogeneous regression slopes was considered next. The significance of the interaction term was tested to evaluate this assumption. This tests whether the relationship between the number of years teaching and roles was the same between the two groups. The results revealed $F(1, 36) = .48$, $p =.49$. This indicates that the relationship is the same between the two groups (i.e., $p >$ alpha) and that the interaction term can be removed from the model.

The purpose of including a covariate in the model may be for two reasons. First, the ANCOVA analysis will attempt to adjust the dependent variable (*roles*, in this case) based on any differences present in the covariate (years teaching, in this case). The second purpose is to reduce the error variance, which allows for a more powerful statistical test. In this case, if this relationship is not statistically significant, the researcher may decide to take the covariate out of the model if this is the primary purpose of including it. The primary reason for including the covariate in this analysis was to control for the potential differences in years teaching among the participants, as well as to reduce the error variance for a more powerful test. Therefore, the relationship between years teaching and roles was examined through a visual observation of a scatter plot. The scatterplot indicated that there was not a linear relationship between the variables. However, the test results also revealed $F(1, 37) = 1.27$, $p = .27$. This indicated that there was no linear and statistically significant relationship between years teaching and roles, and thus, it is not likely that including this variable in the model would reduce the error variance. Thus, the covariate was removed from the model and the analysis of variance (ANOVA) test would instead be the most appropriate test to answer the research question.

Analysis of Variance (ANOVA)

To determine if there were mean differences between the novice and advanced, secondary mathematics PBL facilitators on their *roles* scores, the ANOVA test was conducted. First, the following three assumptions were tested for the ANOVA model: independence, normality, and equal variances (Rutherford, 2011). The assumption of independence was satisfied due to the lack of dependence or relationship among the participants. The mean and median of the dependent variable (*skills*) (M = 3.37 and Mdn = 3.33) were approximately equal. Normality was also examined based on the criteria that the skewness and kurtosis of the dependent variable fell within the range from -1.0 to +1.0. Both of these test supported the assumption of normality for the roles variable. The Levene's test revealed $F(1, 38) = .301$, p = .59. This finding supports equal variances between the two groups.

The mean *roles* score in the novice group (M = 3.33, SD = .44) was slightly lower than the mean *roles* score in the advanced group (M = 3.39, SD = .08). The results of the ANOVA test revealed $F(1, 38) =.22$, $p = .64$. Although the mean score for the advanced group was larger than the mean score for teachers in the novice group, the results indicated that there were no differences in the perceptions of roles and responsibilities among secondary mathematics PBL facilitators with different levels of facilitation experience (i.e., novice and advanced) as measured by the *Facilitator Perception Survey-Revised.* At an alpha of .05, this finding supports that there is no statistically significant difference between mean *roles* perception scores of novice and advanced secondary mathematics PBL facilitators. The effect size statistic, eta-squared, revealed .0056, which indicates a very small effect based on Cohen's (1988) guidelines. However, this value indicates that .56% (less than 1%) of the variance in the *roles* score can be explained by facilitation experience (number of problem scenarios facilitated).

Research Question 3

Research question three addressed whether there were any differences in the perceptions of the skills needed for effective implementation of PBL among secondary mathematics PBL facilitators with different levels of facilitation experience (i.e., novice and advanced) as measured by the *Facilitator Perception Survey-Revised*. Like the previous research question, analysis of covariance (ANCOVA) was proposed to answer this research question. All assumptions were examined in the same manner as discussed above. In summary, the assumptions of independence, normality, equal variance, and homogeneity of regression slopes were met. However, the test of the covariate revealed no statistically significant reduction in the error variance. Therefore, the ANOVA test was also conducted for this research question.

To determine if there were mean differences between the novice and advanced, secondary mathematics PBL facilitators on their skills scores, the ANOVA test was conducted. First, the following three assumptions were tested for the ANOVA model: independence, normality, and equal variances. The assumption of independence was satisfied due to the lack of dependence or relationship among the participants. The mean and median (M = 3.43 and Mdn = 3.31) of the dependent variable (*skills*) were approximately equal. Normality was also examined based on the criteria that the skewness and kurtosis of the dependent variable fell within the range from -1.0 to +1.0 (Lomax, 2001). Both of these tests supported the assumption of normality for the *skills* variable. The Levene's test revealed $F(1, 38) = .51$, $p = .48$. This finding supports equal variances between the two groups.

The mean *skills* score for the novice group ($M = 3.28$, $SD = .62$) was lower than the mean *skills* score for the advanced group ($M = 3.53$, $SD = .65$). The results of the ANOVA test revealed $F(1, 38) = 1.63$, $p = .21$. Although the mean score for the advanced group was larger than the mean score for the teachers in the novice group, the results indicated that there were no differences in the perceptions of the skills needed for effective implementation of PBL among secondary mathematics PBL facilitators with different levels of facilitation experience (i.e., novice and advanced) as measured by the *Facilitator Perception Survey-Revised*. At an alpha of .05, this finding supports that there is no statistically significant difference between the mean *skills* perception scores of novice and advanced secondary mathematics PBL facilitators. The effect size statistic, eta-squared, revealed .0411, which indicates a small effect based on Cohen's (1988) guidelines. Given the small effect detected, it is possible that the sample size in this study might have influenced the results. More discussion about this finding will be discussed in Chapter V.

Research Question 4

Research question four addressed the challenges secondary school mathematics, PBL facilitators perceive they encounter while they are planning for and implementing PBL into the classroom as measured by the *Facilitator Perception Survey-Revised*. Twenty-five participants responded to the invitation to comment on this open-ended question: Describe any challenges and/or frustrations you have experienced in the PBL facilitation process. Participants had mixed responses. Comments were coded, and themes that emerged from the comments were grouped into five categories (i.e. roles, students' refusal to participate, time constraints, curricular constraints, and lack of sufficient resources).

Roles and Participation

The most frequent comments were related to challenges concerning the roles of a facilitator. Thirteen participants commented on the difficulty and challenge of their roles. For instance, this is how one participant described the issue: "The students have had little experience of working together in a group. The process of trying to teach them how to work together while doing the problem was very difficult." At the same time, another participant explained that with time they improved in the role of facilitating the small group learning process. Specifically, the participant stated, "I am always working on the group dynamics. I am getting better at teaching students how to work in groups." These and other comments indicated that a diverse group of facilitators viewed the same roles as a challenge.

Those who had been teaching mathematics the longest but were new PBL facilitators made references to some of the same challenges and struggles in their roles as facilitators with significantly less mathematics teaching experience. For instance, one facilitator with 22 years teaching experience and had facilitated four PBL problem scenarios commented:

> Since PBL is fairly new for me, I found that I really had to think about my actions. The role of facilitator did not come naturally to me, so I had to focus on my actions and reflect on whether they were consistent with the PBL process. Also, even though I went through the training, I needed to look back at my materials and notes as I reflected on my actions. I hope that the process of facilitating will become easier and more natural with continued practice.

Similar views were echoed in the comments of a facilitator with 12 years mathematics teaching experience who had facilitated two problem scenarios. The participant stated, "Being a novice with PBL, it was difficult to just jump into the process." In other words, the perception that the role of a facilitator did not come naturally and was challenging was consistent across all levels of teaching experience.

Another major challenge that emerged was students' refusal to participate. Six respondents indicated that they had one or more students who refused to participate in the learning process. One respondent who had 12 years of teaching experience but had only facilitated one problem scenario stated, "The refusal of some students to participate in this type of learning was frustrating." Another facilitator with 28 years of teaching experience who had facilitated four problem scenarios explained it this way: "It was not easy to get EVERY student to participate." Another veteran mathematics teacher (23 years teaching experience) who had facilitated five problem scenarios also expressed that she had a few students that refused to participate in the learning process. This same facilitator described the socioeconomic status of the majority of the students she taught as "low" and commented she had a few "students listening to music or going to inappropriate websites not wanting to do the research." Though, some participants viewed students' non-participation as a major PBL implementation challenge there were also other challenges that emerged from the data.

Time and Curricular and Resources Constraints

Time constraints, curricular constraints, and lack of sufficient resources were other themes that emerged from the data. Five participants suggested that time constraints were a challenge and can impede the PBL process (e. g., need more prep time, time limitation of class periods, and estimating time needed). One participant stated, "We needed more prep time." Another participant commented, "The time limitations of the class periods can sometimes interfere with the PBL process, especially when a very good discussion is taking place and the students are excited and eager to participate." A different participant commented, "Estimating the time-frame needed and planning for it in schedule" is a challenge. There was also some indication in the comments that a few facilitators had not yet implemented PBL into their classrooms because they believed they lacked the time needed for its implementation. For instance, one participant who had been teaching for six years and described the socioeconomic status of her students as high stated, "I haven't tried PBL in my classroom because I feel as though I don't have time." However, in general, time constraints was a significant theme but to a lesser extent than the previously mentioned challenges of the roles of a facilitator.

Curricular constraints were only indicated by two respondents as a challenge. One participant who had seven years teaching experience and had facilitated two problem scenarios commented on curricular constraints. This same facilitator described the socioeconomic status of the majority of her students as 'low" and commented, "Due to curricular restraints [*sic*] from our district, it has been difficult to implement PBL in my classroom." A participant who had twelve years of teaching experience but had only facilitated one problem scenario reiterated similar concerns, which indicated that the Common Core Standards made implementing PBL into the math classroom challenging. This participant described the socioeconomic background of the majority of his students as "medium." Specifically, the responded stated:

> Most of the ways that math is learned in a PBL is either contrived or data analysis based. Perhaps it is more the fault of our standards than the PBL practice, but the majority of Common Core Standards don't fit well in a PBL environment.

Also, two participants commented on lack of sufficient resource (human resources and teaching and learning resources) as an implementation challenge. One of these participants had taught mathematics for ten years was told that she had to implement PBL as part of the school curriculum and attend a three-day summer workshop. She enjoys nontraditional teaching and learning but was unable to implement the approach into her classroom due to lack of resources.

She commented, “When I did my PBL, I had too many students, not enough teachers, and not enough resources to do the entire PBL process effectively. In the end though, the students did learn and benefit from having the PBL implemented.” Similar, a participant who had taught mathematics for 15 years and trained in a two-week workshop commented, “I was trained but unable to use any of it due to the setup within my building. We didn’t have enough teachers trained, or enough staff to work in teams.”

In general, facilitators indicated that they face a number of challenges, many of which describe the discomfort with their role. The level of discomfort seemed to vary from facilitator to facilitator. Time, curricular, and resource constraints were also perceived as challenges, though of a lesser magnitude than facilitators’ discomfort with their roles.

Chapter Summary

In summary, this chapter presented the results concerning the facilitators’ demographics, their perceptions on their training, classroom experiences, roles, and skills. A strong majority of participants indicated that their PBL training provided them with sufficient insight on how to manage the small group learning process, and that they would prefer to implement PBL into their classrooms rather than direct instruction. Findings from the ANOVA test support that there is no statistically significant difference between mean *roles* scores based on level of facilitation experience. Likewise, findings from the ANOVA test support that there is no statistically significant difference between mean Skills scores based on level of facilitation experience. The open response question on the perception of facilitators’ PBL implementation challenges suggests that challenges vary among participants with the roles of the facilitator mentioned most often as a significant challenge. In addition, the responses from this open-ended question seemed to support the results from the closed response questions.

CHAPTER V:

CONCLUSIONS AND RECOMMENDATIONS

This chapter presents the conclusions, limitations, and recommendations resulting from analysis of the data collected from the *Facilitator Perception Survey-Revised*. The PBL facilitators who participated in this study were members of the Problem-based Learning Network (PBLN) of the Illinois Mathematics and Science Academy (IMSA). The purpose of this study was to gain a better understanding of the viewpoints of PBL facilitators on facilitation. It was completed to provide information on PBL facilitation for present and future facilitators and other education stakeholders including teachers and teacher educators. Therefore, this chapter presents conclusions from data analysis guided by the following research:

1. What are the perceptions of secondary school mathematics PBL facilitators of facilitator training and facilitator experiences, as measured by the *Facilitator Perception Survey-Revised*;
2. Are there any differences in the perceptions of roles and responsibilities among secondary mathematics PBL facilitators with different levels of facilitation experience (i.e., novice, intermediate, advanced, and expert) as measured by the *Facilitator Perception Survey-Revised*;
3. Are there any differences in the perceptions of the skills needed for effective implementation of PBL among secondary mathematics PBL facilitators with different levels of facilitation experience (i.e., novice, intermediate, advanced, and expert) as measured by the *Facilitator Perception Survey-Revised*;

4. What challenges do secondary school mathematics, PBL facilitators perceive they encounter while they are planning for and implementing PBL into the classroom as measured by the *Facilitator Perception Survey-Revised*?

The first section of this chapter is organized according to the four research questions and discusses findings and conclusions related to each question. The second section of this chapter summarizes the limitations of the study. Next, implications for practice are discussed, and the final section of this chapter presents recommendations for future research.

Research Question 1

Facilitator Training

What are the perceptions of secondary school mathematics PBL facilitators of facilitator training and facilitator experiences, as measured by the *Facilitator Perception Survey-Revised*? As indicated in the literature on facilitator training, it is essential for PBL facilitators to understand the philosophy that supports PBL (Torp & Sage, 2002; Ronis, 2008) to experience successful classroom implementation. Almost all (95%) respondents (n = 39) reported they had participated in basic PBL training. Twenty six percent (n=10) of the participants reported that they had also participated in advanced PBL training, and 2% (n = 2) had facilitated at least one PBL workshop. Before PBL training, only 8% of the participants rated their understanding of the PBL philosophy as good or excellent. After training, 78% (n = 32) of the participants rated their understanding of the PBL philosophy as good or excellent. When asked if PBL training provided them with sufficient insight into how a facilitator should manage a small PBL group, 82.5% (n = 33) of the respondents agreed or strongly agreed that the training provided them with sufficient insight into how they should manage the small group learning process. These results indicate that a strong majority of the sample perceived their training as beneficial and understood the PBL philosophy as a result of the training. They were more knowledgeable on how to facilitate the group process. Thus, these facilitators understood more about the teaching and learning values embedding in the design of PBL. The results further indicate that the PBL training, though effective for the majority of participants, was not effective for a few participants.

The implication for these findings points to modifications of training and professional development for facilitators. There may be a need to provide more instances for facilitators to reflect critically on their practice and to engage facilitators in self-evaluation of their practice. Also, professional development should provide opportunities for facilitators to observe experts and to be observed by and to be given feedback from them. As suggested in the literature, professional development should also consist of opportunities for facilitators to reflect on their practice within the context of their daily classroom experiences (Hawley & Valli, 1999; Putnam & Borko, 2000; Wilson & Berne, 1999). Findings also have implications to aid in the understanding of facilitator's roles and in particular facilitators comfort with their roles.

Implementation Experiences

Data collected from survey questions 17, 18, 19, 20, 21, and 22 revealed a profile of secondary school mathematics PBL facilitators' perceptions toward their PBL experiences. The survey results presented a summary of these PBL Network members' perceptions toward these experiences. Participants were asked to rate their first facilitation or classroom coaching session. The responses to this question revealed that 25% (n = 10) of the participants had no not yet, implemented PBL into their classrooms. This indicated that a significant number of participants had no classroom experience with PBL. This may explain why only 44% of the participants stated they felt confident with PBL after their training. Of those who did implement PBL (n =

30), the majority (*n* = 19) felt more confident about facilitation after their first facilitation experience. These same participants perceived that PBL was effective at promoting mathematics learning, and 65% (*n* = 26) of the sample reported that once they used the facilitation process in their own classrooms their PBL training made more sense to them in terms of understanding their roles. These results indicate that over time (with practice facilitating), the facilitators' training will likely help those who implement the instructional approach develop into more effective and confident PBL facilitators.

Sixty percent (*n* = 24) of the participants indicated they would prefer to implement PBL into their classrooms than to use direct or lecture-based instruction, but 25% (*n* = 10) of the participants were not sure, if they would prefer PBL. These results indicate that the majority of the participants perceive PBL as a more effective instructional approach than direct instruction, for learning mathematics. The results also suggest that likely some of the facilitators that were unsure or preferred to implement direct instruction had no classroom experience with PBL to base their perceptions.

The researcher speculates that for some of those who did not implement the instructional approach, the training, though effective, did not extend far enough to fully address issues of school and teaching culture and tradition that may impede its implementation once they returned to their respective schools. Perhaps the teachers were not prepared to be instructional leaders back at their respective schools. In a previous study of teaching practices in Germany, Japan, and the US, Stigler and Hiebert (1999) found that teachers in the US have a tradition of presenting mathematics as a collection of terms and procedures. Thus, for most teachers, problem-based approaches to teaching represent a substantial shift in practice (e.g., Boaler, 2002). This supports the notion that although these facilitators were trained, it was likely difficult for some of them to implement this innovative instructional approach, due to a strong school culture of using traditional instructional approaches (e.g., Brooks & Brooks, 1999; Savery & Duffy, 1995).

Also, frequency percentages revealed that almost 40% of participants experienced having one or more tutorial groups in their classes that were difficult to control or at least one student in the group who disrupted the group process. More than half of the participants had one or more students who did not participate in the discussions. These data indicate that many facilitators have a difficult time choosing or creating a problem scenario to engage all their students, which likely led to classroom management issues. Consistent with Erickson's (1999) views, teaching, it is sometimes difficult to create or select a problem scenario that will engage all students. Erickson proposes that the problems facilitators choose should be engaging and challenging for students. Although the problems chosen should be challenging, they should be of reasonable difficulty level so as not to discourage learners from participating.

The implication for these findings, rest once again, on training and professional development, but extends to include a need for more collaboration and administrative support. This implies that time during the school day should be scheduled for teachers to collaborate on designing engaging problem scenarios. Other methods of collaboration need to be explored if PBL is not a school or grade level initiative. Collaboration on problem selection and problem designs is needed to determine characteristics of problems that will likely engage different subgroups of students. These findings also suggest some facilitators lacked the support needed from their school administrators to change their instructional approach. A shift in curriculum and instruction from a culture of traditional instructional approaches will not only require strong teacher leadership skills, but it will also require administrative support, school based professional development, collaboration, reflection, and a total school buy in.

Research Question 2

Research question two addressed whether there were any differences in the perceptions of roles and responsibilities among secondary mathematics PBL facilitators with different levels of facilitation experience. The statements on survey question 25 were used to answer this question. The results of the ANOVA test revealed $F(1, 38) = .22$, $p = .64$. These results indicate that there were no differences in the perceptions of roles and responsibilities among secondary mathematics PBL facilitators with different levels of facilitation experience (i.e., novice and advanced) as measured by the Facilitator Perception Survey-Revised. This finding reveals that, in the population, there is no statistically significant difference between mean *roles* perception scores of novice and advanced secondary mathematics PBL facilitators. In other words, regardless of the amount of facilitation experience (i.e., number of problem scenarios facilitated) there may not be any difference between the perceptions of what a novice or advanced facilitator would perceive as the roles of a PBL facilitator. This finding might be because their PBL training was effective in aiding the sample in becoming knowledgeable about the roles of a facilitator. The data showed that almost all participants were well informed on the roles of a facilitator through PBL training. Regardless of their level of facilitation experience, their perceptions of those roles (or being able to identify those roles) were similar (indicating no difference).

Another explanation of these findings should also be considered. The mean *roles* score in the novice group ($M = 3.33$, $SD = .44$) was slightly lower than the mean *roles* score in the advanced group ($M = 3.39$, $SD = .08$). Though, the mean of the novice group was only slightly lower than the mean of the advanced group, the researcher was encouraged with this outcome. In other words, the data support that the advanced group had a higher *roles* mean score than the novice group; however, this difference was not statistically significant. One strong possibility of a Type II error is due to the low sample size. However, this study provided useful information for the researcher to plan future studies. A significant difference would likely be detected with a larger sample size. Therefore, in the future the research plans to expand this study and acquire a larger sample by having more resources to locate and acquire participants.

Frequency counts indicated that participants' perceptions of what they considered a role of a PBL facilitator were in general consistent with the roles of a PBL facilitator indicated in the literature. For example, the literature indicates that facilitators have numerous roles, but the primary roles are to ensure student learning and interaction during the small group sessions (e.g., Mergendoller, Maxwell, & Bellisimo, 2006). Consistent with this view, almost 90% of participants agreed that ensuring that all small groups run smoothly is an essential role of the facilitator. Also, data from the open response questions suggested that the role of managing the small group learning process is a continuous challenge. Data from the open response questions support that regardless of the number of problem scenarios participants facilitated, they held similar views on what they perceived as their roles. For example, a participant who had facilitated 10 problem scenarios and a participant who had only facilitated two problem scenarios both suggested in their comments that ensuring that the small groups run smoothly is an essential role of a PBL facilitator.

These findings suggest that the portion of the PBL training at the PBLNetwork concerning identifying and understanding the roles of a facilitator was effective for many participants, regardless of their level of facilitation experience. This implies that this section of the training should continue without major modifications. These findings would be useful to the PBL Network and others designing PBL training and professional development.

Research Question 3

Research question three addressed whether there were any differences in the perceptions of the skills needed for effective implementation of PBL among secondary mathematics PBL facilitators with different levels of facilitation experience. Thirteen statements on survey question 25 measured the participants' perceptions of facilitator skills and ability to undertake certain tasks during the small group learning process. The results of the ANOVA test revealed $F(1, 38) = 1.63$, $p=.21$. This finding supports that there were no differences in the perceptions of the skills needed for effective implementation of PBL among secondary mathematics PBL facilitators with different levels of facilitation experience (i.e., novice and advanced) as measured by the *Facilitator Perception Survey-Revised*. This finding supports that, in the population, there is no statistically significant difference between the mean *skills* perception scores of novice and advanced secondary mathematics PBL facilitators. This indicates that regardless of the amount of facilitation experience (number of problem scenarios facilitated), there was no difference between the perceptions of novice and advanced facilitators of their ability to undertake certain tasks during the small group learning process. This finding is inconsistent with what is suggested in the literature in that research shows that facilitators will build their skills and become more comfortable with their abilities with increased PBL facilitation experience (e.g., Ertmer & Simons, 2006; McLean, 2003). This indicates there should be a difference in the perceptions of novice facilitators and advanced facilitators of their abilities to undertake certain task. One possible explanation for the inconsistent findings is that this sample did not have a significant amount of facilitation experience. Eighty eight percent (*n*

= 35) of the participants had facilitated five or fewer problems and 98% (*n* = 39) had facilitated 10 or fewer problems. The participants' lack of actual facilitation experience may be the reason there was not a difference between the two groups.

Another possible explanation for the inconsistency in this finding is also directly related to the low sample size and power available to detect an effect. However, the mean *skills* score for the novice group (*M* = 3.28, *SD* = .62) was lower than the mean *skills* score for the advanced group (*M* = 3.53, *SD* = .65). Similar to the outcome of the previous research question, this data reveals some evidence to indicate that the *skills* mean score *in* the population for the advanced group is actually higher than the novice group. Likewise, the researcher believes because of the low sample size there was not enough power to detect a statistically significant difference between the groups. This is specifically due to the small effect size detected for this effect. This also provides useful information for the researcher to plan for future studies, which will include a larger sample size to aide in detecting a statistical significant difference when one is present.

Research Question 4

Research question four addressed the challenges secondary school mathematics, PBL facilitators perceive they encounter while they are planning for and implementing PBL into the classroom. Previous studies have reported that many PBL facilitators struggle to implement the instructional approach effectively in the classroom (e.g., Gallagher, 1997; Grants & Hill, 2006). In this study, the open coding process revealed five main themes (i.e. roles, refusal to participate, time constraints, curricular constraints, and sufficient resources).

Roles and Participation

The majority of respondents (13 respondents) found one or more roles of a PBL facilitator difficult or challenging. Three respondents commented that they had one or more students who refused to participate. Time constraints, curricular constraints, and lack of sufficient resources were other themes that emerged as a challenge from the data to a lesser degree. These challenges were consistent with challenges of PBL facilitators reported in previous studies. However, the researcher did not expect that a small but significant number (three participants) of participants had not yet implemented the process into the classroom.

Even though some facilitators struggled with the implementation process, they had also witnessed the positive effects of PBL on their students. For instance one participant stated:

> The students are for the most part more motivated; they learn to think critically; they learn to solve real-world problems; they gain confidence in their intellectual abilities; they learn to work collaboratively, and they retain more of what they learn because they discover many of the principles to be learned.

This indicates that though many facilitators will face challenges and a level of discomfort when implementing PBL, their students will likely experience many of PBL's intended positive benefits (e.g., increased motivation, increased higher order thinking level, increased self-efficacy, improved collaboration skills, and increased knowledge retention). This will allow these students the opportunity to become equipped with 21st century skills and more likely successful in college and the workforce.

As previously indicated participants commented most often on the difficulty of the roles of a PBL facilitator (e.g., designing engaging problems, managing the small groups). However, the literature also suggests that one of the major challenges of the roles is to encourage student independence (e.g., Hemlo-Silver, 2004; Wilkerson, 1995). When Wilkerson looked at the facilitation process, the researcher found that allowing student control was one of the most difficult aspects of the PBL facilitator roles. In the present study, facilitators did not mention directing students towards becoming autonomous learners as difficult or a challenge. This finding may suggest facilitators in the present study were comfortable with their skills on building independent self-directed learners.

Some participants expressed the challenge of the role by commenting that trying to keep the groups on task when working with another group was difficult. Another participant stated, "the process of trying to teach them how to work together while doing the problem was very difficult." Eighteen participants (73%) perceived ensuring all students participate as an essential role of a facilitator. Six (24%) participants also commented that some students did not participate in the small group learning process. This indicates that some students were not engaged in learning. Erickson (1999) has suggested that the problems teachers choose should be interesting and challenging for students and of a suitable level of difficulty for a variety of students. The implication is that facilitators should select tasks linked to students' experiences so students can see the relevance of ideas and skills they already possess. Contrary to the previous mentioned challenges, when asked about the strengths and weakness of PBL, several facilitators indicated that their students not only participated in the process but were motivated and eager to participate. For example, one respondent stated, "I believe that the PBL process has many strengths. The students are for the most part more motivated." Another respondent indicated that her students not only participated but were engaged in the learning process. Specifically, the participant commented, "The students are for the most part more motivated; the majority of the students buy in and are motivated to do a good job."

In terms of teaching experience, the literature indicates that regardless of the number of years teaching experience (novice and veteran teachers) those who are new to PBL struggle with effectively implementing the approach and developing the needed skills (e.g., Ertmer &Simons, 2006; Schoen & Charles, 2003). This is because becoming an effective PBL facilitator requires practice facilitating. Also, because it is so different from how many participants are accustomed to teaching and PBL requires them to learn many new skills that may not have been required of them when using traditional teaching approaches.

Time and Curricular and Resources Constraints

Time constraints, curricular constraints, and lack of sufficient resources were commented on to a lesser extent than the previously mentioned themes. Five participants suggested that time constraints were a challenge and can impede the PBL process. Specifically one participant stated "we needed more prep time." Two participants commented on curricular constraints and lack of sufficient resources as a challenge. District curricular constraints and the Common Core Standards were both viewed as a barrier or challenge to implementing PBL. Others commented that they did have not enough resources to do implement the process effectively.

These results indicate that some participants' need more scheduled time during the school day to plan and collaborate on PBL. These results also indicate that some participants perceive they would have more time to implement PBL if they did not have to follow a mandated curriculum guide. Thus, they perceived that PBL and the standards cannot coincide in the same classroom. It further indicates that some participants do not feel the support from their school or district to acquire the resources needed to implement successfully this instructional approach.

The implication of these findings is that schools and school districts need to find ways to schedule more planning time into the school day (e.g., Schoen & Charles, 2003). The researcher recommends facilitators who do not have the support of their school or district may be able to individually or work collaboratively with other facilitators to write a grant to fund PBL lesson studies and acquire needed PBL resources. The implication of these findings is also that PBL training and professional development should focus more on training facilitators to use PBL with their existing or required curriculum; thus, enabling them to observe that PBL can be effectively used to teach the required curriculum, not replace it. Other recommendations include developing PBL facilitator mentoring programs, follow-up in class support, and the development of regional, and national PBL networks. In conclusion, a culture resistant to change can have a significant impact on teachers' ability to effectively plan for and implement PBL into their classroom. The researcher in agreement with the literature proposes that a successful change in culture must be supported and modeled at the administrative level. Therefore, the researcher recommends that school administrators, teacher leaders, as well as other teachers, participate in PBL training and professional development

Limitations

There were several limitations associated with the study. First, the small number of problems the participants had facilitated was a limitation of the study. Almost half the participants had facilitated less than three problem scenarios. Also, almost 80% of the participants had less than three years of facilitation experience. This may be due to the fact that even though PBL originated in the late 1960s in medical school education, it is still a relatively new instructional approach in secondary school education. What the researcher did not anticipate is that so many participants completed the PBL training but did not implement the approach into their classrooms. This was also a limitation of the study because a significant number of the participants did not have this experience to reflect on and to guide their responses to the survey questions. Secondly, the low Cronbach's alpha generated on the *roles* subscale (alpha = .271) and the *training* subscale (alpha = .35) was a limitation of the study. Fink (2009) has suggested that an alpha over .5 is commonly regarded as acceptable.

Also, the indirect delivery of the survey invitation by the director of the PBL Network was a limitation of the study. This indirect method resulted in the researcher's inability to verify the number of facilitators that were sent email invitations or match email invitations with responses. As the researcher was unable to contact potential participants directly, she was unable to troubleshoot or be aware of any technical problems that may have occurred. Finally, the low sample size also limited the analysis. The lower number of responses in each category (basic, intermediate, advanced, expert) meant that responses to items had to be transformed to two response categories rather than the original four response categories resulting in some loss of valuable information. In addition, the low sample size contributed to a loss in statistical power which appeared to affect the hypothesis test results.

Recommendations for Future Study

The first recommendation for future research prompted by this study is to include a question on the survey asking participants if they would be willing to participate in a follow up interview. Follow up interviews would be beneficial to accompany the *Facilitator Perception Survey -Revised* to obtain a more in-depth view of participants' perceptions. Another recommendation would be to include a follow up question to the survey question "How many PBL cases have you facilitated?" If participants report that they have not facilitated a PBL case or problem scenario, there should be an open response area for them to explain why they have not yet facilitated a PBL case. The rationale for this is because in this study several facilitators indicated that they had not facilitated any PBL cases or problems scenario. Therefore, future research should further investigate the reasons many facilitators who receive PBL training do not implement the instructional approach into their classrooms. Another recommendation is to expand the study to include facilitators who have not had formal PBL facilitation training. This could help further identify challenges and barriers facilitators have in successfully implementing the approach into their classrooms. Perceptions of facilitators with a larger sample are also needed to enhance the survey findings from this study. A larger sample would allow an adequate number of participants to be included in each facilitation experience category (i.e., novice, intermediate, advanced, and expert) as originally planned, and provide a more informative study.

Implications for Practice

With minor revisions, the *Facilitator Perception Survey-Revised* may be useful in other secondary education content areas using the PBL approach. It is applicable for new facilitators, practicing facilitators, individuals considering PBL facilitation, and researchers. The survey and the findings of this research also have practical implications for teacher educators involved with teacher development in secondary education. Barrows (1994) argued that the training of the PBL facilitator impacts the success or failure of PBL. Individuals designing learning experiences for facilitator training workshops may find this instrument useful as a vehicle to examine facilitators' perceptions. It may serve as a tool to engage workshop participants in activities to stimulate discussion on PBL issues. It can also be used as a self-evaluation tool. This may also increase self-awareness of a commitment to the PBL model that may benefit professional development programs and individuals.

Conclusions

In closing, continuous facilitation support, training, and professional development for teachers and administrators are needed to aid facilitators in successfully implementing PBL into the classroom. It is also needed to sustain those who have already effectively implemented it. The *Facilitator Perception Survey-Revised* is a tool useful for professional development. Limitations in this study include the low number of problems PBL facilitators had facilitated, the low Cronbach's alpha for the *training* and *roles* subscales, and the small sample size.

Consistent with existing research (e.g., Cezero, 2004; Lubienski, 2000; Mergendoller et al., 2006), with the scarce amount of research on PBL in secondary schools, there is an enormous need for more research. This research is needed to validate PBL in the secondary school classrooms. Teachers, who may be dissatisfied with traditional instructional approaches or just seeking an instructional approach with the intended learning outcomes of PBL, need evidence of its effectiveness. Research is also needed to help facilitators effectively implement the approach and examine the claims that PBL is more effective for a specific group of students, or to teach a specific content area, or certain concepts more effective than traditional instructional approaches. Therefore, the challenge to investigate the perception of PBL facilitators and other significant aspects of PBL continues.

REFERENCES

Albanese, M. A., & Mitchell, S. (1993). Problem-based learning: A review of literature on its outcomes and implementation issues. *Academic Medicine, 68*(1), 52-81.

Barrows, H. (1994). *Practice-Based Learning: Problem-Based Learning Applied to Medical Education.* Springfield, IL: Southern Illinois, University School of Medicine.

Barrows, H. S. (1996). Problem-based learning in medicine and beyond:A brief overview. In L. Wilkerson, & W. Gilselaers (Eds.), *Bringing problem-based learning to higher education: Theory and practice.New Directions For Teaching and Learning Series, No. 68* (pp. 3-11). San Franscisco: Jossey-Bass.

Barrows, H. S., & Tamblyn, R. M. (1980). *Problem-based learning.* New York: Springer.

Berkson, J. (1993). Problem-based learning: Have the expectations been met? *Academic Medicine, 10*, 579-588.

Boaler, J. (1999). Mathematics for the moment, or the millinnium? *Education Week, 58*, 23-29.

Boaler, J. (2002). Exploring the nature of mathematical activity: Using theory research and "working hypotheses" to broaden conceptions of mathematics knowing . *Educational Studies in Mathematics, 51*, 3-21.

Borgatta, E. G. (1964). *Quick word test: Level1-Form CM.* New York: Harcourt, Brace and World.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (2000). *How people learn: brain, mind, experience, and school.* Washington D. C.: National Academy Press.

Brooks, J. G., & Brooks, M. G. (1999). *In search of understanding: The case for constructivist classrooms.* Alexandria: Association for Supervision and Curriculum Development.

Cangelosi, J. S. (1996). *Teaching mathematics in secondary and middle school.* New Jersey: Prentice-Hall.

Cerezo, N. (2004). Problem-based learning in the middle school: A research case study of the perceptions of at-risk females. *Research in the Middle Level Education Online, 27*(1), 1-13.

Clarke, D. M. (1997). The changing role of the mathematics teacher. *Journal for Research on Mathematics Education, 28*(3), 278-308.

Clarke, D., Breed, M., & Fraser, S. (2004). The consequences of problem-based mathematics curriculum. *Mathematics Educator, 14*(2), 7-16.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences.* Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.

Creswell, J. (2005). *Educationaal research: Planning, conducting, and evaluation* (2nd ed.). Columbus, Ohio: Pearson Education.

Crocker, L., & Algina, J. (1986). *Introduction to classical and modern test theory.* Fort Worth: Harcourt Brace Jovanovich College Publishers.

Darling-Hammond, L. (1998). Teacher learning that supports student learning. *Educational Leadership, 55*(5), 6-11.

Darling-Hammond, L., & McLaughlin, M. (1995). Policies that support professional development in an era of reform. *Phi Delta Kappa, 76*, 597-604.

De Vos, A. (2003). *Research at Grass Roots: For the social sciences and human service professions.* Pretoria: Van Schaik.

Delisle, R. (1997). *How to use problem-based learning in the classroom.* Alexandria: Association for Supervision and Curriculum Development.

Dewey, J. (1938). *Logic: The theory of inquiry.* New York: Holt.

Dochy, F., Segers, M., Van den Bossche, P., & Gijbels, D. (2003). Effects of problem-based learning a meta-analysis. *Learning and Instruction : The journal of the European Association for Research on Learning and Instruction, 13*(5), 533-568.

Elmore, R. F. (2002). *Bridging the gap between standards and achievement: The imperative for professional development in education.* Washington, D C: Albert Shanker Institute.

Erickson, D. (1999). A problem-based approach to mathematics instruction. *The Mathematics Teacher, 92*(6), 516-521.

Ertmer, P. A., & Simons, K. D. (2006). Jumping the PBL Implementation Hurdle: Supporting the Efforts of K–12 Teachers. *Interdisciplinary Journal of Problem-based Learning, 1*(1), 40-54. doi:10.7771/1541-5015.1005

Fink, A. (2009). *How to conduct surveys: A step-by-step guide* (4th ed.). Thousand Oaks, CA: Sage.

Fosnot, C. T. (1996). Constructivism: A psychological theory of learning. In C. T. Fosnot (Ed.), *Constructivism: Theory, perspectives, and practice* (pp. 8-33. New York). New York: Teacher College Press.

Gallagher, S. A. (1997). Problem-based learning: Where did it come from, what does it do, and where is it going? *Journal for the Education of the Gifted , 20*, 332-362.

Gallagher, S. A., Rosenthal, H., & Stepien, W. (1992). The effects of problem-based learning on problem-solving. *Gifted Child Quarterly, 36*(4), 195-200.

Gallagher, S., & Stepien, W. (1996). Content acquisition in problem-based learning:Depth versus breadth in American Studies. *Journal for the Education of the gifted*, 257-275.

Gay, L. R., Mills, G. E., & Airasian, P. (2006). *Educational research: Competencies for analysis and application* (8th ed.). Columbus: Pearson Education, Inc.

Gordon, P. R., Rogers, A. M., Comfort, M., Gavula, N., & McGee, B. P. (2001). A taste of problem-based learning increase achievement of urban minority middle-school students. *Educational Horizons, 79*(4), 171-175.

Grant, M. M., & Hill, J. R. (2006). Weighing the rewards with the risks? Implementing student-centered pedagogy within high-stakes testing. In M. M. Grant, J. R. Hill, R. Lambert, & C. McCarthy (Eds.), *Understanding teacher stress in the age of accountability* (pp. 19-42). Greenwich: Information Age.

Greeno, J. G., Collins, A. M., & Resnick, L. B. (1996). Cognition and learning. In D. C. Berliner, & R. C. Calfee (Eds.), *Handbook of educational psychology* (pp. 15-46).

Hawley, W. D., & Valli, L. (1999). The essentials of effective professional development:A new consensus. In L. Darling-Hammond, & G. Sykes (Eds.), *Teaching as the learning professional: Handbook of policy and practice* (pp. 127-150). San Francisco: Jossey-Bass.

Hemlo, C. E., & Evensen, D. H. (2000). Problem-based learning: Gaining insights on learning interactions through multiple methods of inquiry. In D. J. Eversen, & C. E. Hemlo (Eds.), *Problem-based learning: A research perspective on learning interactions* (pp. 1-16). Mahwah: Lawrence Erlbaum Associates.

Hemlo-Silver, C. (2004). Problem-based learning: What and how do students learn? *Educational Psychology Review, 3*, 235-266.

Hemlo-Silver, C., & Barrow, H. S. (2006). Goals strategies of a problem-based learning facilitator. *The Intrdisciplinary Journal of Problem-Based Learning, 1*(Spring), 21-39.

Hiebert, J. (1999). Relationship between research and the NCTM standards. *Journal for Research in Mathematics Education, 30*, 3-19.

Hiebert, J., Carpenter, T., Fennema, E., Fuson, K., Human, P., Murray, H., . . . Werne, D. (1996). Problem solving as a basis for reform in curriculum and instruction: The case of mathematics. *Educational Researcher, 24*(4), 12-21.

Huitema, B. E. (1980). *The analysis of covariance and alternatives* . New York: John Wiley.

Hunter, J. (2009). Developing a productive discourse community in the mathematics classroom. In R. Hunter, B. Bicknel, & T. Burgess (Ed.), *Proceedings of the 32nd Annual General Conference of the Mathematics Education Research Group* (pp. 260-260). Wellington: MERGA.

Huntley, M. A., Rasmussen, C., Villarubi, R. S., & Fey, J. T. (2000). Effects of standard-based mathematics education: A study of the Core-Plus Mathematics Project algebra and functions strand. *Journal for Research in Mathematics Education, 31*(3), 328-361.

Kirschner, P., Sweller, J., & Clark, R. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist, 41*(2), 75–86.

Kwak, N., & Radler, B. (2002). A comparison between mail and web-based surveys:Response pattern, respondent profile, and data quality. *Journal of Official Statistics, 18*(2), 257-273.

Lambros, A. (2004). *Problem-based learning in middle and high school classrooms: A teacher's guide to implementation.* Thousand Oaks: Corwin Press.

Lewellen, H., & Mikusa, M. G. (1999). Now here is that authority on mathematics reform, Dr. Constructivist! *The Mathematics Teacher, 92*(2), 158-163.

Lomax, R. G. (2001). *An introduction to statistical concepts for education and the behavioral sciences.* Mahwah, N J: Lawrence Erlbaum Associates.

Loucks-Horsley, S., Hewson, P. W., Love, N., & Stiles, K. E. (1998). *Designing professional development for teachers of science and mathematics.* Thousand Oaks, CA: Corwin Press.

Lubienski, S. T. (1999). Problem-centered mathematics teaching. *Mathematics Teaching in the Middle School, 5*(4), 250-255.

Lubienski, S. T. (2000). Problem solving as a means toward mathemmatics for all: An exploratory look through a class lens. *Journal for Research in Mathematics Education, 31*(4), 454-482.

Manoucheri, A., & St John, S. (2006). From classroom discussion to group discourse. *Mathematics Teacher*, 544-552.

Maxwell, S. E., & Delaney, H. D. (2004). *Designing experiments and analyzing data: A model comparison perspective* . Mahwah, N J: LEA.

Mayer, R. (2004). Should there be a three-strikes rule against pure discovery learning? The case for guided methods of instruction. *American Psychologist, 59*, 14–19.

McCaffrey, D., Hamilton, L., Stecher, B., Klein, S., Bugliari, D., & Robyn, A. (2001). Interactions among instructional practices, curriculum, and student achievement: The case of standards-based high school mathematics. *Journal for Research in Mathematics Education*, *32*(5), 493–517.

McLean, M. (2003). What can we learn from facilitator and student perceptions of facilitation skills and roles in the first year of a problem-based learning curriculum? *BioMed Central Medical Education, 3*(9), 1-10.

Mergendoller, J. R., Maxwell, N. L., & Bellisimo, Y. (2006). The effectiveness of problem-based instruction: A comparative study of instructional methods and student characteristics. *The Interdisciplinary Journal of Problem-based Learning*, *1*(2), 49-69.

Murray, H., Olivier, A. I., & Human, P. G. (1998). Learning through problem solving. Malati Project IWWOUS. In *Wessels, DCJ 2000 Reader for MEDMA.* Unisa, Pretoria.

National Council of Teachers of Mathematics. (1989). *Curriculum and evaluation standards for school mathematics.* Reston: Author.

National Council of Teachers of Mathematics. (1991). *Professional standards for teaching mathematics.* Reston: Author.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics.* Reston: Author.

National Science Foundation. (2006, March). Panel reviews a decade of mathematics.

O'Brien, T. C. (1999). Parrot mathematics. *Phi Delta Kappan, 2*, 23-27.

O'Brien, T. C. (2004). What's basic in mathematic? *Principal*, *10*, 25-28.

Partnership for 21st Century Skills/AACTE . (2010, September). *21st century knowledge and skills in educator preparation. Pearson.* Retrieved from http://www.p21.org/storage/documents/aacte_p21_whitepaper2010.pdf.

PBLNetwork. (2008). *Problem-based learning matters.* Aurora, Illinois: Illinois Mathematics and Science Academey.

Putnan, R. T., & Borko, H. (2000). What do new views of knowledge and thinking have to say about research and learning? *Educational Research*, *29*(1), 4-15.

Reys, R., Reys, B., Lapan, R., Holliday, G., & Wasman, D. (2003). Assessing the impact of standards-based middle school mathematics curriculum materials on student achievement. *Journal for Research in Mathematics Education*, *34*, 74-95.

Richardson, V. (2003). Constructivist pedagogy. *Teachers College Record* , *105*(9), 1623-1640.

Ronis, D. L. (2008). *Problem-based learning.* Thousand Oaks: Corwin Press.

Roth, W. M. (1995). Affordances of computers in teacher-student interactions: the case of interactive Affordances of computers in teacher-student interactions: the case of interactiveAffordances of computers in teacher-student interactions: the case of interactive physics . *Journal of Research in Science Teaching, 32*(4), 329–347.

Roth, W. M. (1995). Affordances of computers in teacher-student interactions: the case of interactive physics. *Journal of Research in Science Teaching, 32*(4), 329–347.

Rutherford, A. (2011). *ANOVA and ANCOVA: A GLM Approach* (2nd ed.). Oxford, United Kingdom: John Wiley & Sons.

Savery, J. R. (2006). Overview of problem-based learning: Definitions and distinctions. *Interdisciplinary Journal of Problem-based Learning, 1*(1), 9-20.

Savery, J. R., & Duffy, T. M. (1995). Problem-based learning: An instructional model and its constructivist framework. *Educational Technology, 35*(5), 31-35.

Schmidt, H. G., & Moust, J. H. (2000). Factors affecting small-group learning: A review of the research. In C. E. Hemlo, *Problem-based learning: A research perspective on learning interactions* (pp. 19-52). Mahwah, N J: Erlbaum.

Schoen, H., & Charles, R. (Eds.). (2003). *Teaching mathematics through problem solving grades 6-12.* Reston: The National Council of Teachers of Mathematics, Inc.

Schoen, H., Cegulla, K., Finn, K., & Fi, C. (2003). Teacher variables that relate to student achievement when using a standards-based curriculum. *Journal for Research in Mathematics Education, 34*(33), 228–259.

Schoenfeld, A. (1989a). Problem solving in context(s). In *The teaching and assessing of mathematical problem solving* (pp. 82-92). Reston, VA: National Council of Teachers of Matheamtics.

Schoenfeld, H. A. (1992). Learning to think mathematically. In D. Grouws (Ed.), *Handbook for Research on Mathematics Teaching and Learning* (pp. 334-370). New York: MacMillian.

Sherin, M. G. (2002a). A balancing act: Developing a discourse community in a mathematics classroom. *Journal of Mathematics Teacher Education, 5,* 205-233.

Slattery, J., & Douglas, J. (2011). Exploring novice and experienced PBL facilitators' perceptions of their roles and skills. Does experience matter? *Third International Conference on Problem Based Learning in Speech Language Pathology and Audiology.* Hong Kong University.

Smith, C. M. (1998). A Discourse on discourse: Wrestling with teaching rational equations. *The Mathematics Teacher, 91*(9), 749-753.

Speck, M., & Knipe, C. (2005). *Why can't we get it right? Designing high quality professional development for standard-based schools* (2nd ed.). Thousand Oaks, CA: Sage.

Star, J. R., Smith, J. P., & Jansen, A. (2008). What students notice as different between reform and traditional mathematics programs. *Journal for Research in Mathematics Education, 39*(1), 9-32.

Stein, M., Smith, M., Henningsen, M., & Silver, E. (2000). *Implementing standards-based mathematics instruction: A casebook for professional development.* New York: Teachers College Press.

Stigler, J. W., & Hiebert, J. (1999). *The teaching gap: Best ideas from the world's teachers for improving education in the classroom.* New York: Free Press.

Strauss, A., & Corbin, J. (1990). *Basics of qualitative research: Grounded theory procedures and techniques.* London: Sage.

Tarr, J. E., Reys, R. E., Reys, B. J., Chavez, O., Shih, J., & Osterlind, S. J. (2008). The impact of middle-grades mathematics curricula and the classroom learning enviornment on student achievement. *Journal for Research in Mathematics Education, 39*(3), 247-280.

Torp, L., & Sage, S. (2002). *Problems as possibilities:Problem-based learnning for K-16 education.* Alexandria: Association for Supervision and Curriculum Development.

Vernon, D. T., & Blake, R. L. (1993). Does problem-based learning work? A meta-analysis of evaluative research. *Academic Medicine*, *68*(7), 550-563.

von Glasersfeld, E. (1989). Cognition, construction of knowledge, and teaching. *Synthese*, *80,* 121-140.

Walker, A., & Leary, H. (2009). A Problem based learning meta analysis:Differences across problem types, implementation types, disciplines, and assessment levels. *The Interdisciplinary Journal of Problem-based Learning*, *3*(1), 12-43.

Wilkerson, L. (1995). Indentification of skills for the problem-based tutor:Student and faculty perspectives. *Instructional Science, 22*, 303-315.

Wilson, S. M., & Berne, J. (1999). Teacher learning and the acquisition of professional knowledge: An examination of research on contemporary professional development. In A. Iran-Nejad, & P. D. Pearson (Eds.), *Review of research in education* (pp. 173-209). Washington , D C: American Educational Research Association.

Winn, W. (2003). Research methods and types of evidence for research in educational psychology. *Educational Psychology Review*, *15*, 367–373.

Wubbels, W. T., F, K., & Broekman, H. (1997). Preparing teachers for realistic mathematics education. *Education Studies in Mathematics*, *32*, 1-28.

APPENDIX A

FACILITATOR PERCEPTION SURVEY- REVISED

Problem-based Learning Facilitator Perception Survey-Revised

Instructions: Answer all questions. None of the data collected will be used to identify or single out any teacher and all answers will be treated confidentially.

Part 1

This section asks a few questions about your background.

1. What is your gender?
   A. Male
   B. Female

2. Which state do you live in?

3. What is your age in years?

4. How many years have you taught mathematics?

5. What is the highest level of education you attained?
   A. Bachelor's Degree
   B. Master's Degree
   C. Education Specialist Degree
   D. Doctoral Degree

6. I have participated in a basic training PBL workshop.
   □ Yes
   □ No

7. I have participated in an advanced PBL training workshop.
   □ Yes
   □ No

8. I have facilitated a PBL training workshop.
   □ Yes
   □ No

9. Have you had the experience of implementing PBL into a classroom?
   □ Yes
   □ No

10. How many years have you been a PBL facilitator (e.g., zero, one, two, three, etc.)?

11. How many PBL cases (or problem scenarios) have you facilitated (e.g., zero, one, two, three, etc.)?

12. How would you describe the socioeconomic status of the majority of your students?
A. Low
B. Medium
C. High
D. NA (There is no dominant socioeconomic status among the students whom I teach)

Training:

13. PRIOR TO PBL TRAINING, how would rate your knowledge/understanding of the PBL philosophy?

_ none
_ scant
_ reasonable/average
_ good
_ excellent
_N/A (I have not participated in PBL training)

14. AFTER PBL TRAINING, how would you rate your knowledge/ understanding of the PBL philosophy?

_ none
_ scant
_ reasonable/average
_ good
_ excellent
_N/A (I have not participated in PBL training)

15. The PBL training provided me with sufficient insight into how a facilitator (classroom coach) should manage a small PBL group.

_ strongly disagree
_ disagree
_ not sure
_ agree
_ strongly agree
_N/A (I have not participated in PBL training)

Facilitation Experiences:

16. I feel or felt confident after facilitating my first session.

_ strongly disagree
_ disagree
_ not sure
_ agree
_ strongly agree
_N/A (I have not participated in PBL training)

17. To become a more effective facilitator, one must facilitate more than one problem scenario.

_ strongly disagree
_ disagree
_ not sure
_ agree
_ strongly agree

18. I would prefer to facilitate (to be a classroom coach) rather than continue to teach students using traditional instructional approaches (i.e. lectures) as is undertaken in the traditional classrooms.

_ strongly disagree
_ disagree
_ not sure
_ agree
_ strongly agree

19. I would rate my first facilitation/classroom coaching session (i.e. of a. case or problem scenario) as successful.

_ strongly disagree
_ disagree
_ not sure
_ agree
_ strongly agree

20. After facilitating my first theme (i.e., case or problem scenario) I generally feel confident about facilitation.

_ strongly disagree
_ disagree
_ not sure
_ agree
_ strongly agree

21. After facilitating for one theme (case or problem scenario), how did you feel about the PBL process in terms of promoting learning in mathematics?

_ strongly disagree
_ disagree
_ not sure
_ agree
_ strongly agree

22. Once I facilitated one theme, the PBL training made more sense in terms of understanding the role of the facilitator in small group learning sessions.

_ strongly disagree
_ disagree
_ not sure
_ agree
_ strongly agree
_N/A (I have not facilitated)

23. After facilitating one theme, my opinion of PBL being beneficial in terms of student learning changed.

_ strongly disagree
_ disagree
_ not sure
_ agree
_ strongly agree
_N/A (I have not facilitated)

24. One or more tutorial groups (small groups) in my class were difficult to control based on my understanding of how a small group should function.

_ strongly disagree
_ disagree
_ not sure
_ agree
_ strongly agree
_N/A (I have not facilitated)

25. I had a student in one of the groups in my classroom that disrupted the group process.

_ strongly disagree
_ disagree
_ not sure
_ agree
_ strongly agree

_N/A (I have not facilitated)

26. I had a student in one of the groups in my classroom that did not participate in the discussions.

_ strongly disagree
_ disagree
_ not sure
_ agree
_ strongly agree
_N/A (I have not facilitated

Part II

For each of the questions below, please answer in terms of what you perceive about problem-based learning based on your experience and knowledge. Please respond to the following statements about problem-based learning by selecting one response for each question.

Perceptions of your roles as a PBL facilitator:

27. A role of a facilitator is to ensure that the small group process runs smoothly.

_ strongly disagree
_ disagree
_ not sure
_ agree
_ strongly agree

28. A role of a facilitator is to ensure that all students participate equally in the group.

_ strongly disagree
_ disagree
_ not sure
_ agree
_ strongly agree

29. A role of a facilitator is to assess individual students in the group.

_ strongly disagree
_ disagree
_ not sure
_ agree
_ strongly agree

30. Through probing questions the facilitator ensures that the group achieves their learning goals.

_ strongly disagree
_ disagree
_ not sure
_ agree
_ strongly agree

31. The role of the facilitator is **NOT** to provide expert knowledge related to the case (or problem scenario).

_ strongly disagree
_ disagree
_ not sure
_ agree
_ strongly agree

32. A facilitator should treat learners in small group sessions as colleagues despite them being novices.

_ strongly disagree
_ disagree
_ not sure
_ agree
_ strongly agree

33. A facilitator should become a mentor (e.g., for whom students can confide) for learners in his/her group.

_ strongly disagree
_ disagree
_ not sure
_ agree
_ strongly agree

34. A facilitator should serve as a role model (i.e. professional behavior; ethical, etc.) for learners in his/her group.

_ strongly disagree
_ disagree
_ not sure
_ agree
_ strongly agree

35. Did you/will you find it difficult **NOT** to share your expertise with students during sessions?

_ strongly disagree
_ disagree
_ not sure
_ agree
_ strongly agree

Perceptions of your ability to undertake certain tasks during the PBL small group tutorials (small group learning process):

36. What is your perception of your ability to ask probing questions to get students to think about issues relating to the posed problem or scenario?

_effective
_weak
_satisfactory
_good
_excellent

37. What is your perception of your ability to encourage students to clarify their ideas?

_effective
_weak
_satisfactory
_good
_excellent

38. What is your perception of your ability to encourage students to examine new ideas?

_effective
_weak
_satisfactory
_good
_excellent

39. What is your perception of your ability to point out inconsistencies in students' explanations?

_effective
_weak
_satisfactory
_good
_excellent

40. What is your perception of your ability to get students to effectively brainstorm hypotheses?

_effective
_weak
_satisfactory
_good
_excellent

41. What is your perception of your ability to encourage students to utilize their prior experience to the benefit of the group?

_effective
_weak
_satisfactory
_good
_excellent

42. What is your perception of your ability to encourage all group members to contribute?

_effective
_weak
_satisfactory
_good
_excellent

43. What is your perception of your ability to support each member of the group?

_effective
_weak
_satisfactory
_good
_excellent

44. What is your perception of your ability to ensure that everyone has a chance to contribute?

_effective
_weak
_satisfactory
_good
_excellent

45. What is your perception of your ability to encourage students to extend themselves beyond the learning objectives (i.e. instill in them that knowledge is not finite or can change)?

_effective
_weak
_satisfactory
_good
_excellent

46. What is your perception of your ability to test for a consensus between group members?

_effective
_weak
_satisfactory
_good
_excellent

47. What is your perception of your ability to encourage students to read widely (to a great extent)?

_effective
_weak
_satisfactory
_good
_excellent

48. What is your perception of your ability to summarize the progress of the group?

_effective
_weak
_satisfactory
_good
_excellent

Part III

Open-ended response

Please answer the following questions based on your perception and experiences in terms of Problem-based learning. Include as much details as possible to help support your ideas.

49. What motivated (or prompted) you to implement PBL in your classroom (e.g., believed in the PBL philosophy, my head of Department/School asked me to implement PBL)?

50. Based upon your facilitation experience, describe the strengths and weaknesses of the PBL approach to teaching.

51. Describe any challenges and / or frustrations you have experienced in the PBL facilitation process.

52. Describe any aspects of the PBL facilitation process that you enjoy.

53. How could your school system or administration best provide ongoing support for PBL facilitators?

54. Describe the type of PBL training you participated in?

APPENDIX B

SUMMARY OF CRONBACH ALPHA

OVERALL CRONBACH ALPHA

Case Processing Summary

		N	%
Cases	Valid	39	95.1
	Excluded[a]	2	4.9
	Total	41	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.893	.891	36

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
QU1	115.7692	337.498	.098	.	.895
QU2	113.9231	335.862	.254	.	.892
QU3	113.9744	332.026	.271	.	.892
QU4	115.0256	315.710	.444	.	.890
QU5	113.6923	333.640	.270	.	.892
QU6	114.2308	326.182	.408	.	.890
QU7	115.2308	292.551	.798	.	.881
QU8	115.0256	293.499	.793	.	.881
QU9	114.8718	299.273	.688	.	.884
QU10	114.6923	292.429	.759	.	.882
QU11	115.2821	295.576	.686	.	.884
QU12	115.4615	315.255	.412	.	.891
QU13	115.4359	307.410	.519	.	.889
QU14	115.0513	300.208	.615	.	.886
QU15	113.8718	336.694	.172	.	.893
QU16	114.1538	331.713	.294	.	.892
RQU17	114.2051	340.325	.029	.	.895
QU18	113.8205	332.099	.346	.	.891
RQU19	115.0513	347.260	-.172	.	.899
QU20	114.5385	338.308	.082	.	.895
RQU21	114.2821	341.945	-.026	.	.895
QU22	113.6667	331.649	.320	.	.892
RQU23	115.2821	336.103	.133	.	.894
QU24	114.5897	326.038	.458	.	.890
QU25	114.3590	323.920	.581	.	.888
QU26	114.2308	328.235	.477	.	.890
QU27	114.1538	331.713	.399	.	.891
QU28	114.6154	327.085	.446	.	.890
QU29	114.3590	325.552	.503	.	.889
QU30	114.5128	322.730	.515	.	.889
QU31	114.3077	321.219	.648	.	.887
QU32	114.3077	324.113	.512	.	.889
QU33	114.2564	333.459	.298	.	.892
QU34	114.4103	328.722	.418	.	.890
QU35	114.7179	327.997	.407	.	.890
QU36	114.3590	331.657	.366	.	.891

SCALE: ROLES

Case Processing Summary

		N	%
Cases	Valid	39	95.1
	Excluded[a]	2	4.9
	Total	41	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.271	.340	9

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
QU15	27.5641	6.937	.237	.125	.184
QU16	27.8462	6.344	.289	.280	.136
RQU17	27.8974	6.621	.281	.304	.153
QU18	27.5128	6.941	.234	.397	.185
RQU19	28.7436	7.985	-.113	.355	.381
QU20	28.2308	7.235	.071	.188	.265
RQU21	27.9744	7.184	.171	.156	.216
QU22	27.3590	7.078	.144	.627	.225
RQU23	28.9744	8.552	-.199	.311	.421

SCALE: ROLES

Case Processing Summary

		N	%
Cases	Valid	40	97.6
	Excluded[a]	1	2.4
	Total	41	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.426	.453	8

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
QU15	24.8750	7.804	.228	.089	.377
QU16	25.1500	7.464	.218	.132	.377
RQU17	25.2000	7.292	.319	.237	.336
QU18	24.8500	7.413	.319	.364	.340
RQU19	26.0750	8.789	-.097	.180	.532
QU20	25.5750	7.840	.115	.138	.425
RQU21	25.2750	7.999	.177	.143	.397
QU22	24.7750	6.538	.304	.367	.325

SCALE: ROLES-WITH RQU19 AND RQU23 EXCLUDED

Case Processing Summary

		N	%
Cases	Valid	40	97.6
	Excluded[a]	1	2.4
	Total	41	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.532	.525	7

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
QU15	22.1250	7.394	.228	.088	.507
QU16	22.4000	6.862	.264	.123	.493
RQU17	22.4500	7.228	.231	.189	.506
QU18	22.1000	6.759	.391	.364	.447
QU20	22.8250	6.969	.213	.091	.516
RQU21	22.5250	7.846	.108	.130	.547
QU22	22.0250	5.666	.415	.355	.416

SCALE: ROLES-WITH RQU19 AND RQU21 AND RQU23 EXCLUDED

Case Processing Summary

		N	%
Cases	Valid	40	97.6
	Excluded[a]	1	2.4
	Total	41	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.547	.541	6

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
QU15	18.5750	6.456	.242	.084	.523
QU16	18.8500	5.926	.283	.122	.505
RQU17	18.9000	6.605	.161	.092	.556
QU18	18.5500	5.946	.381	.336	.466
QU20	19.2750	5.999	.236	.085	.529
QU22	18.4750	4.717	.456	.349	.404

SCALE: ROLES-WITH RQU17 AND RQU19 AND RQU21 AND RQU23 EXCLUDED

Case Processing Summary

		N	%
Cases	Valid	40	97.6
	Excluded[a]	1	2.4
	Total	41	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.556	.553	5

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
QU15	14.9500	5.382	.215	.065	.551
QU16	15.2250	4.999	.226	.084	.552
QU18	14.9250	4.635	.453	.325	.433
QU20	15.6500	4.900	.226	.074	.555
QU22	14.8500	3.567	.502	.349	.364

SCALE: SKILLS

Case Processing Summary

		N	%
Cases	Valid	39	95.1
	Excluded[a]	2	4.9
	Total	41	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.942	.943	14

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
RQU23	44.4872	72.783	.308	.455	.950
QU24	43.7949	66.483	.783	.819	.935
QU25	43.5641	67.147	.816	.849	.934
QU26	43.4359	69.989	.657	.665	.939
QU27	43.3590	71.657	.599	.549	.940
QU28	43.8205	67.572	.739	.678	.936
QU29	43.5641	66.252	.852	.819	.933
QU30	43.7179	65.471	.783	.825	.935
QU31	43.5128	66.625	.822	.891	.934
QU32	43.5128	66.888	.742	.757	.936
QU33	43.4615	70.623	.636	.611	.939
QU34	43.6154	68.348	.724	.763	.937
QU35	43.9231	66.283	.818	.790	.934
QU36	43.5641	69.568	.727	.730	.937

SCALE: SKILLS

Case Processing Summary

		N	%
Cases	Valid	40	97.6
	Excluded[a]	1	2.4
	Total	41	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.949	.949	13

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
QU24	41.4500	60.613	.742	.716	.945
QU25	41.1750	60.661	.838	.834	.942
QU26	41.0500	63.382	.679	.667	.947
QU27	40.9500	64.767	.610	.557	.949
QU28	41.4250	61.225	.742	.644	.945
QU29	41.1750	60.199	.842	.781	.942
QU30	41.3250	59.251	.788	.822	.944
QU31	41.1250	60.317	.832	.886	.943
QU32	41.1250	60.984	.719	.743	.946
QU33	41.0750	64.481	.611	.589	.949
QU34	41.2250	61.820	.743	.766	.945
QU35	41.5250	59.999	.819	.790	.943
QU36	41.1750	62.969	.748	.730	.945

SCALE: TRAINING

Case Processing Summary

		N	%
Cases	Valid	40	97.6
	Excluded[a]	1	2.4
	Total	41	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.345	.430	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
QU1	7.7250	1.435	.150	.222	.379
QU2	5.8750	1.548	.506	.268	-.176[a]
QU3	5.9500	1.690	.058	.109	.558

a. The value is negative due to a negative average covariance among items. This violates reliability model assumptions. You may want to check item codings.

SCALE: TRAINING - EXCLUDED QU3

Case Processing Summary

		N	%
Cases	Valid	41	100.0
	Excluded[a]	0	.0
	Total	41	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.537	.587	2

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
QU1	3.9024	.340	.415	.172	.
QU2	2.0976	.940	.415	.172	.

SCALE: FACILITATION EXPERIENCES

Case Processing Summary

		N	%
Cases	Valid	40	97.6
	Excluded[a]	1	2.4
	Total	41	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.930	.914	11

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
QU4	28.7000	164.267	.468	.467	.934
QU5	27.3250	183.046	.037	.431	.942
QU6	27.9000	174.862	.330	.515	.936
QU7	28.9500	145.485	.864	.838	.917
QU8	28.7500	144.090	.911	.940	.914
QU9	28.6000	146.656	.840	.830	.918
QU10	28.4250	140.558	.936	.954	.913
QU11	29.0000	144.103	.836	.830	.918
QU12	29.1750	151.635	.739	.848	.923
QU13	29.1500	148.900	.762	.874	.922
QU14	28.7750	144.538	.831	.880	.918

APPENDIX C

SURVEY COVER LETTER

Date

Dear Participant:

My name is Shelia M. Ingram and I am a doctoral student in Curriculum and Instruction (Secondary Mathematics Education) at The University of Alabama. For my research study, I am examining the perceptions of facilitators (classroom coaches) on various aspects of Problem-based Learning (PBL). Since you are a secondary mathematics teacher who has previously participated in PBL professional development, I am inviting you to participate in this research study.

Taking part in this research study involves completing a survey that will take approximately 30 minutes. Your confidentiality will be protected as your responses to the survey will be anonymous. The survey data will only be accessible by me. The data will be password protected. Only summarized data will be presented at meetings or in publications. If you choose to participate in this study, please answer the questions as honestly as possible and submit the completed survey promptly through *Survey Monkey,* by April 30, 2013. Participation is strictly voluntary, and you may refuse to participate at any time.

There is no foreseeable risk in participating in this study. There is no compensation for participating. However, the findings will provide useful information regarding teachers' perceptions of the roles and skills needed to implement PBL effectively into the classroom. It will also provide insight on the type of support and professional development the participants perceived as beneficial. If you would like a summary copy of this study, please contact me at the email address listed below.

If you have questions about this study, please contact Shelia M. Ingram at 205-540-7314 or by email, sdingram1@crimson.ua.edu. If you are not satisfied with the manner in which this study is being conducted you may report any complaints to my dissertation committee chair, Dr. B. Joyce Stallworth at 205-348-6051 or by e-mail, jstallwo@bamaed.ua.edu. Also, If you have any questions about your rights as a research participant you may report (anonymously if you so choose) them to The University of Alabama Research Compliance Office, at 205-348-8461.

You are free not to participate or stop participating at any time before you submit your answers. If you freely consent to participate in this study, click on this link to begin: http://www.surveymonkey

Thank you for taking the time to assist me in my educational endeavors and for your interest in this research study.

Sincerely,

Shelia M. Ingram

APPENDIX D

SURVEY INVITATION EMAIL

Dear **PBLNetwork** members:

We have been asked to help provide some data for a doctoral student, Shelia Ingram from The University of Alabama. I'm always encouraged when people pursue research in PBL, so I told Mrs. Ingram I would send this information out to PBL practitioners. Please read through the attached cover letter, which provides more details about Mrs. Ingram's study and the purpose for the survey she is asking you to take. She includes her contact information in case you have additional questions.

Thank you for taking the time to assist Mrs. Ingram in her educational endeavors. I hope your second semester is off to a great start!

Sincerely,

Deb Gerdes
Program Director for Problem-Based Learning at IMSA
dgerdes@imsa.edu or 630-907-5957

APPENDIX E

SURVEY THANK YOU PAGE

Thank you for completing my survey! Your input will be very valuable to me in my efforts to examine PBL facilitators' perceptions of the PBL process and gain insight into the type of support and professional development facilitators find helpful. It will also significantly aid me in accomplishing my education goals. As a respondent, the results of the survey will surely be beneficial to other facilitators and education stakeholders. If you would like a summary copy of the study, please email me to request one.

Thank you for your participation.

Yours sincerely,

Shelia M. Ingram
Sdingram1@crimson.ua.edu

APPENDIX F

REMINDER EMAIL

Dear **PBLNetwork** members:

If you have not already responded, this email is to remind you that the deadline to complete the *Facilitators' Perception Survey-Revised* is April 30, 2013.

We have been asked to help provide some data for a doctoral student, Shelia Ingram from The University of Alabama. I'm always encouraged when people pursue research in PBL, so I told Mrs. Ingram I would send this information out to PBL practitioners. Please read through the attached cover letter, which provides more details about Mrs. Ingram's study and the purpose for the survey she is asking you to take. She includes her contact information in case you have additional questions.

Thank you for taking the time to assist Mrs. Ingram in her educational endeavors. I hope your second semester is off to a great start!

Sincerely,

Deb Gerdes
Program Director for Problem-Based Learning at IMSA
dgerdes@imsa.edu or 630-907-5957

APPENDIX G

IRB APPROVAL

February 28, 2013

Shelia M. Ingram
Department of Curriculum & Instruction College of Education
The University of Alabama
Re: IRB # EX-13-CM-021 "Facilitators' Perceptions of Facilitation in the Problem-Based Learning Classroom"

Dear Ms. Ingram:

The University of Alabama Institutional Review Board has granted approval for your proposed research.

Your protocol has been given exempt approval according to 45 CFR part 46.101(b) (2) as outlined below:

(2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless:
(i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and

(ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

Your application will expire on February 27, 2014. Ifyour research will continue beyond this date, complete the relevant portions of Continuing Review and Closure From. Ifyou wish to modify the application, complete the Modification of an Approved Protocol Form. <u>When the study closes, complete the appropriate portions of FORM: Continuing Review and Closure.</u>

Should you need to submit any further correspondence regarding this proposal, please include the assigned IRB application number.

Good luck with your research.

Sincerely,

Director & Research
Office for Research Compliance
The University of Alabama

APPENDIX H

SURVEY ROLES ITEMS-TABLE 3

Table 3

Survey Roles Items (Question 23) Relative Frequencies and Count

Survey Item	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree		
		Percent and Count				Mean	SD
Ensure small group runs smoothly	0 n=0	7.5 n=3	5 n=2	72.5 n=29	15 n=6	3.95	0.714
Ensure all students participate	0 n=0	15 n=6	12.5 n=5	62.5 n=25	10 n=4	3.675	0.859
NOT to assess individual students	7.5 n=3	57.5 n=23	25 n=10	10 n=4	0 n=0	2.375	0.774
Ensure groups achieve learning goals	0 n=0	2.5 n=1	20 n=8	55 n=22	22.5 n=9	3.975	0.733
NOT to provide expert knowledge	0 n=0	23.08 n=9	17.95 n=7	48.72 n=19	10.26 n=4	3.25	1.006
Treat learners as colleagues	0 n=1	27.5 n=11	22.50 n=9	47.50 n=19	2.5 n=1	3.25	0.899
Should NOT become a mentor	5 n=2	52.5 n=21	35 n=14	7.5 n=3	0 n=0	2.45	0.714
Should serve as a role model	0 n=0	7.69 n=3	2.56 n=1	56.41 n=22	33.13 n=13	4.15	0.812
Find it difficult NOT to share your expertise	0 n=0	23.08 n=9	17.95 n=7	48.72 n=19	10.26 n=4	3.46	0.969

APPENDIX I

SURVEY SKILLS ITEMS-TABLE 4 AND TABLE 5

Table 4

Survey Skills Items (Question 24: Items 1-7) Relative Frequencies and Count

Survey Item	Ineffective	Weak	Satisfactory	Good	Excellent		
	Percent and Count					Mean	SD
Ask probing questions	0 n=0	25 n=10	37.5 n=15	30 n=12	7.5 n=3	3.20	0.911
Encourage students to clarify ideas	0 n=0	12.5 n=5	35 n=14	45 n=18	7.5 n=3	3.48	0.816
Encourage students to examine new ideas	0 n=0	7.5 n=3	32.5 n=13	52.5 n=21	7.5 n=3	3.60	0.744
Point out inconsistencies in students' explanations	0 n=0	2.5 n=1	35 n=14	52.5 n=21	10 n=4	3.70	0.687
Get students to effectively brainstorm hypotheses	0 n=0	22.5 n=9	37.5 n=15	35 n=14	5 n=2	3.23	0.862
encourage students to utilize their prior experience to the benefit of the group	0 n=0	12.5 n=5	37.5 n=15	40 n=16	10 n=4	3.48	0.847
encourage all group members to contribute	0 n=0	22.5 n=9	35 n=14	30 n=12	12.5 n=5	3.33	0.971

Table 5

Survey Skills Items (Question 24: Items 8-13) Relative Frequencies and Count

Survey Item	Ineffective	Weak	Satisfactory	Good	Excellent	Mean	SD
	Percent and Count						
support each member of the group	0 0	10 n=4	40 n=16	37.5 n=15	12.5 n=5	3.53	0.847
ensure that everyone has a chance to contribute	0 n=0	12.5 n=5	37.5 n=15	35 n=14	15 n=6	3.53	0.905
encourage students to extend themselves beyond the learning objectives	0 n=0	2.5	47.5 n=19	40 n=16	10 n=4	3.58	0.712
test for a consensus between group members	0 n=0	10 n=4	47.5 n=19	32.5 n=13	10 n=4	3.43	0.813
encourage students to read widely	0 n=0	25 n=16	45 n=18	22.5 n=9	7.5 n=3	3.13	0.882
summarize the progress of the group	0 n=0	7.5 n=3	42.5 n=17	45 n=18	5 n=2	3.48	0.716