

An Exploration into Effective Practices for Implementing Project-Based Learning (PJBL)  
in an Integrated, Elementary Mathematics Curriculum

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## **Abstract**

This qualitative study explored how elementary school teachers negotiate common challenges associated with the implementation of project-based learning (PJBL) when enacting this strategy in an integrated, mathematics and science project. Based on an extensive literature review, 6 challenges associated with PJBL were identified. These include transforming teacher and student roles, learner readiness, motivation and engagement, group dynamics and collaboration, authenticity, and assessment. A case study methodology was used in which qualitative data were collected from an interview with 1 elementary school teacher who facilitates PJBL in an integrated, mathematics curriculum. Based on the data analysis of this study, the strategies discussed can be divided into 3 major themes: providing general facilitation guidelines for PJBL, promoting a growth mindset, and facilitating the development of process skills. The results of this case study offer insight and recommendations for elementary teachers who are implementing PJBL in their context and provide elementary and novice teachers with a number of suggestions and strategies to optimize their success when implementing PJBL in an integrated, mathematics curriculum for the first time.

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## CHAPTER ONE: INTRODUCTION

In order to meet the growing needs of today's 21st century learners, especially in mathematics, students need to become engaged in their learning, pursue their interests, collaborate with their peers, and solve real-world problems that are relevant to their everyday lives and experiences (Hernandez-Ramos & De La Paz, 2009; Lee, Blackwell, Drake, & Moran, 2014). Project-based learning (PJBL) is an instructional model that is known for these attributes. In this study, I focus on effective practices used by elementary school teachers when implementing PJBL in an integrated, mathematics and science curriculum. More specifically, the study investigated how an elementary school teacher overcomes challenges associated with PJBL in an elementary, integrated context that includes mathematics.

### **Research Problem**

PJBL is an instructional strategy which promotes performance based learning through real-world connections, technology, and peer collaboration in order to enhance students' problem solving skills (David, 2008; Hung, Hwang, & Huang, 2012). When used in mathematics education, PJBL significantly enhances students' motivation and attitude towards mathematical learning, heightening their academic achievement (Yetkiner, Anderoglu, & Capraro, 2008). Since 2005, PJBL is aligned with the current curriculum initiatives of the Ontario Ministry of Education (2005), which call for students to acquire 21st century skills and higher-order thinking through authentic and interdisciplinary learning tasks. The 21st century skills include communication, problem solving, collaboration, critical thinking, and creativity. Although these gains of PJBL are monumental, many teachers experience difficulty when executing PJBL in their

classrooms. As a result, teachers often require extended professional development and support, especially when implementing PJBL for the first time (Yetkiner et al., 2008). This points to the need for a study that explores perspectives of experienced teachers who have successfully implemented PJBL in their classroom in order to identify effective practices for executing this instructional strategy. I developed the interview questions around the PJBL challenges that have been widely noted in the literature to narrow in on the specific strategies used by elementary school teachers.

My reasoning for exploring the effective practices used by teachers when implementing PJBL in mathematics education stems from two significant reasons. The first has been derived directly from the gaps in the literature and the need for more Canadian studies on this topic. The second reasoning stems from the personal and professional challenges I experienced, while implementing PJBL in an Ontario elementary school.

From an extensive literature review, it was apparent that there are limited Canadian studies that focus on overcoming the challenges associated with the implementation of PJBL in an elementary, integrated mathematics setting and in accordance with the Ontario curriculum. Similarly, the small number of studies conducted on overcoming the challenges of implementing PJBL validates the need for further research in this area (as will be discussed in greater detail in Chapter Two).

In my role as a teacher candidate in Brock University's Bachelor of Education Program, I experienced PJBL in a grade 6 classroom from the perspective of a future educator and facilitator of this instructional strategy. The students worked in small groups to design a prototype of an electric car that could move at least one meter, to answer the

question: How do electric vehicles produce movement? The project was used to teach both the science and mathematics curriculum through inquiry-based and self-directed learning. Despite many observed advantages to this approach, including enhanced student motivation, interest, and understanding, I did experience many challenges while implementing PJBL in this context. These challenges included keeping the students motivated throughout the project, shifting the focus from teacher directed to self-guiding learning, and encountering time constraints. This experience has intrigued me to investigate how elementary educators successfully implement PJBL in a similar framework and whether their experiences might offer new insights into how teachers can overcome the commonly described challenges of PJBL.

### **Purpose of the Study**

The purpose of this study is to investigate how elementary school teachers overcome challenges associated with PJBL in an elementary, integrated context that includes mathematics. This study aimed to answer one major research question: What specific strategies do elementary school teachers use to overcome the common challenges associated with the implementation of PJBL when enacting this strategy in an integrated, mathematics project? Six challenges on the implementation of problem based learning in the classroom have been identified through a critical review of the literature and were selected based on their reoccurrence in a number of studies. These major hindrances associated with PJBL include transforming roles, learner readiness, motivation and engagement, group dynamics and collaboration, authenticity, and assessment. In order to determine how experienced teachers address and overcome the challenges related to these six categories, I utilized qualitative research design to interview one elementary school

teacher with extensive experience of enacting PJBL in an integrated, mathematics classroom. This exploration allows insight into a number of suggestions and strategies to optimize success when implementing PJBL in an integrated, mathematics curriculum and offers recommendations for elementary teachers who are implementing PJBL in this context.

### **Scope and Limitations of the Study**

This qualitative study explores in depth the experiences of one educator residing in Southern Ontario who has implemented PJBL in an elementary school setting. The findings are specific to this individual; therefore, the study will not allow for generalization of findings to all elementary school teachers who have enacted this instructional strategy in an elementary mathematics, integrated curriculum. Furthermore, the study's findings cannot be generalized to those educators who practice PJBL across educational contexts (e.g., in secondary schools). Although this project voices the experiences of only one educator, her unique experiences, insights, and resources offer an array of suggestions for elementary teachers who are implementing (or planning to implement) PJBL in an integrated, mathematics curriculum.

### **Outline of the Remainder of the Document**

The remainder of this document is divided into four distinct chapters: Chapter Two: Literature Review, Chapter Three: Research Methods, Chapter Four: Findings, and Chapter Five: Conclusions. In Chapter Two, a critical review and summary of the literature about PJBL is provided, identifying a gap in the literature in terms of PJBL implementation strategies and providing a strong rationale for this research. The literature review focuses on the implementation of project-based learning, specifically in an

elementary, integrated mathematics context. From this review, the challenges of PJBL implementation were identified and the major challenges were divided into the six themes: transforming roles, learner readiness, motivation and engagement, group dynamics and collaboration, authenticity, and assessment.

In Chapter Three, the research methodology used in the research project is presented. The chapter begins with a discussion of the research context, design, and rationale for a qualitative research design. The research participant is then described in great detail, along with the methods used for data collection and analysis. Ethical considerations and the efforts made to establish trustworthiness are also outlined towards the end of this section.

In Chapter Four, I highlight the findings of the study and interpret the data in light of the PJBL model and literature review. The results section is divided respectively into the three common themes noted by the participant and each of these themes and their subsequent parts are discussed here in great detail.

Finally, the summary, conclusions, and implications of the research are outlined in Chapter Five. The chapter begins with a summary of the research, followed by the implications of the research for elementary teachers who are looking to implement PJBL in their own integrated, mathematics classrooms. The chapter concludes with the limitations of the project and suggestions for further research.

## **CHAPTER TWO: LITERATURE REVIEW**

PJBL is an instructional strategy that is derived from the constructivist educational theory and emphasizes for learning to be constructed through experience and to build upon students' prior knowledge (Heyl, 2008). In general, PJBL can be described as an inquiry-based approach to teaching and learning, where students collaborate to create a common project in response to a driving question, which investigates a real-world problem and is interdisciplinary in nature (David, 2008; Yetkiner et al., 2008).

The purpose of this review is to examine the state of the current literature in relation to PJBL, especially in an integrated, mathematics curriculum. This literature review will focus on the challenges associated with the implementation of PJBL in an elementary school context, with a focus on an interdisciplinary curriculum, integrating mathematics and at least one other subject area. The review will include an overview of the literature on (a) the defining features of PJBL, (b) the definition to be used for the purpose of this exploration, (c) the research on the effectiveness of PJBL with reference to the advantages and disadvantages of this approach, (d) the research on the implementation of PJBL, and (e) the challenges associated with enacting PJBL in the elementary school classroom.

### **Defining Features of Project-Based Learning**

Throughout the literature, PJBL has been defined using a number of criterion, including the reoccurring features of PJBL, the constructivist framework, the perceived advantages of this approach, or from a list of core elements that aim to constitute what is considered to be PJBL (Heyl, 2008; Tamim & Grant, 2013; Thomas, 2000; Zhenyu, 2012).

There is an agreement within the literature that PJBL is an instructional teaching method that allows students to work collaboratively, analyze real-world problems, and create an authentic product through the development of a real-world project (Karacalli & Korur, 2014; Meyer, Turner, & Spencer, 1997). PJBL is a long-term, interdisciplinary, and student-centered approach to learning, which emphasizes the development of students' 21st century skills (Feng, 2005; Hung et al., 2012; Park Rogers, Cross, SommerfeldGresalfi, Trauth-Nare, & Buck, 2010). The teacher is seen to be a facilitator of student learning, through active experience, including problem solving, data collection, and discussion (Beckett, 2002; Hung et al., 2012; Park Rogers et al., 2009). The projects are based on a driving question that allows the students to work autonomously to acquire an understanding of the curricular content and 21st century skills, and develop a realistic product, through a community of inquiry and technology-based tools (Thomas, 2000).

Similarly to Thomas (2000), Heyl (2008) defines PJBL as an instructional approach derived from constructivist theory, which stems from the work of John Dewey and Jean Piaget. From the constructivist theory framework, project-based instruction is emphasized to be an active and cooperative approach to learning, whereby the teacher takes on the role of the guide and is responsible to coach students to construct their own knowledge through experience and from building on their prior understanding (Heyl, 2008). From the constructivist framework, Hernandez-Ramos and De La Paz (2009) define PJBL learning to be a reflective and communicative process, where there is a need for social interaction in order to demonstrate multiple ways of thinking and learning.

Thomas (2000) constitutes PJBL to include five main criteria in order to be considered an instance of PJBL. These five elements include (a) centrality, where the

project is seen to be the curriculum and is the central teaching strategy that is used to teach the curriculum; (b) a focus on inquiry-based problems or a major question that drives the project; (c) the need for a constructivist investigation led by inquiry and experience, whereby the student constructs new knowledge by carrying out the project; (d) student-driven motivation or autonomy, which requires students to take responsibility for their learning; and (e) realism, which incorporates real-life, authentic challenges that are assessed through genuine tools or audiences (Thomas, 2000). This is similar to the research of Zhenyu (2012), who defines PJBL based on the inclusion of the five core elements: inquiry-based, open, practical, integrated, and emerging activities.

In contrast, Tamim and Grant (2013) found that teachers define PJBL in terms of its perceived advantages for learning. These advantages included enhanced student performance and improved research, communication, cooperation, and time management skills as well as differentiated instruction and creativity, motivating and engaging students in their learning process and collaborative group work (Tamim & Grant, 2013).

### **Definition**

Due to the lack of a universally accepted definition for PJBL, there is a need for future research to establish common criterion that would better distinguish PJBL from similar approaches such as problem-based learning and project work (Thomas, 2000). For the purpose of this study, PJBL will be defined using the five criteria outlined by Thomas. In order to be classified as PJBL, all five of these elements must be included:

- Centrality: the project must be seen to be the curriculum and is the central teaching strategy that is used to teach the curriculum;
- A focus on inquiry-based problems or a “driving” question;

- A constructivist investigation led by inquiry and experience, whereby the student constructs new knowledge by carrying out the project;
- Student-driven motivation or autonomy, which requires for the student to take responsibility for his or her learning;
- Realism which incorporates real-life, authentic challenges that are assessed through genuine tools or audiences. (Thomas, 2000, pp. 3-4)

Thomas' definition was selected as it summarizes the main defining features of PJBL in a broad sense that allows teachers to have the leeway to implement this strategy in a way that fits their unique demographic and teaching style.

### **The Effects of Project-Based Learning**

There have been both positive advantages and negative disadvantages that have been tied to PJBL in the literature. Both these advantages and disadvantages will be explored now, in detail.

#### **Advantages of Project-Based Learning**

A number of advantages to PJBL have been cited in the literature, including significant gains in students' problem-solving capabilities, heightened understanding of the subject matter, improved academic performance, enhanced work habits, and attitudes towards learning, heightened motivation and engagement, as well as improved communication and cooperative learning skills (Hung et al., 2012; Thomas, 2000). Supplementary benefits of PJBL include increased attendance, improved student confidence and self-reliance, and the development of 21st century skills, such as critical thinking, problem-solving, collaboration, and communication (Thomas, 2000; Uyangor, 2012).

Uyangor (2012) used a pre- post-test experimental model, with a single experimental group that included 32 students, to examine the effects of a project-based approach on the students' achievements and attitudes towards learning mathematics (i.e., towards learning a grade 9 unit on polygons and plane geometry). In the results, the students displayed substantial improvement in mathematical achievement and slight gains in their attitudes towards learning mathematics from the pre-test to the post-test, with students receiving post-test scores that were on average almost 40 points higher than the pre-test scores for academics and on average almost 12 points higher than the pre-test scores for attitudes (Uyangor, 2012). The reason for these gains was suggested to be active group work, learner-centered nature of the task, and the enjoyment students experienced while completing the project (Uyangor, 2012).

These results were similar to findings of Karacalli and Korur (2014) who utilized a quasiexperimental design with a pre-test and post-test and divided 143 students between an experimental group and a control group to study the effects of PJBL in a fourth grade science course titled *Electricity in Our Lives*. Here, PJBL significantly enhanced the students' academic achievements and retention of knowledge (Karacilli & Korur, 2014). There were no significant differences found in the students' attitudes across the two groups. The authors suggested that similar attitudes towards learning mathematics were identified in both groups because the period of the experimental study was too short to increase students' attitudes towards the method (Karacilli & Korur, 2014).

Hung et al. (2012) examined the effects of a different approach to PJBL known as the project-based digital storytelling approach, which adds digital storytelling tasks to the traditional approaches to PJBL; students take pictures with a digital camera and create a

film to communicate their learning. The authors investigated the motivation, problem solving competence, and learning of 117 grade 5 students during a science unit on saving energy. More specifically, the authors used a pre-test and post-test designed quasiexperiment over a 16-week duration. The results suggest that PJBL with a digital storytelling approach did effectively enhance the motivation, science learning achievement, and problem-solving competence of the students who participated in this group (Hung et al., 2012). Similarly, of the 30 students who were interviewed following the experiment, seven verbally indicated that the experience improved their learning attitude, while nine students felt a real sense of achievement after finishing the program (Hung et al., 2012).

While the work of Uyangor (2012), Karacilli and Korur (2014), Hung et al. (2012), and Hernandez-Ramos and De La Paz (2009) do position the overall benefits of PJBL, a major limitation of these studies is that the projects were centered on the material of one subject only and are not interdisciplinary in nature. Hoppe (2010) outlined action research projects that were implemented in a summer program for remedial students in grades 7 or 8. The summer projects integrated science and mathematics content and skills around case studies and probing questions that require real-world connections and problem solving (Hoppe, 2010). The results of the program were analyzed by student interest surveys, teacher comments, teacher observations, attendance records, the discipline referral rates, and the passing rate of the students (Hoppe, 2010). Based on the results of the 24 participants in the program, the PJBL approach was described to have a positive impact on the students' learning and engagement (Hoppe, 2010). Among the students involved in the program, the number of referrals decreased from the previous

year and the passing rate increased when compared to the grades of students in the traditional programming (and also from the previous year). The students enjoyed the program and were more engaged, which resulted in fewer classroom behaviour issues (Hoppe, 2010). Additionally, Thomas (2000) cited dramatic gains in student achievement in Expeditionary Learning Outward Bound Schools (ELOB) and Co-nect Schools. Each of these American schools has been devoted to a whole school reform that emphasizes PJBL, interdisciplinary studies, and authentic applications of the content that connect to the real-world (Thomas, 2000). Ross et al. (1999) reported that a Co-nect school in Tennessee gained a 26% overall increase in academic achievement in all subject areas when compared to the control schools in the same area (as cited in Thomas, 2000). In addition to the overall academic achievement, the schools noted increased attendance, with an average attendance increasing over 20% across a 2-year span at an ELOB school in Cincinnati, as well as decreased rates of suspensions and disciplinary problems (Thomas, 2000).

PJBL offers an approach to instruction that accommodates for all learners, allowing for students to use their strengths. As a result, “teachers find that students who benefit the most from PJBL tend to be those for whom traditional instruction methods and approaches are not effective” (Uyangor, 2012, p. 214). Likewise, Horn (2006) suggests that students who come from disadvantaged backgrounds demonstrated much higher levels of achievement and were more likely to enroll in advanced mathematics courses in the future if they participated in classes that offered an experiential approach to mathematics (as cited in Heyl, 2008).

Cross et al. (2012) examined a 16-hour project-based statistics unit that was implemented with 13 female students in grades 4 to 6 who identify as African American. The authors sought to determine if PJBL would present an equitable approach to mathematical learning. The results from students' responses following the program indicated that PJBL allowed the students to feel empowered and have a voice in the problem-solving process; they developed a greater understanding of statistics as a result of the program and cultivated expertise that was relevant to them.

### **Disadvantages of Project-Based Learning**

While literature that highlights the advantages of PJBL is more abundant, there have been a few disadvantages cited in the research on this educational approach. Shortcomings of PJBL include the extended length required for proper implementation, mixed results reported on standardized testing, and the need for PJBL to be enacted effectively in order to yield positive results (Han, Yalvac, Capraro, & Capraro, 2015; Karacilli & Korur, 2014).

Beckett (2002) found that English as a Second Language (ESL) teachers reported mixed feelings about project-based instruction while teaching students from Eastern cultures, with many ESL teachers indicating that they experienced lower participation and attendance when using this approach, and felt that this type of instruction decreased the amount of respect that the students had for their teachers. Beckett noted that a possible reason for these discrepancies could be due to cultural differences, especially because Eastern cultures are more accustomed to teacher-centered practices and desire this form of teaching when they immigrate to Western schools. This finding is similar to the research of Zhenyu (2012) who noted many challenges when implementing PJBL in a

middle school in China. The participating teachers noted a disconnect between their content knowledge and the topics that were explored by their students, which created additional pressure on standardized testing because all of the students were not covering the same material (Zhenyu, 2012).

Another challenge with PJBL, especially in mathematics, is the required standardized testing (Heyl, 2008). While there is some literature that examined how students' standardized testing scores were effected when using a constructivist theoretical framework in the classroom, Heyl noted that the research was seldom and yielded mixed results. Similarly, Han et al. (2015) found that limited time in the classroom was a major disadvantage that teachers faced. Due to their perception that a project-based approach would not properly prepare students for state-wide testing, the five teachers examined in this case study were reluctant to dedicate the necessary time to enact PJBL (Han et al., 2015). Thomas (2000) contradicts this finding as he found several studies on the ELOB schools reported by the New American School Development Corp (1997, 1999a, 1999b) indicating that students exhibited greater academic achievement on standardized tests when taught through PJBL, and in comparison to their peers who learned through more traditional methods. Geier et al. (2008) also supported this finding as they found that students who participated in PJBL outscored their traditionally educated peers on standardized testing (as cited in Bell, 2010).

Han et al. (2015) suggest that the “content achievement, beliefs, self-efficacy, and motivation” can negatively influence students if PJBL is ineffectively implemented (p. 73). Bell (2010) noted a similar finding, which suggests that students could develop low level of motivation and initiative if they do not receive the appropriate guidance and

support during the process. As a result, the teacher is seen to be a critical factor to the implementation of PJBL and enhanced professional development; the teacher's beliefs about PJBL, as well as the teacher's experience with this complex approach, can all shape the teacher's success when implementing this instructional strategy.

### **Implementing Project-Based Learning in the Classroom**

Researchers have identified several common processes that teachers should execute in the classroom in order to ensure the success of PJBL (Colley, 2008; Feng, 2005; Nobori, 2012). Colley created the project cycle as a tool that could be used to organize the project work as it is implemented in the science classroom. In the project cycle, these steps include: the six stages of orientation, identifying and defining a project, planning a project, implementing a project, documenting and reporting project findings, and evaluating project learning (Colley, 2008). More specifically, during the orientation process, teachers should provide students with an overview of the expectations, requirements, responsibilities, assessment criteria, and roles that will be crucial throughout the process (Colley, 2008). In the second and third steps, the teachers should assist the students to make sure their questions are clear and tangible, and then the students should create a plan for the project that generally includes: a title; question; purpose; methods or procedure; a list of tools, materials, and technology required; roles and responsibilities; and assessment activities. In the next step, the students are expected to present their projects to their peers to receive feedback and then the teacher will also assess their work and provide the students with an opportunity to self-reflect on their learning. In some cases, students are encouraged to carry out the sixth step which involves putting their learning into practice to take action through their results. For

example, if the students created a proposal to build a new garden for their school, the final step would be to build the desired product.

Nobori (2012) presented a different approach to PJBL which involves 10 steps that are always carried out before, during, and after the implementation of PJBL by the teachers at Manor High School. Here, the first step involves looking for connections between the curriculum standards as they relate to the teacher's project idea. Next, these ideas are shared with critical colleagues who provide feedback. In the third step, an entry event is used to introduce the project to students in order to get them engaged in the project and present an exemplar. Next, each student must create a list of new concepts and key terms they will need to learn in order to successfully complete the project. In steps five and six, the rubric is presented to the students to provide clear goals for the project and the students write a group contract with their team to define each member's role and responsibility for the project. Step seven comprises the largest step as this is where students conduct their research and collaborate on their project. Teachers offer workshops based on the students' needs in order to help them understand key concepts and reinforce their learning. The final three steps involve providing students with feedback, students' presentations to a public audience, and a final teacher-evaluated assessment using a rubric.

English and Kitsantas examined how teachers could best support their students' self-regulated learning by applying the work of Mergendoller et al. (2006), which breaks the process of PJBL into three main phases of project launch, guided inquiry and product/solution creation, and project conclusion (as cited in English & Kitsantas, 2013). The authors argue that teachers should support students' development of self-regulated

skills using different approaches throughout each of these three phases in PJBL. During the first phase of the project, it is particularly important for the teacher to provide more explicit instruction and modeling as well as necessary steps with estimated timelines for each milestone, to ensure that the students have a clear understanding of the learning goals and purpose of the project. Providing students with more structure in the first phase will assist them to develop self-regulated learning as their goals and focus will be directly aligned with the purpose and framework that the teacher has set out for the project. The authors also suggest that a balance of structure, by providing students with overviews, a set of criteria for a good project, planners, templates, and handouts with suggested timelines, will provide students with the guidelines that they need while allowing them the freedom and independence that is known to PJBL. During the second phase of PJBL, teachers should gradually release control and transition into the role of a guide. This means that “the level of support given meets the level of support needed” (English & Kitsantas, 2013, p. 141). At this phase, teachers should no longer give direct instructions and, instead, steer students in the right direction using prompting to get them to think deeper about their learning. Similarly to Tamim and Grant (2013), English and Kitsantas suggest that through numerous opportunities for formative assessment, teachers should provide students with feedback about their projects and celebrate the students’ success at each milestone. In the final phase of PJBL, known as project conclusion, the teacher should provide opportunities for students to reflect on their learning. This discussion may include prompting students to consider (a) which self-regulation strategies were most effective, (b) where they struggled with the project (in terms of academic or self-regulation skills), or (c) what they would do differently.

## **Project-Based Learning in Mathematics Education**

When enacting PJBL in mathematics education, slightly different approaches have been noted in the literature, which are unique to this subject area. These approaches include the use of a more experienced student mentor (Bakke, Kieke, & Krueger, 2013) and the notion of real-life mathematics (The George Lucas Educational Foundation, 2011).

The work of Bakke et al. (2013) outlines an integrated Inquiry-Based Student Research Project that the students in the Science Research Institute program completed to develop a greater understanding of the mathematics and science curriculum. The projects were designed in a series of three experiments and carried out over a 4-week period, during which the participating high school students were placed into groups of three or four and overseen by a college-student mentor (Bakke et al., 2013). The overall outcome of the project was to allow the students to develop a better appreciation of the work that scientists and mathematicians do. The use of a college mentor helped to clarify the job roles of these professionals for the secondary school students (Bakke et al., 2013).

In comparison to Bakke et al. (2013), the work of Park Rogers et al. (2010) focused on the implementation of PJBL by three teachers who were trying this approach for the first time in their mathematics and science curricula. The authors examined how the teachers' previous teaching experiences and existing teaching philosophy, as well as their perceived purpose for teaching mathematics and science, influenced how they implemented PJBL. The study took place over a year-long time period, during which the three participants were each interviewed four times, a survey on their teaching philosophy was conducted, and classroom observations were completed at the beginning

and end of the year. The findings of the study indicated that each of the three teachers held different perspectives on the purpose of teaching their discipline and, thus, held different opinions about PJBL implementation and the most important effects of such an instructional strategy. For example, two of the teachers felt that enhancing students' engagement was the most important component of PJBL while the third teacher thought that preparing students for careers by developing their 21st century skills was more beneficial. Similarly, two teachers believed that their role should be facilitating their students' learning throughout the process, whereas the third teacher took on a managerial role that was parallel to his personal teaching orientation.

Han et al. (2015) found that the teacher's perceived purpose of PJBL influenced how they implemented this instructional strategy. The authors focused on PJBL in science, technology, engineering, and mathematics (STEM) and studied five in-service teachers during their first experience enacting STEM PJBL in a high school setting. Han et al. specifically examined the effectiveness of hosting required professional development days to educate teachers on PJBL and then, observed their ability to effectively implement this instructional strategy in their secondary mathematics or science classrooms. Although the teachers participating in this case study were provided with the same training, they all exhibited different understandings and views of PJBL, which impacted how they applied this instructional strategy in their practice. Han et al. found the teachers' perceptions of PJBL to be an extremely critical factor for implementing PJBL. For example, two of the teachers perceived the purpose of PJBL to briefly review content that was already taught in the course, which caused the projects to be small-scale and supplementary to instruction. This approach did not resonate as

strongly with the students. However, if the teachers perceived PJBL to be a valuable approach to enhance their students learning and teach the students new content and skills, then the project was found to be more meaningful to the students and they took a greater interest in the task.

The George Lucas Educational Foundation (2011) offers tips for teachers who were looking to use PJBL to teach mathematics. The Foundation urges one to reframe the notion of real life math and turn the curriculum into a real-life problem such as “to find the most cost effective design for a classroom, given materials and certain parameters” (p. 1). These new definitions of real world problems allow students to practice inquiry and make authentic connections to the real world. The second most significant tip that the foundation provided is to ensure that teachers have an appropriate amount of time before implementing PJBL. It is suggested that teachers should get creative with their time and try to integrate multiple curriculum standards into the project in order to maximize the time and learning (The George Lucas Educational Foundation, 2011). The final suggestion is for teachers to pick the curriculum standards and strands that they know are easier to align with real-life application. This will not only make the implementation of PJBL easier for the teacher, but it will also help students to understand the purpose of this dynamic instructional strategy.

The reasoning why PJBL is especially beneficial in mathematics education stems from two main reasons: the need for more practical applications of the mathematical curriculum and the need to align classroom instruction with the recent reforms in mathematics education (Heyl, 2008). In connection to the notion of real-life mathematics presented by The George Lucas Educational Foundation (2011), mathematics is a critical

subject to implement PJBL because the abstract notions of this subject sometimes enable students to see the relevance this subject has to their everyday lives. Heyl also found that a project-based approach to mathematics would allow for her students to see the relevance of the curriculum to their daily lives and, therefore, be able to better retain the concepts and become engaged in their learning.

In Ontario, Educational Quality and Accountability Office's (EQAO) Provincial Elementary School Report for 2013 indicates that the number of students performing at the provincial standards for mathematics has substantially decreased since 2008, especially in grades 4 to 6, which has made mathematics education a recent focus in the province. In order to teach mathematics effectively, *The Ontario Curriculum Grades 1 to 8: Mathematics* calls for mathematics to be investigated through problem solving (Ontario Ministry of Education, 2005). For this to occur, a collaborative and experiential learning environment should be established to empower student-centered learning (i.e., PJBL).

Meyer et al. (1997) further justifies the significance of PJBL in mathematics by emphasizing the need for deeper thinking in mathematics, which allows students to learn and understand the content at a higher level because they must represent their learning in a number of ways and solve real problems in relation to the content to create an artifact through the process of PJBL. Due to the challenging nature of PJBL, this approach is especially important to implement in an elementary school setting to allow students to gain frequent opportunities to practice and gain confidence with this approach as well as develop a greater appreciation for the type of work that students could fulfill in their adult careers (Bakke et al., 2013).

### **Project-Based Learning in an Elementary School Setting**

The work of Lattimer and Riordan (2011) and Bell (2010) offers insight into two distinctive processes that were used when implementing PJBL in the intermediate division, with consideration to the stages of project design and the acquisition of 21st century skills. Lattimer and Riordan discussed how PJBL was implemented in grade 7 and 8 at High Tech Middle (HTM). The article emphasized the need for PJBL to focus on the learning and suggested that teachers consider the six “As” of design by Steinberg (1997) when developing projects for their students ( as cited in Lattimer& Riordan, 2011). These six As include academic rigor, authenticity, applied learning, active exploration, adult connections, and assessment practices. Academic rigor involves the curricula that the project will expose students to. Authenticity involves how the project provides meaningful real-world connections. Applied learning and active exploration require students to develop self-management skills (i.e., meeting deadlines and allocating resources) while conducting field-based activities such as conducting interviews or using online sources to gather information. Adult connections help students to develop a sense of the real-world work that experts are carrying out in the field and assessment practices involve opportunities for self-assessment, peer-assessment, and teacher developed assessments, such as a rubric.

In comparison to the previous literature on PJBL which was driven by inquiry questions, the work of Lattimer and Riordan (2011) places a stronger emphasis on the need for teachers to create projects that are associated with the work of professionals out in the field, and for teachers to connect their students with adult mentors and coaches from the wider community. Through connections to community members in the field,

students are able to receive feedback from these experts to strengthen their work and answer questions that go beyond the scope of the curriculum. While Lattimer and Riordan held that PJBL must address issues that are aligned with the standards of the curriculum and the interest of the students, they found that the assessment practices for PJBL can be the most valuable and motivating aspect of this instructional strategy. The authors argue that assessment should go beyond a formal, teacher-directed assessment within the classroom. They suggest that students need to be able to share their work with an authentic audience including parents, the school community, and experts in the field. The feedback and responses that the students receive from these observers is far more valuable than that of a grade or a formal assessment.

Bell (2010) focuses on the long-term effects of PJBL, as it provides students with 21<sup>st</sup> century skills. The author emphasizes the elements of student choice, natural curiosity, and cooperative group work in order for PJBL to be successfully implemented. While the emphasis is on the process and the planning activities throughout the project, Bell does agree with Lattimer and Riordan (2011) that having an audience and a due date motivates students to keep on track throughout the project. While Lattimer and Riordan stress the need for adult connections and experts to aid in the students' assessment of their projects, Bell suggests that peer and self-evaluation are more valuable measures of assessment for PJBL. She also argues that the social learning that is developed through teamwork and collaboration teaches students to communicate in a way that mimics the work of employers in today's economy. Furthermore, Bell argued that the differentiated nature of PJBL provides intrinsic motivation for students as they are able to research topics of interest to them, learn at their own pace, and select resources that align with

their knowledge level and learning styles. Similarly, students use their individual strengths and talents to enhance the quality of the project for the group (Bell, 2010). Here, the motivation does not need to come from external sources (e.g., field learning experiences or adult experts), as all students feel supported in their classroom environment through collaborative learning and scaffolding instruction. While both of the articles take a differing stance on how PJBL prepares students for a 21st century workforce, the overall idea is the same; through the implementation of collaborative projects that mimic real-world experiences, students are able to see the value of their learning as it relates to the work of professionals out in the field.

**Project-based learning integrated with mathematics and at least one other subject.** An integrated, elementary context is of distinct importance because Pinzker (2001) found that interdisciplinary units increased students' engagement in mathematics as this approach better connects students' learning to the real world, where topics and knowledge is interconnected rather than subject-specific (as cited in Heyl, 2008). The range of the literature on PJBL that meets these three criteria (i.e., implementation of PJBL, an elementary school setting, and an integrated curriculum with mathematics and at least one other discipline), however, is particularly limited. Furthermore, the small scope of research that meets these criteria mostly references the implementation of PJBL that was used for the purpose of a singular research study only, and did not investigate how to effectively implement this strategy as a whole in an elementary, integrated context that includes mathematics.

Hoppe (2010) implemented a project-based program that integrated mathematics and science in an intermediate summer program. More specifically, the grade 7 program

focused on a story that involves exploring heart rates, blood pressure, and respiration to diagnose a young male patient. Similarly, the eighth grade program integrated mathematics and science in a two-part project. The first part of the project explores a weather related incident which causes the students to inquire about the atmosphere, weather maps, seasons and extreme weather conditions (Hoppe, 2010). Then, in the second part of the program, the students learn about how force and motion (and mathematics) are integral to NASA's rocketry.

Horton, Hedetniemi, Wiegert, and Wagner (2006) enacted PJBL in a grade 8 classroom that centered mathematics at the integration of the science, language, arts, and social studies curricula. The authors centered the projects on themes that were relevant to the landforms in the project location of South Carolina. The students were able to investigate and produce a final product based on their group's landform region. For example, the Rocky Mountain was one region that was developed (Horton et al., 2006).

The work of Schooler (2004) describes a collaborative implementation of a project that combined mathematics, science, and technology in a seventh grade classroom. Here, the students worked in teams to design and build an ice container to hold ice and keep it from melting for 24 hours, in order to investigate the surface area and volume of 3-dimensional objects in mathematics and the technology of design, based on the science and technology curriculum. Schooler paid close consideration to the assessment processes known to PJBL by providing her students with assessment guidelines at the beginning of the project, and allowing numerous opportunities for the students to receive feedback from the teacher and their peers throughout the process.

While these sources validate that there is some literature on the implementation of PJBL in an integrated, elementary school setting which includes mathematics education, there is a need for more research to concentrate on this specific context (i.e., implementation of PJBL, an elementary school setting, and an integrated curriculum with mathematics and at least one other discipline) and topic of study. Thomas (2000) also found the research to be limited on the implementation of PJBL, and further validates the need for more research into the best practices for implementing and managing PJBL. Thomas suggests that future research should determine “the PBL features, materials, requirements, technologies, and assessment strategies that are associated with productive inquiry and maximum achievement” (p. 37). Furthermore, Thomas highlights a need for researchers to determine those interventions that teachers have used during PJBL in order to overcome the challenges and ensure that their students successfully benefit from the implementation of this instructional strategy during its practice.

### **The Challenges of Effectively Implementing Project-Based Learning**

Thomas’ (2000) literature review referenced a number of challenges that teachers encountered when implementing PJBL; teachers often struggled with aligning new instructional approaches with their teaching philosophy and beliefs. Similarly, the work of Marx et al. (1997) was particularly useful as the authors divided the challenges teachers faced into six areas: time, classroom management, control, support of student learning, technology use, and assessment (as cited in Thomas, 2000). Furthermore, within his literature review, Thomas found that multiple constraints associated with the organization of schools interfere with the successful implementation of PJBL. The work of Thomas and Mergendoller (2000) expressed the need for a classroom culture that

promotes self-management and self-direction, exemplars of excellent student work, and a physical environment that aids in the facilitation of project work (as cited in Thomas, 2000).

Lee et al. (2014) focused on the successes and challenges that educators faced during their first implementation of PJBL. Although the research in the article was within a higher education institution, the initial research and literature review focused on PJBL in K-12 education. The authors found that three common successes and challenges are evident in both K-12 and higher education settings during the implementation of PJBL. These three themes include the use of community partners, student engagement, and assessment of student work. Similar to teachers in K-12 classrooms, the university faculty faced difficulties designing and aligning their projects with the needs of community partners, while remaining inside the limits of the course objectives and curriculum (Lee et al., 2014). Time constraints in the classroom and working within the community partners' timelines were also challenges faced at both levels. In both settings, the students and the teachers experienced difficulty reestablishing their roles as the instruction moved from a teacher-centered to the student-centered, self-directed, and collaborative learning known to PJBL. The faculty found it necessary to carefully scaffold the projects in order to ensure effective group work and support the students during their first experience with PJBL. This step-by-step approach helped to ensure confidence and success for both the instructors and the students during this trial with such a dynamic instructional strategy. Finally, the assessment process was completely different than the traditional pen-and-paper tasks known to the university faculty, which challenged them to step outside of their comfort zone. For example, the teachers no longer used a traditional lecture and

pencil-and-paper testing approach. Instead, they allowed their students to create a product to demonstrate their learning (Lee et al., 2014).

Zhenyu (2012) followed the experiences of 22 teachers in China, who were implementing PJBL in grades 6 and 7. Through field notes and interviews, most of the teachers exposed that they were also struggling with their roles during the process and were unsure how to effectively facilitate their students' project work. The teachers were required to allow their students to have full freedom over determining their research purposes and questions. This immediately proved to be problematic; students did not have the necessary question forming skills and content knowledge in the subject areas that they required in order to devise questions that would be attainable and allow for real-life understanding of the content. This confusion led to additional problems during the data collection stage as many teachers noted that they did not have adequate knowledge of the topics their students were studying and could not help them to find additional references at this stage. Furthermore, many of the students overrelied on the internet for data collection instead of taking a critical approach and examining multiple sources (Zhenyu, 2012).

Stemming from the reoccurring challenges that were noted in these studies, six major themes emerged from the literature on the challenges of PJBL. These themes include transforming teacher and student roles, learner readiness, motivation and engagement, group dynamics and collaboration, authenticity, and assessment. For the purpose of this exploration, the literature related to these six main challenges associated with PJBL and the suggestions for overcoming these challenges will now be explored in greater detail.

**Transforming roles.** Transition from the teacher to the role of a facilitator can be a particularly challenging shift, especially for teachers who are implementing PJBL for the first time (Lee et al., 2014; Zhenyu, 2012). After exploring how teachers implemented PJBL in their first year, Park Rogers et al. (2010) noted that all three teachers had distinct beliefs about their roles as teachers, which conflicted with the roles of facilitators and caused them to experience difficulty when switching over to this new role. In order to surmount this obstacle, teachers need to be aware of and accept this shift in their function and allow their students to recognize the value of intrinsic learning (Tamim & Grant, 2013). Teachers can do this by promoting an environment of inquiry and challenge, and by frequently implementing student-centered pedagogies, such as PJBL, to allow their students to get accustomed to this style of learning (Tamim & Grant, 2013).

Park Rogers et al. (2011) found that the students also had difficulty adjusting to this new style of teaching and learning and their reestablished roles as learners, which required them to grow in independence and take responsibility for their own learning. In order to overcome the challenges and discomfort the students faced with their transforming roles, English and Kitsantas (2013) suggest for teachers to gradually release the level of authority and structure in the classroom, while maintaining a central focus on metacognition, making the students more aware of their progress. Furthermore, the authors advise teachers that freedom should also be balanced with structure. This can be achieved by providing students with templates, handouts, and assessment criteria, in order to shape and guide their learning. This process allows the students to still have choice and freedom in the process, but ensures that they gradually adjust to the responsibilities that come with PJBL (English & Kitsantas, 2013).

**Learner readiness.** After investigating five teachers during their implementation of STEM PJBL, Han et al. (2015) reported students' readiness to engage in this instructional strategy as one of the main challenges. This was challenging especially for students who were not academically ready to participate in the project as they did not have the necessary background information and knowledge, and often exhibited behavioural issues as a result. Due to time constraints, it was difficult for the teachers to postpone implementing the projects until they felt that all of their students were academically ready. In order to overcome this challenge, Nobori (2012) suggests holding additional workshops for those students who may need to go over previous concepts or reinforce their understanding. Additionally, teachers should also provide students with extra scaffolding and support, depending on their needs. Differentiating the instruction for the students based on their academic readiness and level will allow all of the students to experience the amount of support that is directly matched with their readiness.

English and Kitsantas (2013) are concerned with the students' level of self-regulated skills and caution teachers that PJBL is a student-centered instructional strategy that demands students to take responsibility for their learning; students need to have the necessary self-regulation skills in order to be successful throughout the PJBL process. Self-regulated skills include the ability to set goals, carry out research, select appropriate strategies, monitor learning and self-assess the results (English & Kitsantas, 2013). The authors argued that self-regulated learning is not developed in students without guidance and support from the teacher. Teachers can foster their students' self-regulation skills (a) by helping their students to bridge the gap between what they know and what they need

to know, (b) by engaging their students in dialogue, and (c) by explicitly modeling the practices of metacognition and self-assessment.

In regards to student readiness at the postsecondary level, Hubbard (2012) notes that there is never a perfect time for all students to begin a project. To overcome this challenge, he has students start projects during the first or second week of classes. This way he encourages students to take risks and promises them that grading will weigh heavily on attendance, participation, and effort. Hubbard takes on the role of a leader and a guide until the students feel comfortable and ready to work independently on their projects. Starting projects early on ensures that students will have plenty of time to work at their own pace and will feel confident before the end of the semester (Hubbard, 2012).

**Motivation and engagement.** Since PJBL is largely inquiry-driven and challenges the students to think in new and stimulating ways, it is not uncommon for students to lose motivation and become disengaged during challenging aspects of the process (Lee et al., 2014; Meyer et al., 1997). Similarly, students can sometimes exhibit frustration moving from teacher-directed to student-centered learning, especially when they are accustomed to the teacher providing them with deliberate instructions and scaffolding of their learning (Lee et al., 2014).

The work of Meyer et al. (1997) is valuable as it offers insight into the source of students' motivation in PJBL through examining students' self-perceptions and behaviours towards challenge. The research also offers insight into personality differences and the drive of students who thrive during academically challenging work. Here, it was evident that risk takers "who endorsed challenge seeking also reported higher self-efficacy, more mastery-focused goal orientation, and more deep strategy use

than their peers” (Meyer et al., 1997, p. 509). The personality and drive of these risk takers allowed these students to remain motivated and persevere throughout the PJBL process.

Caniglia (2003) found that teachers help students to become more engaged in their learning process when the teacher too gets involved with making connections between the mathematics they are teaching and the real world (as cited in Heyl, 2008).

In order to sustain student engagement and motivation throughout PJBL, Lee et al. (2014) suggests that students were the most engaged when they worked in collaboration with community partners and had an authentic audience with whom they could share their work throughout the process, receive ongoing feedback from, and present their end project. In addition, seeing the relevance of their project to the real world also proved to be a motivating factor of PJBL that allowed the students to become passionate about something they are doing and knowing that their work will solve driving questions or problems that are relevant to their lives (Lee et al., 2014). Additionally, Hernandez-Ramos and De La Paz (2009) found that the inclusion of technology in the project also proved to be a motivating factor for the students as it allowed them to enhance the appearance and features of their projects, and also allowed for their projects to be viewed by a variety of audiences, including their peers, other students in the school, and the community at the school open house. This notable aspect of PJBL added pressure on the students, which helped them to feel like professionals, motivated them to stick to their timelines and produced a project that was to the best of their abilities (Hernandez-Ramos & De La Paz, 2009).

**Group dynamics and collaboration.** Perhaps one of the most challenging aspects of PJBL is the ability for students to work together in a team (Tamim & Grant, 2013). In order to overcome this challenge, Kolodner et al. (2003) suggest that teachers need to create a collaborative classroom climate that encourages students to learn from their mistakes and work in equal partnership with their peers (as cited in Tamim & Grant, 2013). Similarly, Nobori (2012) suggests using a group contract to outline the responsibilities and roles of each member and hold them accountable for their contributions to ensure that all of the students are equally participating in the project.

**Authenticity.** While the inclusion of community partnerships was seen to be one of the most motivating and authentic elements of PJBL, Lee et al. (2014) report this aspect to be one of the most challenging components in PJBL. The authors noted that it was difficult to initially find, recruit, and maintain a partnership with authentic experts in the field. Similarly, Sage (1996) found that identifying problem scenarios to drive authentic project work was also a challenge that many teachers faced when first implementing PJBL (as cited in Lee et al., 2014). In order to defeat these difficulties, students must work collaboratively with teachers, attend professional development events in discipline related fields, and network with colleagues while establishing community partners and devise authentic project questions or topics (Lee et al., 2014). Moreover, connecting with experts and presenting projects through the Internet is also a great way of reducing the stress of timelines and communication (Hernandez-Ramos & De La Paz, 2009).

**Assessment.** The final major challenge that teachers face during the implementation of PJBL involves assessing the students' work. Lee et al. (2014) suggest

that new methods of assessment are required in order to more efficiently assess this process-oriented instruction and consider the students' development of 21st century skills. According to the authors, several teachers participating in their study reported feeling inexperienced with assessing student work in this context. Furthermore, the teachers revealed their discomfort with assessing the students' acquisition of the 21st century skills of critical thinking, communication, collaboration, and creativity. In order to overcome these challenges, Lee et al. suggest scheduling regular check-in points with each group so that the teachers can track and monitor the students' individual and group progress over time and assess their students in terms of their development. Thus, assessment in PJBL should go beyond evaluating the final product or artifact produced at the conclusion of the project, and should instead be a holistic approach to assessment that considers portfolios, discussions and dialogue, rubrics, performance assessments, peer assessments, and self-assessments (Lee et al., 2014; Tamim & Grant, 2013). Tamim and Grant highlighted the importance for teachers to provide their students with clear assessment expectations and criteria prior to the start of the project so that students will have an understanding of the prospect through which they will be formally evaluated. Finally, teachers should evaluate both the individual contributions of the students and the group work, and should even combine the weight of each of these elements when providing the students with a final mark for the project (Lee et al., 2014; Nobori, 2012; Tamim & Grant, 2013).

### **Summary**

In order to narrow in on the topic of PJBL, the focus of this exploration was on the enactment of this strategy in an elementary school setting (with a focus on grades 4 to

8), where the mathematics curriculum has been integrated with at least one other subject area. To conclude, there is a range of literature that has referenced the challenges that teachers face when enacting PJBL in their classrooms, with particular reference to the six major challenges of transforming roles, learner readiness, motivation and engagement, group dynamics and collaboration, authenticity, and assessment. However, there is a limited amount of literature cited, to date, that has investigated how experienced teachers have overcome these challenges associated with PJBL in an elementary, integrated context that includes mathematics and at least one other subject area. As a result, this literature review has substantiated the need for further research on the effective implementation of PJBL in this particular context (i.e., implementation of PJBL, an elementary school setting, and an integrated curriculum with mathematics and at least one other discipline), and with reference to overcoming these six major challenges.

### **CHAPTER THREE: RESEARCH METHODS**

The methodology chosen for this research was a qualitative research study that utilized an in-depth, semistructured interview with a teacher who has implemented PJBL in an integrated, elementary mathematics curriculum. This chapter outlines the appropriateness of using a qualitative study, the rationale for conducting semistructured open-ended interviews, the strategy used for the site and participant selection, the method for data collection and data analysis, efforts that have been taken to establish trustworthiness, and the ethical considerations.

#### **Research Design**

A qualitative methodology was most suitable for this study as Lapan, Quartaroli, and Riemer (2011) describe qualitative research as research that places “more emphasis on the study of phenomena from the perspective of insiders” (p. 3). In this study, the insider was one experienced elementary teacher and the phenomenon involved was her lived experience of implementing PJBL in an integrated, mathematics curriculum. A qualitative design is appropriate for this study because open-ended, semistructured interview questions allowed the participant to voice the full depth of her experiences and disclose the details of her practice implementing this strategy (Creswell, 2013).

As with any research, the methodology of choice must be appropriate for the context and the research goals (Pearson, Albon, & Hubball, 2015). A general qualitative research study was the most appropriate methodology for the purpose of this study as the goal of the project was to identify how an experienced teacher developed effective practices for executing PJBL and how she was able to overcome the challenges associated with enacting PJBL in an integrated, elementary school context. For the

purpose of this study, generic qualitative research was the most appropriate methodology as the purpose of the research was to understand the experience of PJBL. This placed the emphasis of the study on the understanding of an experience or an event and did not require for the methodology to claim a particular viewpoint (i.e., the cultural lens in ethnography) or be guided by an established set of philosophic assumptions (Caelli, Ray, & Mill, 2003). Examining the lived practices and experiences of one participant allowed for a broader understanding of her approaches throughout her entire experience facilitating PJBL including the events that occurred prior to, during, and following her implementation of PJBL.

### **Site and Participant Selection**

In order to recruit participants for this study, a purposeful-sampling technique was utilized by inviting educators, who have experience enacting PJBL in an integrated mathematics curriculum and in an elementary educational setting, to participate in the study. The Ontario elementary school teachers were invited through email based on their partnership with and participation in the Ontario Association of Mathematics Educators (OAME). Through this tactic, only one participant was recruited. From here, snowball sampling was used to recruit additional participants by asking the existing participant if she had any colleagues who meet the criteria and would be interested in participating in this study. Two additional teachers responded to this invitation expressing their interest, but, unfortunately, did not have experience with executing PJBL in the required setting. Next, the participant was provided with a formal Letter of Invitation to outline the details of the study and a Consent Form for her consideration. In order to accommodate the

participant, the time of the interview and the setting was mutually negotiated based on her preference and schedule.

While initially the goal was to select at least two participants and conduct a cross-case analysis, the complexity of this instructional practice proved it to be challenging to find an additional participant who had experience with PJBL in the required context. The sole participant was selected based on her experience and her PJBL teaching practice.

### **Data Collection**

This project used a semistructured interview as the sole method of data collection. This method was chosen because an interview is the most authentic method to honour the experience of the participant and allow her to share her insight and perspectives. Conducting an interview allowed me to develop a rapport with the teacher and understand the processes that she went through in entirety, including the planning and preparation involved in PJBL, as well as any additional support and professional development she received while enacting PJBL.

During the interview, I asked the questions and carefully listened to the participant's responses. A semistructured interview format allowed me to ask additional questions to follow-up on specific details of the participant's responses and seek clarification when necessary. During the interview, I followed a script with open and semistructured interview questions (see Appendix A). These questions were developed based on the six major themes that emerged from the literature review on the challenges of implementing PJBL. These themes include transforming roles, learner readiness, motivation and engagement, group dynamics and collaboration, authenticity, and assessment. With the exception of the first question, which requests the participant to

describe her experience implementing PJBL, the interview can be divided into six sections, with the questions in each section narrowing down on overcoming the challenges as they relate to each of these themes.

### **Data Analysis**

The first and second stage of the data analysis involved transcribing the data and member checking to confirm with the participant that the information she shared during the interview was accurately transcribed (See Appendix B). Member checking also gave the participant a chance to add any additional information that was missed, if necessary. To transcribe the data, punctuation decisions were carefully considered and all sounds, tones, and expressions were recorded in the transcript using Tilley and Powick's (2002) "Transcription Conventions" (p. 130), in order to represent the conversation in its purest form and relay the meaning.

The next stage entailed coding the data. Creswell's (2013) coding process was used by "making sense of the of the text data, dividing it into text or image segments, labeling the segments with codes, examining codes for overlap and redundancy, and collapsing these codes into broad themes" (p. 243). This involved an inductive process, which narrowed the data into three broad themes by highlighting and ranking the data that fit into these themes.

### **Efforts to Establish Trustworthiness**

As an interviewer, I hoped to ensure that my participant felt comfortable describing her experiences to me. In order to do so, the participant was able to determine the location and time of the interview. I also used member checking by sending the participant her transcript and a synopsis of my interpretation of the transcript to review

and check for accuracy (Creswell, 2013). This ensured that the participant remained involved in the process and that her responses were represented in the best possible way. Finally, I offered to send the participant a final version of my Major Research Paper (MRP) prior to its submission for member checking and for her records.

### **Ethical Considerations**

All aspects of this research adhere to the Brock University Research Ethics Board's ethical protocols. The participant recruitment and interviews began following clearance from the Research Ethics Board (File #14-293 – MGOMBELO). Eligible participants were then sent a Letter of Invitation that outlined what was to be expected of them should they decide to participate in the research. The participant was also made aware that she can withdraw from the research at any point during the process, and her data would be destroyed.

During the data collection, the interview was audio-recorded. The identity of the participant was kept confidential as the participant was assigned a pseudonym. As a result, all details regarding the participant's identity and connection to her respective institution remained confidential and withheld.

### **Summary**

This study investigated the effective implementation of PJBL in an elementary, integrated curriculum with mathematics and at least one other subject area. General qualitative data collection methods and analysis were used to guide this study, with an open-ended teacher interview utilized as the method for data collection. The participant has experience implementing PJBL in this specific context and as a result, engaged in an hour-long interview for this study. The interview was audio-recorded and the

transcription was sent to the participant for member checking prior to coding the data.

This study received clearance from the Research Ethics Review Board of Brock

University before proceeding to recruit participants and conduct the interview.

## **CHAPTER FOUR: FINDINGS**

In this chapter, the participant's strategies to overcome the six common challenges associated with the implementation of PJBL when enacting this strategy in an integrated, mathematics context will be described, allowing for connections to be made across the data. Additionally, an overview of the major themes found in the data, as well as additional subthemes that emerged, will be discussed. Foremost, the participant's definition and understanding of PJBL is outlined and compared to the definition used for the purpose of this study. Then the data were analyzed holistically to determine the commonalities across the participant's experience. The PJBL strategies shared were divided into three major themes: (a) providing general facilitation guidelines, (b) promoting a growth mindset, and (c) developing students' process skills. Several subthemes were also identified within each of the three themes, allowing for a greater understanding of the participant's experiences. These subthemes will be identified separately in the individual descriptions of each of the three themes.

### **The Context of the Study**

The participant for this study has been teaching in southern Ontario for almost 16 years in two different school boards, predominately in grade 7 and grade 8 mathematics and science. She has been teaching for over the past decade at a fairly small, urban middle school that requires students to be considered a First Generation Student, meaning that they will be the first in their family to graduate from a postsecondary institution. The students who apply to the school generally come from low-income households and are required to demonstrate good learning skills and initiative, and that they are currently meeting (or close to meeting) the grade level expectations in order to be accepted for

enrollment. The particular demographic of school and the subjects that the teacher is exclusive to have allowed for PJBL to be feasible in the participant's regular teaching practice.

In order to get a richer appreciation of the participant's understanding of PJBL and ensure that her perceptions were a direct match with the definition that was established for the purpose of this study, I started the interview by asking the participant to define PJBL. From this conversation, it was evident that the participant views PJBL to be an open-ended, multidisciplinary approach that allows students to investigate authentic questions that are based around real world problems that require the development of 21st century skills. For example, the participant said that through doing "what real scientists or mathematicians do, students are developing the ability to problem solve, on their own." Furthermore, she described PJBL to offer choice, as opposed to a defined approach or "prescribed, algorithmic, kind of solution." While the learning is facilitated by the teacher and restrained to the objectives of the Ontario curriculum, it is student-driven which allows the students to become invested in and take ownership over their learning. Finally, PJBL was described to foster student engagement and collaboration as students work as a team to pose questions, devise a plan, and create a product to showcase their learning. The participant describes the purpose of PJBL as to engage. She reasons "if kids are engaged and they are asking their own questions about something, then there is a greater likelihood that they are going to have a deeper understanding."

This definition provided by the participant directly matches the five criteria outlined by Thomas (2000). From the participant's definition, the element of centrality was evident as the project was often described to be the central teaching strategy used to

teach the curriculum. The projects were based on inquiry-based problems and revolved around one main driving question from which many side questions emerged. Similarly, the participant described PJBL to be student-driven through which the students take responsibility for their learning and construct new knowledge in the process. Finally, the fifth element of realism is evident in the participant's understanding as she describes PJBL to encompass real-life, authentic problems that require students to work collaboratively and develop 21st century skills.

### **Theme 1: General Facilitation Guidelines**

From the interview with the participant, some general suggestions emerged for how to approach and facilitate PJBL in an elementary integrated, mathematics context. First of all, the participant voiced that the timing and initiation of PJBL must be approached with careful thought. She suggests that the teacher sets the context for the project by presenting students with one driving question that integrates the desired curricular strands of focus. This central question starts a dialogue with the students from which many other student-created questions are driven and investigated. In an ideal circumstance, the teacher should be able to introduce a topic or an activity that stems from the curriculum, which will intrigue the students to then develop and investigate the questions that they will be required to answer to be successful. For example, when integrating the grade 8 measurement unit in mathematics (volume and capacity) and science water systems unit, the initial question: How would you design a container to carry all of the water that you use in a day? was posed. This question drove a number of student-driven side questions and experiments which the students investigated prior to building and designing their container, including: How much water do we use in a day?

What shape would be the most economical for my design? Do two shapes with the same surface area also hold the same volume of water? How does the volume of water that I use in a day compare to the average amount that someone uses in a developing country?

However, the participant stresses that in her experience, there is no “one-size-fits-all” approach to initiating or facilitating PJBL. She voices that as a teacher you really need to know you the characteristics of your students and their unique needs as learners. This is necessary in order for the teacher to determine the right amount of background schema your cohort requires in order for success with the project. She cautions that this can sometimes feel like “trial and error” and, in her experience, has been different for each cohort she has taught. She suggests that there is no harm introducing students to the project and asking them what background information they would like to learn prior to starting the task. In this case, the timing of PJBL depends on the needs of the cohort and the complexity of the content and the task. It is also important for the teacher to differentiate the amount of scaffolding that is provided for each individual student to ensure the support is a direct match to his or her needs. In order to find this match, students need to be able to recognize the gaps they have in their learning and take the ownership to pose questions that will allow the teacher to guide them in the right direction towards bridging those gaps. How to guide students towards developing this mindset will be discussed further in the next section.

## **Theme 2: Promoting a Growth Mindset**

In order for PJBL to be effectively carried out in the classroom, the participant voiced that teachers and students have to change the way they view their roles in the classroom and work collaboratively to develop a strong classroom community that is

built on open dialogue and teamwork. Collectively, teachers need to promote a growth mindset in the classroom that allows students to become free, independent thinkers who are self-directing and guiding their own learning. The participant cautions that this process does not happen overnight; however, it does start with the teacher's own transformation into the role of a facilitator.

### **The Role of the Facilitator**

In order to successfully enact PJBL, the teacher must change his/her mindset and role from that of the director or lecturer, to the facilitator of student learning. From the participant's own experiences as well as conversations with colleagues, she has found that the hardest part about this transition for teachers is giving up the control over what and how students are learning. As teachers, we have a tendency to want to know all of the answers and often we do have the answers available at our fingertips through our own knowledge background or commercial-made answer keys. However, in order for self-guided, 21st century learning to occur, teachers need to be comfortable with putting the ownership on students to find the answers. She argues that we need to

allow teachers to help them realize that as a facilitator... it is not our job to have the answers. Our job is to ask the right questions to get the kids to think about what they know and what they don't know and to understand what it is they don't know and to figure out ways to find what they don't know.

Once teachers are freed from being the person with all the answers, this changes the way that teachers and students view the role of the teacher and places the focus on the teacher as the guide of, or supporter to, student learning. When teachers do not know the answer to all of the students' questions, there are no shortcuts that can be made to the learning.

Instead, students and teachers are investigating and learning alongside one another and discovering the answers as they go.

However, the participant does caution that in order to facilitate PJBL, it is important for teachers to have a strong knowledge background of the curriculum content in order to “convey and quickly understand the questions that students are asking and know how you might be able to help facilitate their investigation.” The role of a facilitator does require one to be able to think on the spot and find ways to scaffold each individual’s learning in a way that will give them just enough support to be able to solve the problem independently.

### **Changing the Mindset of Students**

While the transition from the role of the teacher into the role of the facilitator can be particularly challenging for educators, this instructional style can also be initially frustrating for the students. From her own experience, the participant recognizes that “the moment that students understand that the classroom is a place where they are responsible for their own learning, you have a very different dynamic.” As a teacher, it is important to set the expectation for students to come into the classroom already engaged and prepared to think and solve problems. Students need to view education as an investment in themselves and take control over their own learning. Teachers can instill this mindset by developing students’ capacity for investigation and inquiry in the first few weeks of the school year. The participant does this by starting off the first few weeks to the school year with open-ended science and mathematics challenges that force students to build the capacity for investigation and inquiry. By initially focusing on the students’ development of the process skills necessary for PJBL, such as questioning, reflecting, and

collaborating, teachers set the tone for the rest of the year by giving students a gradual taste of inquiry based learning and equip them with the acquisition of the tools that they will need to persevere when they are faced with greater problems and challenges, as in the case of PJBL. The specifics of these challenges and the strategies that the participant uses to promote the development of these process skills will be discussed in greater detail in the next section, Theme 3: Developing Students' Process Skills.

Similarly, students need to be taught that the focus of learning is on the process, not on the end product or final solution. Students can still have success with a problem without ever reaching a final solution. From investigating different solutions and developing an open and collaborative dialogue in the classroom community, students will come to see that inquiry based learning is not black and white, meaning there is no one way of thinking or approaching a problem. The goal is for students to approach each question from a variety of angles and look for new ways to solve the problem by investigating different solutions and collaborating with their peers. Even when the problem proves to be too challenging or the student does not succeed within the restricted amount of time, we want students to “walk out asking the teacher if we can do it again” as opposed to feeling defeated. Promoting this change in their students' mindset can be developed through the strategy of building a strong classroom community and through teaching the character attribute of perseverance.

### **Building a Strong Classroom Community**

When presenting challenging problems to students, it is especially important for teachers to encourage the involvement in community. Students need to recognize the value of collaboration. The participant suggests that one easy way to do this is to have

students write down three questions that they have about a problem on their own, and then have them come together with a group of peers to share their ideas. In simple tactics such as these, students see how collaboration leads to students learning from one another and expanding and extending their own initial ideas almost instantaneously.

The participant observes that from a young age in education, students have this idea that it is cheating to look at what someone else has done or to copy their ideas. However, in order to develop a community of collaboration, teachers need to disvalue them of that idea. As she voices, the reality is that

this is what happens in life all the time... Phone companies didn't invent their smartphone –you know– in a vacuum. They're looking at what else is out there and improving on it. So I want to encourage this idea that we learn from each other and learning from one another can help us.

Students need to build on and incorporate one another's ideas. They need to find a way to collaborate with one another, and communicate their thought process in a way that will allow others to understand their thinking. This means that even if students are not directly working with one another, in the same group, the classroom is seen to be a whole group community as opposed to several individual learners who are competing against one another.

### **Developing Perseverance**

Finally, in order to promote a growth mindset in students, teachers need to instill the character attribute of perseverance in their students. Teachers can do this by challenging their students and putting them in a place of discomfort. From the participant's experience, she finds that students come to school with the view that

learning should be fast and easy. However, they quickly find that this is not the case, which causes students to habitually become frustrated and disengaged. The participant argues that it is important to teach students that “Everything that is new is frustrating and uncomfortable... Learning should be tough! Learning should put you in a place of discomfort!” Teachers need to show students that it is okay to be frustrated. We get frustrated when things are new; however, we need to learn to persevere in the face of challenges in order to learn something new and to succeed. While perseverance is largely influenced by one’s mindset, in order to give students the tools that they need to persevere with challenges, it is important for teachers to develop students’ process skills. Strategies that teachers can use to develop their students’ process skills will be discussed in the next section.

### **Theme 3: Developing Students’ Process Skills**

While the research around PJBL validates how this instructional strategy promotes and develops students’ acquisition of 21st century learning skills, there are also strategies that teachers can use to simultaneously promote the development of these process skills. More specifically, the participant uses particular tactics in her own classroom to further develop her students’ ability to question, plan, investigate, collaborate, communicate, and reflect on their learning throughout the process of PJBL. She suggests that by focusing on the development of students’ process skills (and comparably, enhancing their 21st century learning skills) early on and throughout the year, teachers provide their students with the tools that they need to be successful in order to persevere when faced with more substantial challenges, such as those posed by the

nature of PJBL. In this section, strategies to develop the process skills of organization, collaboration, and reflection will be discussed and shared in greater detail.

### **Organization**

The skill of organization is a process that is necessary in order to successfully solve problems; it is also a learning skill that is reported on for each student in his/her Ontario report card. The participant voices that there are two components of organization that are most critical to PJBL: questioning and planning. As previously mentioned, the participant starts off the first few weeks of the school year by having the students tackle open-ended science and mathematics challenges. These challenges are nonthreatening as they are not assessed and are very loosely related to the curriculum. The sole purpose of these challenges is to help students develop and see the importance of the process skills. In the first challenge she introduces, all she does is tell the students to “design a food separator” and the purpose of this challenge is to teach students the importance of questioning and defining the problem, prior to being able to solve the problem. In the challenge, students are given a baggie filled with dried rice and chickpeas, a few index cards, two Dixie cups, and some masking tape. The students’ initial confusion with the task sparks them to ask questions such as: Can I use my hands to separate the chickpeas and the rice? Can I have more materials? Why do we need to separate the chickpeas and the rice? From asking these questions, the students are developing the skill of questioning and they are able to understand and define the problem so that they can successfully approach it. Here, the students are told that they must separate the two foods without any human intervention and they are able to get more materials if needed. From this, the students learn that questioning is a necessary step at the beginning of any mathematics or

science problem and only once they truly understand the problem are they then able to devise a plan to approach the problem. Similarly, the participant observes that it is only when students thoroughly understand the problem that they can become genuinely engaged or invested in the task. When students feel stuck in a challenge, they will be unable to determine what is holding them back unless they have a clear understanding of the problem and can communicate what specifically they need to know or learn in order to solve the problem. Once students reach this understanding of the problem and can communicate their needs, teachers then can guide the students in the right direction and provide the students with the right amount of scaffolding to make the problem seem less overwhelming.

In the second challenge, the participant teaches her students the importance of planning by giving them a focused problem that requires students to work within a time constraint and they are given a set amount of materials to work with. Here, the students are forced to make a plan and are held accountable to the circumstances. By developing these skills independently, students are able to develop each of these organizational processes in a fun and risk-free environment that sets the stage for PJBL later on in the unit. Furthermore, it creates a group dynamic where the students are informally getting to know each other through collaboration, which is another necessary process in PJBL.

### **Collaboration**

While collaboration is a huge component of PJBL, effective group work is another process skill that needs to be developed and taught to students. The participant voices that one of the major challenges with collaborative learning is that students have not been taught how to work in a group and “you can’t expect kids to work effectively in

a team unless you teach them that.” In order to resolve this issue, the participant focuses her final two challenges on how to work effectively in a group. In the third challenge, she chooses whom the students will be working with and, in the fourth challenge, she allows them to choose their own group members. From the problems that arise within the group dynamics in these challenges, the participant starts an open conversation with her students around group roles. The students collectively discuss how to recognize when a group member feels left out or disengaged or when another member is dominating the group decisions. From here the class brainstorms a script of appropriate phrases that they can say or strategies that they can use to create an equal share of group roles. In the participant’s experience, she finds that teaching students these social skills and how to effectively communicate gives the students a common language that allows them to recognize and independently solve social problems within their group dynamic. By putting this ownership on the students, teachers then are able to focus their own energy on differentiating instruction and facilitating the students’ acquisition of the curriculum. Furthermore, while fostering a sense of collaboration in the classroom, it is important for teachers to help students to recognize their strengths as individuals and leverage those attributes. Through the process of reflection, students are able to recognize their strengths and areas of need as learners. Strategies to develop students’ ability to reflect will be discussed in the next section.

### **Reflection**

In *The Ontario Curriculum Grades 1 to 8: Mathematics*, reflection is a process skill that requires students to validate their solutions using alternative methods and self-monitor their own thought process and progress while solving a problem (Ontario

Ministry of Education, 2005). Based on the participant's experience, she voices that reflection is also an important component to ensure students' success throughout PJBL and can be a valuable tool for teachers to use as an assessment piece. In order to help students develop reflection skills, the participant has students regularly record and respond in a thought journal. This strategy uses opened-ended, teacher directed prompts or questions which the students reflect on and document in writing throughout the course of the year. Here, students and teachers are able to see the growth in their thinking and return to a previous thought or idea when they are faced with a similar challenge or situation. She notes that the thought journal was particularly successful with allowing her students to overcome challenges when they felt stuck throughout the process of PJBL. The records allowed the students to capture what strategy they used in the past, why they did it, and how they knew whether or not it worked. In other words, the thought journal "captures their thinking in a specific moment in time so that we can go back and revisit it." From her experience, the participant also found the reflection to be more valuable to the students if it was directed from the teacher using guided questions that relate to the goals of the lesson. She found open-ended reflection to be too ambiguous for students and that a directed reflection lead to deeper, more valuable thinking.

The strategy of developing a thought journal can also be a value assessment tool that both teachers and students can use as evidence of the improvement and growth that students have made over the course of the project. For the students, the journal allows them to track the progress that they have made over time and to see their improvement as learners. Through the thought journal, students can also self-regulate their own learning as they are taught to become aware of and monitor their own thinking. For the teacher,

the participant states that she uses the thought journal as a large component in her final assessment of PJBL. She uses this piece both in her assessment of the students' learning skills and in the assessment of the content of the project. She argues that the final assessment mark should be in consideration of the students' growth over time and be a reflection of their work throughout the project. Similarly, as students continuously reflect on their own progress, this allows them to self-assess how their learning and progress matches with the assessment criteria that has been co-created and developed for the project in relation to the curriculum expectations. This way students have a clear understanding of where they are and what assessment level they currently fall under. This allows the final assessment mark to be a combination of student and teacher input.

### **Summary**

In conclusion, based on the interview shared from the participant's experience, several strategies to overcome the six common challenges associated with the implementation of PJBL, when enacting this strategy in an integrated, mathematics context emerged and were discussed in this section. The participant's definition and understanding of PJBL was found to directly match the definition outlined by Thomas (2000) for the purpose of this study. The three major themes that emerged from the data were discussed in detail, including (a) general facilitation guidelines, (b) promoting a growth mindset, and (c) developing students' process skills. Several subthemes were also identified within each of the themes. Within these themes and subthemes, several practical strategies and suggestions were shared based on the participant's own practice and experience. These strategies include introducing PJBL with a central driving question, transforming into the role of the facilitator, changing students' mindset,

building a collaborative classroom community, teaching perseverance, and developing students' process skills through inquiry-based challenges. These strategies that emerged within the three major themes and smaller subthemes will now be compared to those that are discussed in the literature and the implications of these findings for future practice will be examined in the next section.

## **CHAPTER FIVE: DISCUSSIONS, CONCLUSIONS, AND IMPLICATIONS**

In this chapter, an overview of the current study in connection to the literature reviewed in Chapter Two will be discussed. Then, the implications of this research will be outlined for future teaching practice and professional development, while noting the narrowness of the scope and the limitations of the study. Finally, an overview of the study's implication for further research will be provided.

### **Discussion**

In the findings section, the data were separated into three major themes: (a) general facilitation guidelines, (b) promoting a growth mindset, and (c) developing students' process skills. In this section, the literature on the challenges of PJBL will be compared to the strategies that were discussed under each of these three themes and their subthemes. Additionally, insight on the effects of PJBL from the literature will be compared to the advantages that were noted by the participant in her interview.

#### **Theme 1: General Facilitation Guidelines**

In the general facilitation guidelines, the participant voiced the importance of knowing your students and their unique needs as learners, as well as finding a time to initiate PJBL that will be a direct match to the needs of your cohort. The participant did not insinuate that there is a correct process to go about introducing the project and she suggests that this initiation should be unique for each group of students that you teach based on their learning styles and readiness. The experience of Hubbard (2012) also shares this notion as he feels that there is never going to be a perfect time to introduce a project. Similar to the participant's own approach, through the use of inquiry challenges at the beginning of the year, Hubbard likes to initiate PJBL within the first few weeks of

school to ensure that students have ample time to adjust and feel comfortable with this instructional method.

While there is some overlap in the implementation of PJBL, the participant's flexible entry to and facilitation of the project does contrast the works of Colley (2008), who suggests a six-stage cycle model, and Nobori (2012), who developed 10 steps for implementing PJBL. In Colley's cycle, the student development of a project contract that outlines their roles, purpose, procedures, and materials, as well as peer presentations, are two steps in the cycle that were missing from the participant's own approach. In the case of Nobori's plan, using the curriculum as a starting point and the use of an entry activity to introduce the project are two steps that the participant also suggests to do initially. Similarly, Nobori also advises the teacher to have the students create a list of the concepts and vocabulary that they think they will need to have as background knowledge in order to be successful with the project and to develop and present the assessment rubric upfront. However, Nobori suggests a few additional strategies for the implementation of PJBL that did not emerge from the discussion with the participant, such as the necessity of sharing project ideas with critical colleagues, presenting project exemplars to students, having students write a group contract to define each member's roles and responsibilities, and offering small-group workshops for students who require the reinforcement of certain concepts. Thomas (2000) also promotes the strategy of having excellent past students' work available for students to use as exemplars and suggests that the physical classroom environment should be designed in a way that allows for the collaborative and experimental nature of PJBL.

Finally, stemming from the participant's own previous career in science, she does share the same view that projects should be designed to mirror the work of professionals out in the field. However, she did not include the strategy of encouraging students to connect with members in the work field and the need for students to celebrate and share their final project with experts out in the community (Lattimer & Riordan, 2011).

### **Theme 2: Promoting a Growth Mindset**

In order to promote a growth mindset in both the teachers and the students, the work of Bell (2010) suggested that the teacher is the most critical factor. This is similar to the participant's own belief as she suggests that the teacher must find the direct level of support and guidance that each individual student needs in order to aid them throughout the process of PJBL. Similarly, English and Kitsantas (2013) suggest that teachers should gradually release the amount of support that they give to students and focus on using prompting to get students to think deeper about their learning. This is similar to the strategy used by the participant as she suggests that the teacher's role as a facilitator is to ask students the right questions to help them to determine what it is that they need to know and how to guide them in the right direction so that they can discover the answers on their own.

In order to help students to adjust to their own role as self-guided learners, teachers should frequently implement student-centered, inquiry-based pedagogies from the beginning of the year in order to allow students to adapt to the flexible nature of this learning style (Tamim & Grant, 2013). The participant does this through her own strategy of using four purposeful, inquiry-based challenges to set the tone for the year and allow students to develop the necessary process skills to be successful with PJBL. English and

Kitsantas (2013) also suggest that teachers should balance the freedom of PJBL with structure through the use of handouts, templates, guidelines, and assessment criteria. While the participant did not mention providing students with handouts or templates to aid with the project, she did voice the necessity of creating the assessment criteria, project questions, developing necessary background information, and developing the roles and guidelines for group work, as a class. Based on the suggestions of English and Kitsantas it is feasible that providing students with an assignment outline and a personal photocopy of any co-created guidelines or aids would also be beneficial for students to have as these guidelines will allow students to quickly reference what was previously discussed and feel a stronger sense of structure within this self-guided strategy.

Similar to the participant's own experience, Zhenyu (2012) found PJBL to be challenging for teachers when they did not have the necessary background knowledge of the content and topics that the students were studying, thus making them feel as if they were unable to give the appropriate assistance. The participant suggests that teachers can combat this by ensuring that they are integrating subjects and topics that stem from the curriculum with which they have a strong background knowledge and to ensure that they provide students with a basic knowledge background on the topics so that the students can determine what it is they still need to know.

### **Theme 3: Developing Students' Process Skills**

In order to develop students' ability to collaborate, the participant uses her own strategy of co-creating a script with appropriate social statements to aid with the sharing of group roles. However, the work of Nobori (2012) and Tamim and Grant (2013) focuses more on structuring the development of collaboration within the team itself and

suggests having students write a group contract to define each member's roles and responsibilities for the problem. This structure will ensure that students feel accountable to their group and delegate an equal contribution among all members (Nobori, 2012; Tamim & Grant, 2013). Similar to the participant's own belief that we should encourage students to sell their own talents and strengths while collaborating with their peers, Bell (2010) feels that students do this naturally to enhance the quality of the project for the group. Furthermore, teachers can encourage collaboration and self-growth by encouraging students to learn from their mistakes (Tamim & Grant, 2013).

The notion of developing and promoting opportunities for self-reflection before, throughout the project, and as an assessment of the project, is a strategy that is also common throughout the literature (Bell, 2010; Colley, 2008; English & Kitsantas, 2013). While the participant's strategy of using a thought journal is not one that is noted among these authors, English and Kitsantas suggest engaging students in ongoing dialogue and explicitly modeling metacognition in order to demonstrate to the students how to reflect on their own thinking. Similarly, Lee et al. (2014) encourage teachers to hold scheduled meetings with each group of students to track, monitor, and support both the individual's and the group's development over time. In order to get an authentic evaluation of the students' progress and reflection throughout the entire process, using a combination of informal dialogue, formal conferencing, rubrics, peer assessments, and self-assessments will allow for a more holistic assessment of student learning (Lee et al., 2014; Tamim & Grant, 2013). While journaling, informal conversations and rubrics are tools that are all utilized in the participant's current assessment; she also voiced that peer and self-assessment are two valuable measures that she would like to incorporate in her future

assessment practices as she feels that the students' reflections and evaluations prove to be far more valuable than a teacher-determined level on a rubric.

### **Effects of Project-Based Learning**

In the interview, the participant noted three significant effects that emerge from the instructional strategy of PJBL: (a) reaching those students who are not regularly academically inclined, (b) developing students' 21st century skills, and (c) enhancing student engagement, which, in turn, leads to fewer behavioural issues. These advantages to PJBL are similar to those noted in the literature. Based on the student demographic that the participant works with, she notes that PJBL has resulted in heightened student engagement and fewer classroom behaviour issues. These findings are similar to those of Hoppe (2010) and Thomas (2000) who found that PJBL had a positive impact on students' learning and engagement and resulted in fewer disciplinary problems for remedial students. Similar to the finding of Uyangor (2012), the participant observed that PJBL particularly benefits students who are creative, outside thinkers for whom more traditional methods of teaching are not effective. While the participant voices that the development of 21st century skills should be taught and developed throughout the course of project, Thomas notes that development of 21st century skills, such as critical thinking, problem-solving, collaboration, and communication, are supplementary benefits to using this instructional strategy. Another additional effect of PJBL that was noted in the work of Thomas was an increase in attendance. This advantage was not noted by the participant, but is likely due to the fact that attendance in the Ontario education system is mandatory.

## **Conclusions**

In conclusion, this study explored how elementary school teachers negotiate common challenges associated with the implementation of PJBL when enacting this strategy in an integrated, mathematics project. Based on the data analysis of this study, the strategies discussed can be divided into three major themes: (a) general facilitation guidelines for PJBL, (b) promoting a growth mindset, and (c) developing students' process skills.

The results of this case study offer insight and recommendations for elementary teachers who are implementing PJBL in this context and provide novice teachers with a number of suggestions and strategies to optimize their success when implementing PJBL in an integrated, mathematics curriculum for the first time. These strategies include introducing PJBL with a central driving question, transforming into the role of the facilitator, changing students' mindset, building a collaborative classroom community, teaching perseverance, and developing students' process skills through inquiry-based challenges. Based on the results of the discussion section, these strategies shared by the case study participant also overlap with and compliment those suggestions that were discussed in the literature on PJBL in a similar context.

## **Implications**

In this section, the implications of this research for future practice and the implications of this research for future research will be explored.

### **Implications for Future Practice**

The primary motivation for this study was to fill the gap in the literature exploring teacher strategies for overcoming the six common challenges associated with

implementing PJBL in an elementary, integrated, mathematics curriculum. The extensive commentary provided by the participant about her own experiences with enacting this instructional strategy in the desired context has allowed for many insights into how teachers who are new or struggling with this method can alter or enhance their existing practices. Some strategies that emerged to overcome the challenges associated with the general facilitation guidelines of PJBL included presenting students with one central driving question, knowing each of the students' learning styles, and differentiating instruction to fit the unique needs of each learner. A number of strategies that teachers can use to promote a growth mindset both in their own approach to teaching and in the students' attitude towards learning were also shared. This begins with teachers becoming comfortable in their own role as facilitators (e.g., being comfortable with not knowing all of the answers and selecting topics from the curriculum with which they have a strong knowledge background). Furthermore, teachers should set the tone for PJBL by starting off the year with inquiry-based challenges that will demonstrate to students that the focus of the learning is on the process, not the end product or final solution. These purposeful challenges also allow teachers to develop a classroom community of collaboration and model and instill the character attribute of perseverance. The final strategy discussed for future practice involves the teaching of the 21st century skills that are essential for PJBL (e.g., defining the problem, questioning, planning, social skills, effective communication, sharing of group roles, and self-reflection). Through the use of a series of inquiry-based challenges, the teacher can explicitly model these processes in a structured environment that allows the students the autonomy of experiencing inquiry-based learning. Finally, to deeply promote effective collaboration and reflection, the collaborative development of a

social script and the use of a thought journal are two strategies, respectively, that have been effective in the participant's experience.

While the participant's own experiences enacting PJBL in this context are extensive and do directly align with and expand on several of the strategies that have been discussed in the literature (as was outlined in the discussion section), it is important to note that this study is limited in both its scope and generalizability. The strategies that the participant uses to overcome the common challenges associated with PJBL in the desired context have only been tested, evaluated, and observed by the participant. While the participant's insights and descriptions as to how she facilitated PJBL and carried out these strategies are extensive, the explanations are subjective to her own experiences. Therefore, the study will not allow for a generalization of findings to all elementary school teachers who have enacted this instructional strategy in an elementary mathematics, integrated curriculum. Similarly, educators who have practiced PJBL in a similar context may have enacted similar strategies to overcome the challenges associated with the implementation, but the study cannot be generalized to include them.

### **Implications for Future Research**

As a whole, this study outlines a number of strategies that were successful for one middle school educator to overcome the common challenges that emerge when enacting PJBL in an integrated, mathematics context. While this constructivist approach has become more predominate in the 21st century, with the push for inquiry based approaches to teaching and learning, the literature on PJBL in an Ontario middle school mathematics, integrated context has been fairly limited to date (Heyl, 2008; Meyer et al.,

1997). This section will focus on the considerations that this study raises for further research and provide some details about topics that appear to require further exploration.

Based on the limitations of this study, further research into the strategies that other teachers use when implementing PJBL in an integrated, elementary mathematics context would be beneficial in order to discuss and compare to this participant's own suggestions to other teachers' experiences. Since the experience of the participant was predominately in grade 8 mathematics and science, further research is needed to determine if teachers in different elementary grades and integrated subjects would share common strategies and suggestions. Similarly, the school where the participant works has a very unique demographic of students, which makes it difficult to generalize these strategies to all students in the same context, subjects, or grade. Further research is needed, along with more extensive methods for data collection that expand beyond the use of teacher interviews. It would be beneficial for future research to observe the teachers in the field as they are enacting PJBL in their classrooms in order to get a broader sense of the approaches that educators take and substantiate the effects of these strategies. Furthermore, future research should include the evaluations and experiences of students through the use of interviews and observations. It would be interesting to conduct a pre-test post-test experiment that would compare the students' and teachers' experiences before and following enacting these suggested strategies in their practice. This method could help to determine how effective these strategies are at combating the six common challenges associated with PJBL. However, based on the nature and description of the participant's responses and the discussions in the literature, it is

important to remember that there is never a “one-size-fits-all” approach to teaching and education.

Finally, future research should look at how educational institutions can work to strengthen the connections between professional experts out in the field and classroom teachers. The use of an authentic audience for expertise, motivation, and assessment was one aspect of PJBL that was absent from the participant’s own practice. This gap was interesting as the participant did voice a connection to the scientific field from her previous career as a geologist. It would be beneficial to look at how educators can develop stronger partnerships with local corporations and experts.

In conclusion, this study used a qualitative methodology to determine the strategies that an experienced middle school teacher utilized to overcome the widespread challenges that are noted with PJBL in an integrated mathematics context. The participant voiced a number of strategies to help teachers overcome the challenges associated with transforming into the role of the facilitator, ensuring learner readiness, motivating and engaging students throughout the project, fostering collaboration among group members, and the authenticity and assessment of PJBL. These suggestions offer insights and ideas for new or struggling teachers who are enacting this strategy in their own teaching practice. Further research with additional participants and in slightly different grades and subject areas will help to determine if these (or similar) strategies are commonly utilized among multiple experienced teachers in their approach to PJBL in an integrated, elementary mathematics context.

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## Appendix A

### Teacher Interview Guide and Interview Script

#### An Exploration into Effective Practices for Implementing Project Based Learning in an Integrated, Elementary Mathematics Curriculum

##### Teacher Interview Guide:

*The goal of the interview is to elicit information from the teachers about how to they would effectively implement project based learning in an elementary, integrated mathematics context. The role of the interviewer is to ask the questions, and encourage the teachers to provide a thorough response. At the same time the interviewer should speak as little as possible during the teachers' responses to avoid interfering with their thinking.*

##### Description of the Project

- 1) Please describe how you would implement project based learning in an elementary, integrated curriculum with mathematics and at least one other subject area?
  - a. How would you describe the purpose for utilizing project-based learning in the classroom?
  - b. How would you go about designing the project? Would the “driving” question(s) be designed by the students or the teacher?

##### Transforming Roles

- 2) Project based learning is an extremely student-centered approach that requires the teacher to be a facilitator of the process.
  - a. Especially for teachers who are implementing project based learning for the first time, the transition from the teacher into the role of a facilitator can be a particularly challenging for teachers. How would you ensure success during the transition from the role of the teacher to the facilitator?
  - b. Similarly, students sometimes experience discomfort and difficulty during student-centered and inquiry-based approaches to learning. How would you shift the direction from teacher-centered, to student-centered learning?

##### Learner Readiness

- 3) One of the challenges with project based learning involves ensuring the learners are ready to engage in this strategy.
  - a. How would you prepare your students academically for the project?

- b. Self-regulated skills to include the ability to set goals, carry out research, select appropriate strategies, monitor learning, and self-assess their results. How would you foster students' self-regulation skills either before or during the project?

#### Motivation and Engagement

4) Since PJBL is largely inquiry-driven and challenges the students to think in new and stimulating ways, it is not uncommon for students to lose motivation and become disengaged, especially during challenging aspects of the process (Lee et al., 2014; Meyer et al., 1997). What would you do to keep students motivated and engaged throughout the process?

#### Group Dynamics and Collaboration

5) Perhaps one of the most challenging aspects of PJBL is the ability for students to work together in a team (Tamim & Grant, 2013). How would you ensure and foster collaboration within a group dynamic?

#### Authenticity

6) Project based learning requires for students to solve real world problems and mimic the work of professionals out in the field. How would you incorporate authentic experiences through project based learning?

#### Assessment

7) Lee et al. (2014) suggests that innovative assessment methods are required to efficiently assess the process-oriented nature of project based learning and consider the students' development of the twenty-first century skills. How would you assess student's content and skill development during or after the project?

**An Exploration into Effective Practices for Implementing  
Project Based Learning in an Integrated, Elementary Mathematics Curriculum**

**Interview Script:**

During this interview, I will be asking about your opinion as an elementary school teacher, who has implemented project based learning in an integrated context, with mathematics and at least one other curricular subject. The interview will focus specifically on how you would implement project based learning, teacher and student roles, learner readiness, student motivation and engagement, group collaboration and dynamics, developing authentic projects, and the assessment of students' work.

**Description of the Project**

1) Please describe how you would implement project based learning in an elementary, integrated curriculum with mathematics and at least one other subject area?

- a. How would you describe the purpose for utilizing project-based learning in the classroom?
- b. How would you go about designing the project? Would the “driving” question(s) be designed by the students or the teacher?

**Transforming Roles**

2) Project based learning is an extremely student-centered approach that requires the teacher to be a facilitator of the process.

- a. Especially for teachers who are implementing project based learning for the first time, the transition from the teacher into the role of a facilitator can be a particularly challenging for teachers. How would you ensure success during the transition from the role of the teacher to the facilitator?
- b. Similarly, students sometimes experience discomfort and difficulty during student-centered and inquiry-based approaches to learning. How would you shift the direction from teacher-centered, to student-centered learning?

**Learner Readiness**

3) One of the challenges with project based learning involves ensuring the learners are ready to engage in this strategy.

- a. How would you prepare your students academically for the project?
- b. Self-regulated skills to include the ability to set goals, carry out research, select appropriate strategies, monitor learning, and self-assess their results. How would you foster students' self-regulation skills either before or during the project?

#### Motivation and Engagement

4) Since PJBL is largely inquiry-driven and challenges the students to think in new and stimulating ways, it is not uncommon for students to lose motivation and become disengaged, especially during challenging aspects of the process (Lee et al., 2014; Meyer et al., 1997). What would you do to keep students motivated and engaged throughout the process?

#### Group Dynamics and Collaboration

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#### Assessment

7) Lee et al. (2014) suggests that innovative assessment methods are required to efficiently assess the process-oriented nature of project based learning and consider the students' development of the twenty-first century skills. How would you assess student's content and skill development during or after the project?

## Appendix B

### Sample Email for Member Check Process

Dear Participant,

Thank you for your participation during the interview!

Attached is a copy of your interview transcript. It is saved in a password protected file. For your privacy and to keep the file secure, you will receive the password to access this file in a separate email following this one, momentarily.

Please review this transcript from your interview. It should take no longer than one to two hours to review your transcript. Please let me know through email correspondence if there are any changes, revisions, or comments that you would like to add to this written transcript, in order to ensure that it is a true representation of your responses to each of the questions. There is a two week time frame allocated to respond to the transcript with any changes or alterations. If I do not hear from you within two weeks time, it will be assumed that you have no changes to the transcript and I will proceed with the data analysis portion.

If you do have revisions that you would like to see made to the interview transcript, please kindly these explain these alterations through email. Within a week of your response, I will send you a revised copy of the transcription with the requested changes for you to confirm. You will then have one week's time to review and confirm the revised transcription. This process will continue, until a confirmation has been reached.

Once you have emailed me to confirm any revisions or alterations to the interview transcript, I will email you a one page synopsis, summarizing the main points shared from your interview.

Thank you for your participation and understanding.

Please do not hesitate to contact me if you have any questions with the process.

Kind regards,

Jessica Varga