ABSTRACT

LAO, HUEI-CHEN. Development of a Survey to Examine the Factors that Motivate Secondary Education Teachers' Use of Problem-based Learning (PBL). (Under the direction of Dr. Margaret R. Blanchard)

In this quantitative study, a survey was developed and administered to middle and high school teachers to examine what factors motivated them to implement problem-based learning (PBL). Using Expectancy-Value Theory by Eccles et al. (1983) and Self-Determination Theory by Ryan and Deci (2000b) as the theoretical framework, this instrument measured respondents' perceived competence, support for autonomy and relatedness, and value and cost they placed on implementing PBL.

Data analyses indicated that the instrument had good reliability. A 3-factor structure was established by exploratory factor analysis which confirmed the construct validity of the instrument. Value of PBL to teachers and their students was the most dominant factor that motivated teachers to implement it. The second most important factor was their self-efficacy and anxiety about failing this pedagogy, and the third factor was teachers' perceived autonomy, and support from schools and colleagues.

Regression models showed the predictive power of the factors on teachers' intention to implement PBL, with their perceptions of the value of PBL being the strongest predictor. Results also indicate that teachers with PBL experience perceived significantly higher levels of competence and support from peers, and placed a higher level of value and perceived less cost in implementing PBL than teachers who had not implemented PBL. Teachers' formal training in PBL played a significant role in positively influencing their perceptions of competence and the value of PBL, and reduced their perceived cost of implementing PBL. This, in turn, enhanced teachers' intention of practicing PBL.

For teachers who had previously taught with PBL, their responses to two open-ended questions in this instrument corresponded with the theoretical framework of this study and triangulated well with the quantitative data. These teachers highly valued PBL and they recognized the challenges associated with its implementation. These teachers also emphasized the importance of formal training and support from schools. This study provides a holistic view of motivational factors underlying teachers' intention to implement PBL and implications for successful implementation of PBL to enhance student engagement.

Development of a Survey to Examine the Factors that Motivate Secondary Education Teachers' Use of Problem-based Learning (PBL)

By

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DEDICATION

To all the teachers who lead and inspire in the classrooms and beyond.

BIOGRAPHY

Huei-Chen Lao was born in 1951 in Taiwan. Her parents fled to Taiwan after the Chinese Civil War of 1949 and raised four children in a difficult environment. Huei-Chen's father was an army general and spent most of his career in the military campaign of "Unifying China." Like most of the Chinese women of her generation, Huei-Chen's mother dedicated her life to her children and family. Huei-Chen's parents considered their children's education their top priority and would never compromise on that no matter how challenging life was.

During her high school years, Huei-Chen passed the tests designed to select and prepare students who desired a career in STEM, a path intended for the brightest and smartest students. It is plausible that she did that to meet her parents' and her own expectations; however, she soon realized that science was interesting and inspiring. She spent four years studying agricultural chemistry at the National Taiwan University, followed by graduate study at The Ohio State University. After graduating with a master's degree in chemistry, Huei-Chen decided to gain some work experience and joined C. B. Fleet Co., a drug company in Lynchburg, VA.

Huei-Chen had a successful career at C. B. Fleet and was promoted to supervise the chemistry laboratory in 1982, less than four years after she joined the company. She then had two beautiful daughters; one was born in 1982 and one in 1988, and stayed at home from 1983 to 1993 to raise her children. Huei-Chen rejoined the work force in 1993 and worked as a project scientist for Arcadis Geraghty & Miller, Inc., a contractor for US Environmental Protection Agency. This work experience provided her exposure to toxicology and she developed a strong interest in this discipline. In 1999 she was offered a fellowship by National Institute of Environmental Health Sciences (NIEHS) for the Ph.D. program in Toxicology at North Carolina

State University, and chose to conduct her dissertation at the Molecular Carcinogenesis Laboratory at NIEHS.

Due to a family financial crisis, Huei-Chen quit her study of toxicology and worked as a biologist at NIEHS from 2001 to 2013. In addition to conducting research in skin cancer, she mentored many student interns to do research and helped them identify their career interest. Huei-Chen was also very involved in organizations such as InterAct of Wake County, an agency that provided services to domestic violence victims and helped them transition into independent and healthy lives through educational programs. She was awarded “InterAct Volunteer of the Year” in 2009 and 2010 for her contributions.

Recognizing her passion for education and working with people, Huei-Chen entered the Science Education doctoral program at North Carolina State University in 2011under the direction of Dr. Margaret R. Blanchard. In 2013, Huei-Chen had an opportunity for a career change and has been working in science education at NIEHS since then. She designs and implements professional development workshops for teachers and develops problem-based learning lesson units with teachers. She believes that teaming teachers with scientists will create synergistic positive effects on science education.

Huei-Chen has two beautiful daughters; one is a public health educator at City of Newton, MA and one is an educator at the Tashjian Bee and Pollinator Discovery Center at the University of Minnesota. Huei-Chen lives in Raleigh. She practices yoga and enjoys reading, particularly history and philosophy.

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CHAPTER ONE

INTRODUCTION

Science permeates nearly every facet of modern life and it significantly influences human welfare, economic development, social progress, and the quality of life in today's world (Hurd, 2000; National Research Council (NRC), 2012a; Zollman, 2012). It is important that our public school science education prepares students not only to pursue careers in science, but also possess sufficient understanding of science to be engaged in science-related daily life issues (NRC, 2012a). However, results from 2012 Program for International Student Assessment (PISA) showed a troubling picture about the science literacy of United States (US) students (Kelly et al., 2013).

By measuring the performance of 15-year-old students in mathematics, science, and reading literacy every 3 years, PISA allows countries in the Organization for Economic Cooperation and Development (OECD) to compare outcomes of learning as students near the end of compulsory schooling (Kelly et al., 2013). The 2012 PISA assessment showed that the US students' science literacy scores were lower than those of 22 education systems, trailing behind China, Singapore, Finland, Canada, Germany, Australia, Slovenia, and Latvia (Kelly et al., 2013). Also, eighteen percent 15-year-old students in the US scored below level 2 in science literacy, which is considered a baseline of proficiency, compared with 3% in China, 10% in Canada, and 8% in Finland (Kelly et al., 2013). The 2009 PISA science literacy assessment showed a similar trend (Fleischman, Hopstock, Pelczar, & Shelley, 2010). This national trend indicates that more needs to be done to prepare a scientifically literate work force in the US that is capable of competing in an increasingly scientifically and technologically oriented global economy.

Traditional science education in the U.S. focuses on students passively receiving the scientific content that they are supposed to learn and know from teachers (NRC, 2012a; van Eijck, 2010). As stated in "A framework for K-12 science education" by the NRC (2012a), which is the basis for the Next Generation Science Standards (NGSS), "Currently, K-12 science education in the United States…emphasizes discrete facts with a focus on breadth over depth, and does not provide students with engaging opportunities to experience how science is actually done" (NRC, 2012a, p. 1). Ideally, learning science should be an active process in which students engage in "problem solving, planning, decision making, and group discussions….Emphasizing active science learning means shifting emphasis away from teachers presenting information and covering science topics" (NRC, 1996, p. 20). Science learning should also be a student-centered process and "…student-centered classrooms tend to be interactive, inquiry driven, cooperative, collaborative, and relevant" (The American Association for the Advancement of Science (AAAS), 2011, p. 22).

Student-Centered Active Learning

Instructional activities and spaces used in active learning. Recognizing the need for change, educators have invested substantial effort to implement various kinds of student-centered active learning in the classroom, and new practices in teaching, learning assessment, and institutional innovations have emerged (Labov, Singer, George, Schweingruber, & Hilton, 2009; NRC, 2011a). The term "active learning" gained popularity after the report that Bonwell and Eison (1991) made to the Association for the Study of Higher Education. In the report, active learning was defined as "instructional activities involving students in doing things and thinking about the things they are doing" (Bonwell & Eison, 1991, p.iii).

The core elements of active learning are students' active involvement in the learning process and their engagement in higher order thinking tasks such as analysis, synthesis, and evaluation. In addition, less emphasis is placed on transmitting information and more on developing students' skills and students' exploration of their own attitudes and values (Bonwell & Eison, 1991). Many instructional activities have been used to practice active learning and some commonly used include: doing problem-solving activities, making inquiries, concept mapping, reflection, and having group discussions (Armbruster, Patel, Johnson, & Weiss, 2009; Drew & Mackie, 2011; Freeman et al., 2014; Kim, Sharma, Land, & Furlong, 2013; Lara-Alecio et al., 2012; Wood, 2009).

Advancement of technology also has led to the invention of tools that could be used during classroom lectures to reduce the likelihood that students will simply sit and passively listen. One of the most popular teaching tools for this purpose is the student response system or 'clickers'. The use of clickers provides instructor immediate feedback and opportunities for active discussion, even in large lecture halls (Beichner, 2014).

In addition to incorporating interactive learning activities into a classroom, innovations that modify the classroom spatial arrangement have also been made to promote active learning. For example, changing the classroom arrangement from the traditional rows of chairs into a combination of lecture and lab, called "Studios." In a studio set-up, students can easily move back and forth between listening to the teacher's presentation and working on experimentation or other activities that complement the lecture. This eliminates the synchronization problem caused by separate lecture and lab sessions and improves students' learning (Beichner, 2014), and has gained popularity in school teaching (Cennamo et al., 2011; Evans, Lopez, Maddox, Drape, & Duke, 2014; Plonczak, Brooks, Lodato, Wilson, & Caliendo, 2014).

The studio-based learning was further expanded to larger classes as in the SCALE-UP (Student-Centered Activities for Larger Enrollment Undergraduate Programs) project at North Carolina State University (Beichner, 2014). Beichner (2014) reports that more than two hundred institutions have adopted the SCALE-UP in various Science, Technology, Engineering, and Mathematics (STEM) areas, as well as art, language, humanities, and literature, in class sizes range from 24 to 200. Because of this expansion, Beichner, the project director of the SCALE-UP, changed the acronym to mean Student-Centered Active Learning Environment with Upside-down Pedagogies.

Active learning improves students' academic achievement and 21st century skills. A meta-analysis of active learning-based interventions in undergraduate STEM courses showed that students who used active learning approaches performed significantly better than students who received traditional lecturing (Freeman et al., 2014). The active learning approach increased students' performance by 0.47 standard deviation which corresponded to a half of a letter increase in average grades. Findings by Freeman et al. (2014) also showed that failure rates for students under traditional lecturing were 55% higher than those found under active learning. This finding is crucial for STEM education. In the report "*Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering, and mathematics*" by the President's Council of Advisors on Science and Technology (PCAST) they state, "Increasing the retention of STEM majors from 40% to 50% would, alone, generate three-quarters of the targeted 1 million additional STEM degrees over the next decade" (PCAST, 2012, p. i). Indeed, there were five recommendations by PCAST in this report and the first one was "Catalyze widespread adoption of empirically validated teaching practices." The report listed several types of active learning approaches that have been demonstrated to enhance learning, such as problem-based learning, case studies, small group discussion and peer instruction (PCAST, 2012, p.16).

In addition, studies show that active learning strategies improve students' critical thinking (Kammer, Schreiner, Kim, & Denial, 2015; Kim et al., 2013), engagement and learning attitudes (Armbruster et al., 2009; Evans et al., 2014; Gillies & Nichols, 2015), conceptual understanding (Hsu, 2008; Kaya, 2008; Minner , Levy, & Century, 2010; Sampson, Enderle, Grooms, & Witte, 2013), provide students opportunities to practice problem-solving and develop self-directed learning (Evans et al., 2014), and promote communication and collaboration among students (Cennamo et al., 2011; Evans et al., 2014). It can be inferred from these studies that students' academic achievement improves in an active learning environment; they also gain important 21st century skills such as problem solving, critical thinking, communication, and collaboration from the process (Partnership for 21st Century Learning, 2016).

Student-centered active learning pedagogy. All of these intervention studies also demonstrate that active learning entails more than simply having students conduct piecemeal learning activities. Instead, all the interventions employed a research-based active learning pedagogy as the framework from which the learning and teaching strategies in the studies were developed. There are multiple pedagogies that use student-centered, active learning approaches (Michael & Modell, 2003; PCAST, 2012) and the following major ones will be discussed: cooperative/collaborative learning, problem-based learning (PBL), and inquiry-based learning (IBL).

Cooperative learning and collaborative learning (Bell, Urhahne, Schanze, & Ploetzner, 2010; Gillies & Nichols, 2015; Kim & Tan, 2013; Rozenszayn & Assaraf, 2011; Sandi-Urena, Cooper, & Stevens, 2011) are similar concepts and involve students working together to achieve a common goal or task. However, cooperative learning introduces a more structured context in which the teachers maintain higher level of direct guidance than they do in collaborative learning (McInnerney & Roberts, 2004, Panitz, 1999).

PBL (Armbruster et al., 2009; Cennamo et al., 2011; Evans et al., 2014; Kammer et al., 2015; Kim et al., 2013) has its origins in medical education and it uses relevant and realistic problems in a chosen discipline to initiate the learning process. Students generally work in small groups under the guidance of the facilitator and engage in self-directed problem solving through data collection and analysis, evaluation, and reflection (Walton & Matthews, 1989).

Finally, IBL (Bell et al., 2010; Gillis & Nichols, 2015; Minner et al., 2010; Rozenszayn & Assaraf, 2011) has its roots in the practices of scientific inquiry. It emphasizes posing questions, collecting and analyzing data, constructing and communicating evidence-based arguments (Hmelo-Silver, Duncan, & Chinn, 2007; Seung, Park, & Jung, 2014). PBL and IBL are similar; however, IBL is also employed for research activities used to investigate scientific phenomena that could be beyond the "life-relevant" problems generally used for PBL; therefore IBL has been proposed to be considered as a broader umbrella term (Deignan, 2009).

These differently named pedagogical approaches are not mutually exclusive and they are often put together and used as combination pedagogy. For example, collaborative learning is, by definition, a component of problem-based learning (Barrows, 1996). It is also commonly used in combination with inquiry-based learning (Bell et al., 2010; Gillies & Nichols, 2015; Rozenszayn & Assaraf, 2011). PBL and IBL also share similarities and there are no clear-cut features to distinguish them from each other (Bozic & Williams, 2011; Hmelo-Silver et al., 2007). Both PBL and IBL are organized around questions/problems that are generally assigned by teachers, although IBL does strive to have students develop questions themselves (Bell et al, 2010; Hsu, Lai, & Hsu, 2015; Seung et al., 2014). In both approaches, students are engaged in planning, investigation, making inquiries, developing evidence-based explanations, and communicating their ideas and results. The teacher functions as a facilitator and guide students through the learning process (Bell et al., 2010; Hmelo-Silver et al., 2007).

The complementary nature of PBL and IBL can also be demonstrated by educators' practice of using a PBL approach to improve students' ability in posing questions (Hung et al., 2014; Kang, DeChenne, & Smith, 2012). The study by Hung et al. (2014) showed that a PBL process significantly improved sixth graders' questioning abilities. Moreover, students with experience in inquiry (experienced group) and students who had never joined any inquiry activity prior to the experiment (novice group) all showed growth in their questioning ability, although the experienced students had greater improvement than the novices. Kang, DeChenne, and Smith (2012) also found that PBL improved high school students' ability to pose active inquiry questions and generate hypothesis-driven approaches to answer their questions, two crucial elements for IBL.

PBL is the choice of active learning pedagogy for current study. Study results mentioned above suggest that there are multiple ways to implement active learning pedagogy in classrooms by combining different strategies to achieve the educational goals and meet school district policy. We choose PBL for the current study for the following reasons:

(1) PBL is listed in the PCAST report (2012) as one of the active learning approaches that have been demonstrated to enhance learning.

(2) PBL was one of the chosen active learning approaches during the 2008 NRC workshops which were held to identify "promising practices" for STEM education (NRC, 2011a).

(3) PBL is a comprehensive pedagogy and students in a PBL setting also practice inquiry and collaborative learning.

(4) PBL uses life-relevant problems to initiate the learning process and this approach corresponds to recommendations in “A framework for K-12 science education” by NRC (2012a). As stated in the framework, a core idea for K-12 science instruction should be to “Relate to the interests and life experiences of students or be connected to societal or personal concerns that require scientific or technological knowledge” (p.31).

As mentioned earlier, PBL is a student-directed collaborative learning method originally developed for medical school students (Neufeld & Barrows, 1974). Studies have suggested that PBL has the potential to improve students’ higher-order thinking skills, comprehension and application of knowledge, learning attitudes and motivation (Deborah, Donham, & Bernhardt, 2011; Dochy, Segers, Van den Bossche, and Gijbels, 2003; Gijbels, Dochy, Van den Bossche, and Segers, 2005; Jerzembek & Murphy, 2013; Walker & Leary, 2009). However, PBL is very different from traditional teaching in that teachers’ roles change from givers of information to facilitators, and this can be a difficult transition for many teachers (Ertmer & Simons, 2006; Spronken-Smith & Harland, 2009). Any pedagogy change like this can have positive effects for teachers overall, but it also brings complications and unknowns, both in the process and final product (Emo, 2015).

Studies demonstrate that designing effective PBL problems is a time-consuming and research-intensive process (Goodnough & Hung, 2008; Ribeiro, 2011). In addition, assessing students’ progress (Hung, Jonassen, & Liu, 2008; Savin-Baden, 2004), dealing with students’ deficiency in self-directed learning skills (Hung, 2011), and classroom management (Ribeiro,

2011) all can be challenging issues for implementing PBL. These studies suggest that in order to successfully adopt PBL into the classroom, teachers will have to develop new understanding and acquire new skills. Hall and Hord (2011) asserted, “Change cannot occur without professional learning” (p. 53). This means that teachers will need to invest a lot of effort for change to happen. What motivates teachers to initiate change in the classroom such as adopting a curriculum innovation?

Many factors influence teachers’ motivation to initiate changes. Studies show that teachers were more motivated to adopt changes and implement innovations when they had high self-efficacy (Holden & Rada, 2011; Kreijns, van Acker, Vermeulen, & van Buuren, 2013), and viewed the innovation as a useful, valuable, and positive change (Drent & Meelissen, 2008; Kreijns et al., 2013). School support for teachers’ autonomy and competence also motivates teachers to implement and persist in educational innovation (Lam, Cheng, & Choy, 2010). In a study conducted by Emo (2015), teachers’ personal identity as someone who enjoys innovation, their purpose to improve students’ learning, and a desire to make their teaching more effective also motivated teachers to initiate innovations.

Theoretical Frameworks

Expectancy-Value Theory. As discussed earlier, teachers’ motivation to adopt changes is influenced by multiple factors such as their self-efficacy, opportunities to exercise professional autonomy during the process, and their perceived value of the changes. These factors led to the choice of expectancy-value theory (EVT) as the theoretical framework for the current study. The premise of EVT is that an individual’s choice, persistence, and performance of certain tasks are influenced by his/her expectancies for success and the value that an individual places on the task (Eccles et al., 1983; Wigfield & Eccles, 2000). Another advantage of choosing EVT as the theoretical framework is that it allows for complexity in understanding individuals' motivations to engage in various activities (Durik, Vida, & Eccles, 2006). As Durik, Vida, and Eccles state, "The model is flexible enough to capture the multiple predictors, while at the same time, specific enough to provide insight to the process underlying these choices" (p. 390). A simplified model of EVT is shown in Figure1.1.

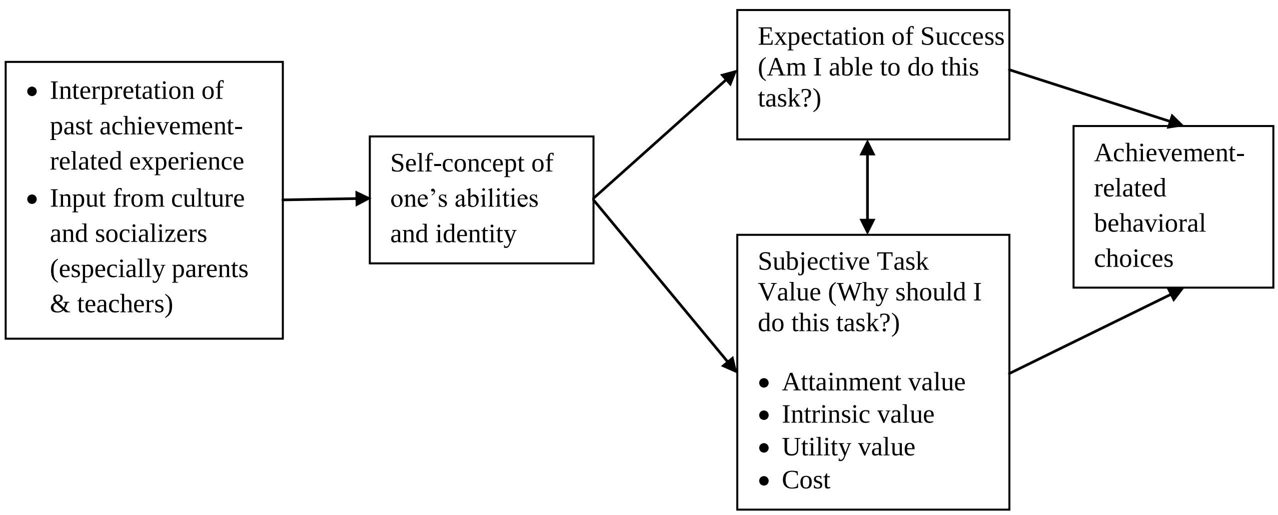

Figure 1.1. Expectancy-value theory (based on Eccles et al., 1983; Eccles & Wigfield, 2002).

As shown in Figure 1.1, there are two types of values that can motivate people to be engaged in achievement-related behaviors: intrinsic value, and extrinsic value such as attainment value and utility value. Attainment value relates to the importance of accomplishing a certain task for the individual and utility value indicates the level of usefulness an individual places on conducting a certain activity. The self-determination theory will examine these various types of values through a different lens and will be used as part of the theoretical framework for our study.

Self-determination theory. Self-determination theory (SDT) by Ryan and Deci (2002) postulates that people have three fundamental and universal needs: the need for autonomy, competence, and relatedness. Satisfaction of these basic psychological needs provides the sustenance for motivation and people function optimally when these three needs are met (Ryan & Deci, 2000a & b). Motivations are generally conceptualized as a dichotomy: intrinsic or extrinsic motivations. Intrinsic motivation is considered as authentic and self-endorsed, and is the most self-determined type of motivation. Contrary to it is extrinsic motivation, which concerns one's participation in a task for contingent outcomes and not for the internal satisfaction from doing the task (Ryan & Deci, 2000b). For example, a teacher might feel intrinsically motivated to do PBL simply because he/she enjoys it. On the other hand, a teacher might be extrinsically motivated to adopt PBL because he/she senses pressure from the principal to meet the district goal of teaching with PBL.

When people engage themselves in a certain task because they are intrinsically motivated, they do it for the inherent enjoyment and pleasure from doing it, without the mediating effects of external rewards or pressures normally associated with extrinsically motivated tasks. Therefore, intrinsically motivated behaviors are considered the prototype of self-determined behaviors (Ryan & Deci, 2000a). Individuals who are intrinsically motivated to carry out an action typically have more interest and confidence in doing it, compared with those who are externally controlled for an action. This interest and confidence, in turn, is manifested as enhanced performance, persistence, and creativity (Ryan & Deci, 2000b).

Instead of viewing motivations as two extremes, SDT suggests that between intrinsic and extrinsic motivation there lies a continuum of extrinsic motivation types reflecting various degrees of self-determination. Through internalizing their externally motivated tasks, individuals experience choice and autonomy, one of the most fundamental psychological needs, and thus are more self-determined to carry out the tasks on their own (Ryan & Deci, 2000a & b). As mentioned earlier in EVT, people's choice and performance of certain tasks is greatly influenced by the value they place on that task, and this value could be intrinsic or extrinsic. Actually, it is quite often that people engage in a certain activity because of its extrinsic value, such as improvement in grade point average or job performance, or acceptance by peers.

Upon identifying and accepting the personal value or utility of certain extrinsically motivated actions, people internalize and integrate the motivation to themselves, and experience higher levels of self-determination and autonomy for the action. Thus, the extrinsic motivation becomes self-endorsed and adopted with a sense of volition. Social environments that support individuals' innate needs for autonomy, competence, and relatedness are critical for their maintaining intrinsic motivation and becoming more self-determined with respect to extrinsic motivation (Ryan & Deci, 2000a), thus increasing individuals' willingness to conduct certain achievement-related activities with higher levels of performance and persistence. For example, teachers in a school environment in which they receive choices and options provided by administrators and support from colleagues in implementing PBL will be more motivated to use this innovative pedagogy.

Purpose Statement and Research Questions

The current study will assess secondary teachers' understanding of PBL and their intention of using this pedagogy. It also investigates the relationship between middle and high school teachers' intention to implement PBL and their expectancy for success, the value/ cost they place on this innovation, and their self-perceived level of autonomy and competence in implementing PBL. The target group for the study is secondary teachers from a southeastern state of the U.S.

PBL is very different from traditional teaching and teachers need professional development to acquire the necessary knowledge and skills for its implementation (NRC, 2012b; Salinitri, Wilhelm, & Crabtree, 2015; Walton, 2014). It can be particularly challenging for implementing PBL in secondary classrooms because teachers specialize in the subjects they teach; therefore teachers' collaboration might be required for PBL due to its interdisciplinary nature (P. Domenico, personal communication, September 9, 2015). Because of this additional challenge, the target group for the current study is middle and high school teachers. In order to find out the relationship between teachers' intention to implement PBL and various factors as stated above, a survey instrument using expectancy-value theory and self-determination theory as its theoretical framework was developed as a part of this dissertation study and was administered to teachers. The survey also includes questions that address teachers' conceptions of and perceived training needs for PBL. Responses from the survey were analyzed to answer the following three research questions:

1. Are there differences between teachers with and teachers without PBL experience in terms of their perceptions of PBL, training, perceived ability, and motivation in implementing this pedagogy?
2. Are there underlying factors that predict teachers' perceptions of PBL and their intention to implement it?

3. What are teachers' perceptions of the advantages and challenges for implementing PBL?

Summary

In this chapter, a case was presented arguing for the need to change science education instruction from one in which students passively receive information from teachers to one that actively engages students in science practices. A rationale was detailed for choosing PBL as the active learning pedagogy to investigate in the current study. PBL has the potential of improving students' 21st century skills, such as problem solving, critical thinking, communication, and collaboration. However, PBL implementation requires teachers to acquire new knowledge and skills and this study seeks to understand what motivates teachers to invest their resources for this curricular innovation. The expectancy-value theory and self-determination theory are the theoretical frameworks guiding the study. A survey instrument based on these two theories and relevant literature was developed and administered to teachers.

In Chapter two, the literature about problem-based learning and more detail about the theoretical underpinnings of the proposed study are detailed. In Chapter three, the methods used for the study are described in detail. Chapter four and five present the findings and discussion, respectively. In Chapter six, the conclusions are presented and implications drawn from the findings of the study.

CHAPTER TWO

LITERATURE REVIEW

What is PBL?

Problem-based learning (PBL) represents a major innovation in education. It was pioneered in the medical school at McMaster University in Ontario, Canada in the late 1960s (Neufeld & Barrows, 1974). The traditional medical school education required students to memorize huge amounts of information and did not pay enough attention to students' capacity to absorb, understand, retain, and use the information in subsequent clinical work. Therefore, educators came up with problem-based, self-directed learning – a teaching-learning approach specifically designed to emphasize students' skills in clinical reasoning and problem solving (Barrows, 1983; Neufeld & Barrows, 1974).

The core principles of PBL. A model developed by Howard Barrows (1996) identified six core principles of PBL:

1. PBL uses a learner-centered approach.
2. Students work in small groups to solve the problem and collaboration among group members is essential.
3. Teachers are facilitators rather than disseminators.
4. Authentic problems are presented at the beginning of the learning sequence and are used as tools to stimulate students' learning and gaining knowledge.
5. The problems encountered are vehicles for the development of students' problem-solving skills.
6. Students acquire new information through self-directed learning.

In a PBL course, the instructor presents a "real-life," authentic problem to students and provides guidelines for learning activities. Real-life problems normally transcend disciplinary boundaries and an interdisciplinary approach for problem-solving is necessary (Savery, 2006). Additionally, using crosscutting concepts to practice scientific activities is the essence of a "Framework for K-12 Science Education" (NRC, 2012) which is the basis of NGSS (NGSS Lead States, 2013). Another advantage of using real-life problems is that they trigger students' learning interest (Sockalingam & Schmidt, 2011).

After receiving the problem, students meet in small groups to identify what they know about the problem and what they need to learn in order to solve the problem. Students then gather needed information through self-directed study and re-convene their small group to re-assess their collective understanding of the problem. When they solve the problem, students will evaluate the information resources they used and re-visit the problem to see how they could have better reasoned their way through it and solved the problem more effectively. This analysis and synthesis could lead to another round of self-directed learning (Barrows, 1986; NRC, 2011a).

Impact of PBL on Student Learning

The impact of PBL on student learning based on studies conducted on medical school students. Educators and researchers have assessed the effectiveness of PBL and found that there is no simple answer to the question "Is PBL better than traditional teaching methods?" Several meta-analyses of the data suggest that PBL had no significantly beneficial effect on medical students' content knowledge learning (Albanese & Mitchell, 1993; Berkson, 1993; Nandi, Chan, Chan, Chan, & Chan, 2000; Vernon & Blake, 1993), as measured by students' score of the National Board Medical Examiners Part I (NBME I), a standardized test that assesses students' knowledge of science concepts. However, data from meta-analyses showed that the clinical performances and skills of students exposed to PBL were better than those of students educated in a traditional curriculum (Albanese & Mitchell, 1993; Vernon & Blake, 1993).

Data provided by two more recent meta-analyses (Dochy et al.,2003; Gijbels et al.,2005) suggest that PBL-based science education has the potential to improve students' ability to link scientific concepts and principles to real-life applications. Although the studies included in these two meta-analyses were almost exclusively conducted in medical schools, this finding is of particular interest because students' ability of transferring and applying what they learned in classrooms to real-life has been a concern to educators (Dixon & Brown, 2012; Khishfe, 2014; Shemwell, Chase, & Schwartz, 2015)

A more recently published meta-synthesis (Strobel, & van Barneveld, 2009) of eight PBL meta-analyses dated from 1993 to 2005 provided the following results:

- Traditional learning approaches tend to favor students' short-term knowledge acquisition and retention, although study results are mixed.
- PBL favors long-term knowledge retention.
- Skill-based assessment such as clinical ratings favors PBL over more traditional approaches.
- Mixed knowledge and skill assessment favors PBL over more traditional approaches.
- PBL improves the affective components of learning, such as teachers' and students' satisfaction with the teaching/learning approach.

Effectiveness of PBLin higher education. Compared to PBL research conducted in medical schools, empirical studies conducted in non-medical disciplines in higher education are relatively scarce (Allen, Donham, & Bernhardt, 2011; Hung, Jonassen, & Liu, 2008). The following studies examined the effects of PBL on students' learning outcomes: students in accounting courses enjoyed PBL and perceived that PBL improved their questioning skills, teamwork, and problem solving ability (Stanley & Marsden, 2012); students in introductory business courses perceived that PBL had a positive impact on their affective skill development (Hartman, Moberg, & Lambert, 2013); PBL improved nursing students' critical thinking, when compared with students who received traditional lectures (Kong, Qin, Zhou, Mou, & Gao, 2014); students in a PBL introductory psychology course also reported higher critical thinking skills and engagement relative to the control students (Muehlenkamp, Weiss, & Hansen, 2015); and PBL was as effective as traditional teaching for students in a master's social work program, in terms of knowledge building and learning skills development (Westhues, Barsen, Freymond, & Train, 2014). However, the PBL students were more committed to deep learning, compared with their non-PBL counterparts.

A large number of science and engineering courses also investigated the use of PBL. The results included finding that: PBL improved introductory biology students' engagement, satisfaction, and performance (Armbruster, Patel, Johnson, & Weiss, 2009); students in a physics class that used PBL improved significantly more in their conceptual understanding, long-term recall, attitudes and interests, and problem-solving strategies than students who received traditional teaching (Becerra-Labra, Gras-Martí, & Torregrosa, 2012); and students in an engineering capstone course perceived PBL as highly motivating and felt empowered (Jones, Epler, Mokri, Bryant, & Paretti, 2013). A study that examined the impact of PBL on students who took a computer II course showed that PBL improved students' critical thinking ability (Sendag & Odabasi, 2009). PBL was also shown to enhance students' critical thinking, self-regulated learning, and confidence in problem solving in an analytical chemistry laboratory course (Yoon, Woo, Treagust, & Chandrasegaran , 2014).

The effect of PBL on students' academic achievement on pre and post content tests has been used as a study outcome (Becerra-Labra et al., 2012; Sendag & Odabasi, 2009; Westhues et al., 2014). However, it is much more common for researchers to use other cognitive and affective learning elements as indicators for the effectiveness of PBL. Examples of other measures of the impact of PBL are critical thinking skills (Kong et al., 2014; Muehlenkamp et al., 2015; Sendag & Odabasi, 2009; Yoon et al., 2014), problem-solving abilities (Becerra-Labra et al., 2012; Stanley & Marsden, 2012; Yoon et al., 2014), and affective learning elements such as interest, enjoyment, motivation, and engagement (Armbruster et al., 2009; Becerra-Labra et al., 2012; Hartman et al., 2013; Jones et al., 2013; Muehlenkamp et al., 2015; Sendag & Odabasi, 2009; Stanley & Marsden, 2012), and the results generally favor PBL. However, one needs to keep in mind that although these are very promising, all of these studies took place with students in college settings and did not study the teachers who were implementing PBL.

PBL enhanced students' critical thinking skills and problem-solving abilities. Although results from PBL studies conducted in college classrooms are in line with the broad conclusion that the effect of PBL on students' content knowledge learning is inconclusive (Allen et al., 2011), data suggest that PBL fosters cognitive abilities for critical thinking (Kong et al., 2014; Muehlenkamp et al., 2015; Sendag & Odabasi, 2009; Yoon et al., 2014) and problem solving (Becerra-Labra et al., 2012; Stanley & Marsden, 2012). One example is the study by Şendağ and Odabaşi (2009), which showed that although PBL did not improve undergraduate students' content knowledge acquisition in a Computer course, students in the PBL group had a significantly higher increase in their critical thinking skills, compared with students who received traditional teaching.

Jones (2008) also compared the critical thinking ability of nursing students who received either traditional teaching or PBL. Students' written care plans were graded using the six levels of Bloom's taxonomy of the cognitive learning domain. Data indicated that the PBL students scored significantly higher than the control group in comprehension, application, analysis, synthesis, and evaluation, while knowledge scores indicated no significant difference between the two groups. Data from two reviews (Kong et al., 2014; Oja, 2011) also showed a positive relationship between PBL and critical thinking skills in nursing students.

In addition, students who were taught with PBL showed significant improvements in their problem-solving abilities, compared with students who received traditional teaching, in a study by Becerra-Labra, Gras-Marti, and Torregrosa (2012). In this study, the authors compared the problem-solving ability of the engineering students who took the first year college physics course, either by PBL or traditional learning approach. The indicators for problem-solving were: (1) analyze the problem qualitatively to understand it, (2) formulate a hypothesis, (3) develop a problem-solving strategy, (4) implement the strategy, and (5) analyze the results. The PBL students outperformed students in the traditional learning group and this ability was maintained even 12 months after the instruction was received (Becerra-Labra et al., 2012).

PBL improved the affective domain of learning. PBL uses methods associated with student engagement, such as active and student-centered learning focused on realistic issues. Therefore, it is plausible to expect that PBL would lead to increased student engagement and interest in learning (Allen et al., 2011). Indeed, studies suggest that PBL enhances the affective domain of student learning. PBL was associated with undergraduate students' improved attitudes and interest toward physics (Becerra-Labra et al., 2012). Studies also indicate that adopting PBL improves students' learning engagement (Armbruster et al., 2009; Muehlenkamp et al., 2015). In addition, Jones, Epler, Mokri, Bryant, and Paretti (2013) found that PBL motivated students in engineering capstone courses. Students felt empowered and that they could be successful, that they believed the PBL study was useful and related to their individual interests. All these opportunities enhanced students' motivation to engage in the engineering courses (Jones et al., 2013).

PBL in secondary education classrooms. Similar to the situation in non-medical field higher education, PBL practice in secondary education has been limited (Hung et al., 2008). PBL has been implemented in various subjects of secondary classroom classrooms such as economics, environmental study, mathematics, and science. In a high school economics class, Maxwell, Mergendoller and Bellisimo (2005) found that PBL improved students' performance; however, only in classes taught by teachers who were well trained in both the PBL technique and economics. Kim and Tan (2013) did an environmental field study and reported secondary school students' gains in knowledge integration, collaboration, communication, and reflection through the PBL process. Using a PBL approach in a high school mathematics class also improved students' learning motivation (Filcik, Bosch, Pederson, & Haugen, 2012).

Liu, Wivagg, Geurtz, ,Lee, and Chang (2012) studied the PBL implementation in sixth grade science classrooms, using a computer program that addressed National Science Standards and aligned closely with state standards. Teachers endorsed this program because it met their curricular needs; and school administrators supported teachers by providing professional development for implementing PBL as well as technical support. Results demonstrated significant gains in students' science knowledge. In addition, students were enthusiastic in using the program, engaged in learning, and there were fewer classroom management issues.

Marle et al. (2014) conducted a 4-day summer STEM camp in which 8th—12th grade students performed laboratory studies that were at the first-year college chemistry and biology level. Students reported that this experience not only increased their science knowledge and their motivation and confidence in learning science, it also helped them to develop a social niche of like-minded peers. Finally, Tarhan, Ayar-Kayali, Urek, and Acar (2008) examined the effectiveness of PBL in 9th grade chemistry class. They found that PBL improved students' academic achievement and critical thinking and also enhanced students' ability to conduct research using relevant and varied resources.

As with the PBL studies conducted in higher education, students' knowledge acquisition gauged by test scores was not the most commonly used indicator to measure the effectiveness of PBL in secondary education classrooms. Data from a number of studies that measured the effect of PBL on students' knowledge acquisition were also inconclusive (Maxwell et al., 2005; Tarhan et al., 2008; Wong & Day, 2009). However, findings from other studies suggests that PBL improves students' higher-order thinking skills (Jerzembek & Murphy, 2013; Liu, Wivagg, Geurtz, ,Lee, & Chang, 2012; Tarhan et al., 2008; Wong & Day, 2009), increases conceptual learning (Vasconcelos, 2012), enhances motivation, learning interest and attitudes (Liu et al., 2012; Marle et al., 2014), improves self-regulated learning (Filcik et al., 2012; Jerzembek & Murphy, 2013; Sungur & Tekkaya, 2006) , and improves collaboration (Kim & Tan, 2013; Tarhan et al., 2008; Vasconcelos, 2012).

PBL improved higher-order thinking skills over an extended time. The study by Wong and Day (2009) investigated the impact of PBL on middle school students' science learning. Two units were chosen for this study: "*Human Reproduction*" and "*Density*." Analyses indicated that PBL was at least as effective as the traditional teaching in students' knowledge acquisition. However, PBL students outperformed students who received lecture-based teaching in their comprehension and application of knowledge acquired from these two units. This improvement in higher-order thinking persisted, as indicated by students' scores on the delayed-posttest, which was administered two months after the completion of the intervention (Wong & Day, 2009).

PBL enhanced students' self-regulatory skills. It has been suggested that in order to be successful in PBL, students need to be self-regulated learners (English & Kitsantas, 2013). Self-regulated learners are meta-cognitively, motivationally, and behaviorally active in their own leaning process (Zimmerman, 1989). Using a quasi-experimental design, Sungur and Tekkaya (2006) examined whether PBL affected 10th graders' self-regulated learning in biology, measured by the Motivated Strategies for Learning Questionnaire (Pintrich, Smith, Garcia, & McKeachie, 1991). They found that PBL significantly enhanced students' motivation in terms of intrinsic goal orientation—they tended to study biology for reasons such as challenge, curiosity, and mastery. Students in the PBL group also placed a higher task value on biology because they perceived it as an interesting, important, and useful course. In addition, students in the PBL group scored higher on using the following learning strategies: elaboration, critical thinking, meta-cognitive self-regulation, effort regulation, and peer learning. That is, PBL enhanced the self-regulatory skills of 10th grade students (Sungur & Tekkaya, 2006).

Using PBL to explore previously unseen academic potential in students. Concerned with the underachievement of students in the lower socioeconomic areas, Gallagher and Gallagher (2013) used PBL to explore the academic potential among 6th graders from two low-income middle schools. Two PBL units that were related to health science and disease, "*Black*

Death" and "*Mosquito Coast*," were used for the study. A total of 271 students participated in the study, twenty of whom were traditionally identified (TI) as gifted.

At the end of intervention, teachers identified students who showed academic potential during the PBL units among students who were not previously identified as gifted. These thirty-four students were termed advanced academic potential (AAP) because they displayed attributes of higher order thinking during PBL even though they did not meet the district criteria for giftedness (Gallagher & Gallagher, 2013). The remaining students were termed general education students. When viewed through the lens of PBL performance, AAP students seemed more similar to the TI gifted students. One plausible explanation for this phenomenon is that PBL created an engaging classroom environment that drew out the learning potential from the students who were not interested in learning with traditional teaching. This hypothesis was supported by the student engagement data that showed the AAP group was substantially and significantly more engaged than either the TI group or the general education students (Gallagher & Gallagher, 2013).

PBL is more effective than traditional teaching for students with limited verbal ability. A study by Mergendoller, Maxwell, and Bellisimo (2006) examined whether PBL in macroeconomics was differentially effective for 12th grade students with limited verbal ability. Both the traditional teaching and PBL students were divided into three groups based on their verbal ability: high, medium, and low. Data showed that the high verbal ability group of the PBL and traditional teaching groups had similar pretest-posttest change (PBL vs. traditional, effect size 0.05). Although not statistically significant, PBL students with medium or low verbal ability had a bigger pretest-posttest change than their traditional learning counterparts (medium verbal group effect size 0.41, low verbal group effect size 0.40). This suggests that while there were no meaningful learning differences by instructional condition for the most verbally proficient students, students whose verbal ability was midrange or below benefited more from PBL. This empirical finding is of particular significance because it indicates the efficacy of PBL instruction for students with limited verbal ability, and verbal ability is considered a key component of cognitive ability measures and highly associated with academic achievement of school-aged children (Kastner & May, 2001). Based on this finding, the authors recommend more research that examines the efficacy of PBL with students who typically have low school performance. They also suggested assessing at risk students by multiple measures and not only their verbal ability.

Summary. It has been close to fifty years since the inauguration of problem-based learning. In addition to medical schools, PBL has been implemented in many other educational settings, including undergraduate and secondary education classrooms. Although the bulk of PBL studies were conducted in medical and nursing education, there is broad support for the conclusion that PBL enhances the affective domain of student learning, improve students' higher-order thinking skills, self-regulated learning, and cultivates longer knowledge retention.

Research also suggests that PBL is differentially effective for students with different characteristics, such as whether they are identified as gifted students or not. This suggests that PBL creates a classroom environment that draws out learning interest from the students who are reluctant learners in a traditional learning environment.

PBL Implementation Issues

PBL uses problems to foster collaborative, self-directed learning, which makes it quite different from traditional instructional methods. Also, in order to reach the full potential of PBL, the curriculum needs to be designed to meet the specific instructional needs and constraints of the students, such as their self-directed learning skills (Hung, 2011). This can be challenging for teachers and students who are unfamiliar with the new responsibilities required by this open-ended learning environment and adjusting to their changing roles. Several factors that play a key role in the success of PBL implementation will be discussed in the following section.

Quality of problems. The quality of the problems has significant influence on student learning in PBL. PBL problem is the vehicle for developing reasoning strategies and constructing knowledge, and a good problem should achieve the learning goals as intended by the curriculum (Sockalingam, Rotgans, & Schmidt, 2012). Sockalingam and Schmidt (2011) conducted a study in which they asked students to pinpoint characteristics of good problems for PBL. From students' perspectives, a good PBL problem should:

- Lead to the intended learning objectives
- Interest students
- Be of suitable format (such as length of text and use of visuals)
- Stimulate critical reasoning
- Promote self-directed learning
- Be sufficiently clear
- Be of appropriate difficulty level
- Be relevant and enable application
- Be familiar to students
- Stimulate elaboration
- Encourage teamwork

Certainly, it requires skill and time to develop problems that meet the above criteria. It is recommended that when teachers implement PBL, they begin by identifying curricular areas in which problems are already embedded (Ertmer & Simons, 2006). Another strategy is to start with "post-hole" problems as a "practice" unit to introduce students to PBL before attempting larger PBL units. Post-holes are short problems that can be used when teachers don't want to design their entire course around problems but do want to use PBL approach occasionally (Stepien & Gallagher, 1993). Not only can post-hole units offer teachers a comfortable entry into the process, they also give students the time and opportunity to build skills required in PBL (Ertmer & Simons, 2006).

Design of the problems. Recognizing the importance of having good problems in PBL, Hung (2006) came up with a 3C3R PBL problem design model. The 3C3R model consists of two classes of components: core components and processing components. The core components—content, context, and connection (3C) —are used to support content/concept learning. Content is important because the acquisition of domain knowledge is the premise for generating solutions to the problem. The content afforded by PBL problems should align with the state or district standards so that PBL does not compromise students' performance on basic knowledge acquisition or standardized tests. The context of the problem is critical because it helps learners link the constructed knowledge and acquired skills to related situations in real life (Hung, 2006). As described by Stepien and Gallagher (1993), "Problem-based learning is apprenticeship for real-life problem solving" (p. 26). The third component of the 3C, connection, is concerned with interweaving problems in the curriculum to guide students to integrate what they have learned into a conceptually sound knowledge base (Hung, 2006).

The processing components of the 3C3R model are researching, reasoning, and reflecting (3R). Researching and reasoning involve using higher order cognitive skills that are essential for problem-solving, and they are generally acquired through training. Guidance and scaffoldings from teachers/facilitators are crucial to keep students from not becoming overwhelmed by the abundance of information and confused by multiple options to solve the problems. Finally, there is the reflecting component which functions as a built-in meta-cognitive guide in the PBL process. Practicing reflection will cultivate students' habit of mind for self-evaluation and developing self-directed learning skills (Hung, 2006). The six components of the 3C3R model are not independent of each other. Rather, they are complementary and mutually supportive of each other, as seen in Table 2.1.

Table 2.1

The Six Components in the 3C3R Problem Design Model (Based on Hung, 2006 & 2009)

Components	Functions & its relationships to other 3C3R components	Issues to be considered
Content	• Meeting curriculum standard • Providing the background for students to identify what they already know and what they need to know in order to solve the problems • Direct students' information research for solving the problem	• Does the scope of the problem support the curriculum standards? • Does the knowledge needed for solving the problem correspond to intended content for the curriculum? • Is the scope of the problem too large and students need to acquire an excessive amount of knowledge that is not within the intended content area to solve the problem?
Context	• Contextualizing the content • Providing a frame of reference which directs students' researching and reasoning processes	• Does the problem provide adequate contextual information to support authentic learning? • Is the problem context relevant to students' lives so they feel motivated to solve the issue? • Is the contextual information sufficiently specific and explicit to direct students' information research?
Connection	• Integrating content • Forming a conceptual framework about the topic • Interweaving content and context	• Are the PBL problems in the curriculum logically and conceptually interconnected to help learners to integrate the domain knowledge? • Are all the concepts and basic knowledge involved in the PBL problem in a curriculum sufficient to form a sound conceptual framework of the subject?
Researching	• Acquiring information that connects with students' prior knowledge and is needed for problem-solving • Supporting reasoning and reflecting processes	• How proficient are the students' information researching abilities? What kind of scaffolding do they need? • Is the information provided in the PBL problem adequate for students' researching abilities and familiarity with PBL?
Reasoning	• Identifying students' prior knowledge • Identifying what students do not know and needs to be researched in order to solve the problem • Examining the different options and generating the most viable solution for the problem • Supporting researching and reflecting processes	• How proficient is the learner's reasoning ability? • How proficient is the learner's ability in evaluating the credibility of, interpreting, summarizing, and organizing the information collected from the search? • Is the information provided in the PBL problem adequate for the student's reasoning ability and familiarity with PBL? • Is the contextual information relevant and interesting enough to stimulate students to be engaged in the reasoning process?
Reflecting	• Examining and evaluating the learning strategies, solution for the problem, and other learning outcomes • Integrating the content, context, researching, and reasoning components; synthesizing the learning experience	• What type of reflective process is more appropriate for the targeted learners (formative, summative, or both)? • Are guidance and scaffoldings provided to students to direct and apply the thoughts from their formative reflection to a more viable problem-solving strategy?

Teachers' role in PBL. One core principle of PBL is that teachers are facilitators instead of knowledge disseminators (Barrows, 1996). A facilitator's goal in PBL is to develop students' thinking and reasoning skills and help them to become independent and self-directed learners who can evaluate their learning and performance (Hmelo-Silver & Barrows, 2006).

This shift requires teachers to undergo a fundamental re-conceptualization of their role in education and to make critical adjustments. In addition, PBL has been perceived as being more time-consuming than traditional teaching, both in terms of planning and implementation, which adds stress to teachers who try to meet the requirements of a mandated curriculum and pacing guide, all of which can very well dampen teachers' desire to use PBL (Ertmer & Simons, 2006). Some issues that a PBL facilitator should pay attention to and prepare for will be discussed below.

Teachers' scaffolding is essential for students to acquire self-directed learning skills and construct knowledge. Miflin (2004) argued that it is flawed to assume that leaving control of the learning to students will inevitably lead to the development of their self-directed learning ability. In other words, for students who are new to PBL, self-directed learning should be the goal, instead of the process of PBL (Miflin, 2004). Teachers need to recognize that successful PBL implementation is critically dependent on the facilitator's scaffolding of students' active learning skills and knowledge construction at the appropriate time (Allen et al., 2011). Instructional scaffolding is an effective tool to support learners in complex or unfamiliar environments such as PBL, and enables them to deal with the complexities of a task while simultaneously learning how to work independently in the domain (Ertmer & Simons, 2006).

Scaffolding may take multiple forms, which range from handouts given to students before the lesson starts to giving timely support, such as conferencing with students who have difficulties during the class (Ertmer & Simons, 2006). When deemed necessary, teachers can plan for intervals of class debriefings or mini-lectures to help students navigate conceptual impasses (Allen et al., 2011; Pecore & Bohan, 2012).

Teachers provide a classroom culture for collaborative and reflective learning. Collaborative learning is another essential element for PBL. It allows students to draw on each other's talents in order to come up better solutions for the problem at hand. Yet, collaborative learning does not happen by itself and effective guidance of group processing from the facilitator is necessary (Hung et al., 2008). Facilitators can help students build on one another's knowledge by modeling how feedback and constructive criticisms are given, guiding groups of students to set appropriate learning goals, and assisting them to identify and integrate learning issues (Goh, 2014; Hung et al., 2008).

Students' reflective thinking ability is important for their understanding of a problem and acquiring the new knowledge needed to solve the given problem. If students lack these reflective-thinking skills, the PBL environment can be chaotic and frustrating rather than supportive of the construction of meaningful knowledge (Song, Grabowski, Koszalka, & Harkness, 2006). However, learners generally tend to focus on the task rather than on conceptual understanding of the key principles and do not pay enough attention to reflection (Ertmer & Simons, 2006). In order to help students to be reflective about their learning process, teachers can provide regular feedback and establish clear criteria so that students can evaluate themselves. Facilitators also need to draw attention to misconceptions and weak reasoning so that students can address them (Goh, 2014).

Teachers design assessments that evaluate students' achievement of PBL objectives and their readiness for standardized tests. Assessment is probably one of the most controversial issues in PBL because of the disparity between the constructivist framework of PBL and classroom realities (Savin-Baden, 2004). This is particularly true for K-12 teachers who are accountable for students' performance on high-stakes standardized tests. Pedersen, Arslanyilmaz, and Williams (2009) examined how ten 6^{th} grade science teachers from four middle schools assessed their students' learning in PBL. All ten teachers used Alien Rescue (Liu, Williams, & Pedersen, 2002), an award-winning computer-based PBL program for middle school science. The teacher's manual for Alien Rescue contained suggestions and materials for assessment, including: worksheets, program artifacts, students' solutions, a factual knowledge test, and a problem-solving transfer test.

Teachers' assessment practices varied. However, they all used multiple data sources to assess student learning and conducted both graded and ungraded assessments. Eight teachers used the objective, multiple-choice test that was included in the manual to assess their students' learning, compared with only one teacher who assessed students' collaboration and only one teacher who assessed students' problem-solving ability by using the problem-solving transfer test contained in the teacher's manual (Pedersen, Arslanyilmaz, & Williams, 2009).

The authors found that one prime factor that drove teachers' assessment decisions was pressure related to students' performance on standardized tests. Teachers also used grading practices as an extrinsic motivator because they felt that students expected to be graded and needed this extrinsic motivator even though they were highly motivated while working on Alien Rescue. Teachers also stated that their assessment practices were influenced by the perceived pressure from school administrators to effectively teach a curriculum that met state and district standards. In addition, using multiple-choice tests for assessment appeared more objective than assessing a product holistically (Pedersen et al., 2009).

It is very challenging for teachers to design an assessment which evaluates whether students meet the learning objectives of the PBL process and in the mean time measures students' readiness for standardized tests. One compromise is to conduct ungraded, formative assessment through observing and interacting with students, as the Alien Rescue teachers did. Using information from formative assessment, teachers can make instructional decisions that support students' needs at that time, as formative assessment is "assessment *for* learning, not assessment *of* learning" (Trauth-Nare & Buck, 2011, p. 35). Depending on students' intellectual and emotional readiness, teachers might even consider letting students self- or peer-assess their work and identify aspects they have done well and those they need to improve (Trauth-Nare & Buck, 2011).

Students transition from traditional learning to PBL. The transition from the traditional passive learning to PBL, in which students take charge of their own learning, is challenging and can cause discomfort among students. Feelings of uncertainty about their roles in PBL and how they will be evaluated could further deepen students' feeling of anxiety about PBL (Hung et al., 2008). Students, particularly those who have had little or no experience with PBL, tend to rely heavily on teachers'/facilitators' guidance and/or information and can even become frustrated (Vasconcelos, 2012). In response to this frustration, teachers might be tempted to revert back to their teacher-directed strategies and provide information to students (Ertmer & Simons, 2006). This can be particularly problematic for teachers who are not as familiar with PBL (Vasconcelos, 2012).

As discussed earlier, for students who are new to PBL, self-directed learning is the goal instead of the process of PBL (Miflin, 2004). In order to achieve this goal, students will need a certain level of structure in their learning. For example, Armbruster et al. (2009) found that students ranked the explicit learning goals presented at the beginning of each lesson as the most helpful element for their learning in PBL. Although PBL students recognize that they should direct their own learning, it is not uncommon for them to resist that responsibility (Tarhan et al., 2008). Sometimes teachers have to push students out of their comfort zone in addition to persistently providing them with scaffolds (Chin & Chia, 2006).

Another aspect of PBL that students often have difficulties with is evaluating the credibility of evidence in order to construct an evidence-based solution for the problem at hand (Dawson & Venville, 2009; Nicolaidou, Kyza, Terzian, Hadjichambis, & Kafouris, 2011). Not knowing what constitutes valid evidence, students tend to treat all information as equally credible, or just mention the supporting information without justification (Nicolaidou et al., 2011). A study was conducted (Nicolaidou et al., 2011) to examine how training provided by teachers and a computer program would develop high school students' capacity to evaluate the information credibility, based mainly on the following criteria:

1. The ability to critique the source of the information: Ask questions such as "Was the information from experimental research or an opinion-based article?" and "Was the information from a peer-reviewed journal article or from a weblog?"
2. The ability to evaluate the methodology used to obtain the information: Students need to think about questions such as "Were the data obtained from a study that included control and experimental groups?" and "Was the study repeated and were results replicable?"

Students took pre- and post-tests that assessed their ability of evaluating the credibility of information. Data showed that students who received the training had substantial and significant improvement in their ability to evaluate the credibility of information. On the other hand, the information evaluation ability of students in the control group remained the same, judged by their pre- and post-test scores. This study indicated that scaffolding and training would improve students' ability in evaluating information credibility (Nicolaidou et al., 2011).

Summary. In order to implement PBL successfully, it is important to understand the characteristics of the three key elements in PBL: problems, teachers/facilitators, and students (Sockalingam, & Schmidt, 2011). Problems are used to initiate students' learning in PBL and good PBL problems should lead to intended learning goals, trigger interest and activate students' prior knowledge, stimulate critical reasoning, and be of appropriate difficulty. It is recommended that teachers begin PBL by using short, "post-hole" units which are easier for teachers to prepare and can be used to introduce students to the problem-based pedagogy.

In PBL, teachers play a very different role compared with that in traditional teaching. Instead of directly transmitting information to students, the main goals of teachers in PBL are facilitating students' developing of reasoning skills that promote critical thinking and problem solving, as well as helping them to become self-directed, reflective learners (Hmelo-Silver & Barrows, 2006). In order to accomplish these goals, teachers use scaffolds to initiate students' inquiry and maintain students' engagement (Ertmer & Simons, 2006; Miflin, 2004). Teachers also help students to integrate concepts and create a classroom culture for collaborative and reflective learning (Hung et al., 2008).

Assessment for PBL is another major challenge for teachers. Ideally PBL assessment should be used to evaluate students' progress in problem solving, higher-order thinking, and application and transfer of the knowledge learned. However, teachers often face pressure from school administrators to prepare students for high-stakes, standardized tests. There is no easy solution for this dilemma and teachers might have to devise the best compromise for each individual situation (Pedersen et al., 2009; Savin-Baden, 2004).

Finally, students also experience great challenges when moving from traditional instructional methods to PBL. They are no longer passive information receivers. Instead, students are initiators of their own learning, the inquirers and problem solvers during the learning process. Students definitely need teachers' guidance and scaffolding, both in terms of conceptual change such as redefining their roles in the learning process and retuning their learning habits (Hung et al., 2008; Miflin, 2004), and building skills such as evaluating the credibility of information used to support their problem solving (Nicolaidou et al., 2011).

It is obvious that a successful execution of PBL requires a lot of effort, particularly from teachers, in terms of both planning and implementation (Ertmer & Simons, 2006). A student-centered learning environment, such as PBL, also inevitably puts a broader set of management responsibilities on teachers than the traditional learning environment does. However, it is important to note that not only does PBL have the potential to improve students' critical thinking ability and cultivate them to become self-directed learners, but teachers can also benefit from this pedagogy (Ribeiro, 2011).

In Ribiero's (2011) study, teachers recognized that there were pros and cons in teaching with PBL. Implementing PBL required more time from teachers compared with teaching in traditional ways. Teachers also felt that implementing PBL increased the probability of losing control in terms of covering the syllabus. In the meantime, teachers found that PBL made classes unique, exciting and intellectually challenging. PBL also provided an important learning opportunity for teachers and contributed to their professional development. These pros and cons either positively or negatively impact teachers' motivation of implementing PBL. Motivation is a complex construct and will next be examined through the lens of expectancy-value theory and self-determination theory.

Expectancy-Value Theory

Teachers' motivation to implement PBL. The contemporary expectancy-value theory (EVT) by Eccles et al. (1983) has emerged as a model to predict and understand individuals' motivation for achievement-related behavior choices such as sustained enrollment in STEM courses (Abraham & Barker, 2014; Anderson & Ward, 2014; Bøe, 2012; Bøe & Henriksen, 2013) and implementation of innovative pedagogies (Foley, 2011; Meyer, Abrami, Wade, & Scherzer, 2011; Wozney, Venkatesh, & Abrami, 2006). In essence, the expectancy-value theory states that people's achievement performance, persistence, and activity choices are most directly linked to their expectancy-related and task-value beliefs (Eccles et al., 1983; Wigfield & Eccles, 2000).

Based on Eccles' EVT model, individuals are more likely to adopt an innovation if they perceive themselves to have high ability and are likely to succeed in implementing the innovation, place high value in the innovation, and consider that the benefits from implementing the innovation outweigh the cost (Wozney et al., 2006). Therefore, teachers' intention to adopt an innovation, such as PBL, in their classrooms depends on (1) how likely they perceive that they will be successful in implementing PBL; (2) how highly they value PBL; and (3) how much they think the adoption of PBL will cost them.

Expectancy for success. Expectancies of success are defined as "individuals' beliefs about how well they will do on upcoming tasks" (Eccles & Wigfield, 2002, p.119). It is most directly influenced by students' self-concept of their ability in a given domain and their estimate of task difficulty, which is shaped by individuals' interpretations of past success and failure, inputs from culture, and socializers such as parents, teachers, peers, and siblings (Eccles et al., 1983). Ability beliefs focus on an individual's belief of his/her current competency at certain tasks, thus conceptually distinguished from expectancies for success which focus on the future. However, these two constructs (ability beliefs and expectancies of success) are highly related and have been used interchangeably (Eccles, 2009; Eccles & Wigfield, 2002; Wigfield & Eccles, 2000). Wigfield and Eccles (1992) suggested merging the two constructs because they are empirically indistinguishable in real-world achievement situations.

Expectancies of success in achievement situations share conceptual and empirical similarities with self-efficacy (Bong, 2001; Meece, Wigfield, & Eccles, 1990), which is a major player in individuals' motivation and achievement goals (Zimmerman, 2000; Zimmerman, Bandura, & Martinez-Pons, 1992). Indeed, expectancy beliefs are measured in a way analogous to measures of Bandura's self-efficacy expectations (Eccles & Wigfield, 2002; Wigfield & Eccles, 2000). In various studies, expectancies have been assessed by asking participants how well they expect to perform on a specific task (Abraham & Barker, 2014; Anderson & Ward, 2014; Guo, Marsh, Parker, Morin, & Yeung, 2015; Liem, Lau, & Nie, 2008; Peters & Daly, 2013).

Subjective task value. Theories of self-efficacy provide powerful explanations of individuals' motivation to achieve (Nugent et al., 2015; Richardson, Abraham, & Bond, 2012; Zimmerman, 2000). However, self-expectancy alone is not enough to explain why people choose to engage in certain tasks. Even if people are confident that they can do a task, they might not have a strong desire or compelling reason to do it. The subjective task value component of EVT can shed some light on this aspect.

Building on Battle's (1965, 1966) work on achievement-related values and Deci's (1972) research on intrinsic and extrinsic motivation, Eccles et al. (1983) defined three subjective task values that can influence individuals' achievement behaviors: attainment value, intrinsic value, and utility value. Subjective task value is determined by both the nature of the task and individuals' needs, value, and identity. As Eccles (2009) stated, "subjective task value is directly related to personal and collective/social identities and the identity formation processes underlying the emergence of these identities" (p. 82).

Attainment value. Attainment value is defined as the importance of doing well on a given task, which refers to how well making a certain choice fits with an individual's identity. People will attribute higher value to choices that are consistent with their identities and offer opportunities to them to fulfill their long-range goals (Eccles, 2009). Attainment value is affected by individuals' self-schema, such as masculinity, femininity, and/or competence in various domains. An individual will place higher attainment value on a certain task if the accomplishment of it identifies with and enhances the individual's self-schema (Eccles & Wigfield, 2002; Wigfield & Eccles, 1992).

Intrinsic value. Intrinsic value is the enjoyment one anticipates gaining from performing the activity (Wigfield & Eccles, 1992). This value component is similar to the construct intrinsic motivation, as defined in the self-determination theory (SDT) by Ryan and Deci (2000a). Intrinsic motivation is a natural motivational tendency that exercises one's capacity to explore and learn, even if there is no external reward for conducting the activity. It is a critical element for individuals' cognitive, social, and physical development (Ryan & Deci, 2000a). Individuals who are intrinsically motivated for a certain task typically show more interest and confidence compared to people who are externally pressured for the action. This intrinsic motivation is manifested as enhanced performance, persistence, and creativity (Ryan & Deci, 2000b).

Utility value. Utility value or usefulness refers to how helpful a certain task is in reaching current and future goals, such as career objectives (Wigfield & Eccles, 2000). A choice that facilitates an individual's future goals has utility value even if the individual is not interested in the task for its own sake, and thus can be considered an extrinsic motivation (Eccles & Wigfield, 2002; Ryan & Deci, 2000a). For example, students might take an advanced math class to fulfill a requirement for a science degree even if they have no interest in the subject.

Cost. Finally, cost is conceptualized as the perceived drawbacks of engaging in a task (Eccles et al., 1983). Eccles et al. (1983) first introduced costs as a mediator that could affect an individual's overall value for a task, which is a function of attainment, utility, and intrinsic values. However, in their subsequent writing, cost was considered as one of four sub-components of value and weighed as a cost/benefit analysis to determine the overall value (Eccles & Wigfield, 2002; Wigfield & Eccles, 1992, 2000). For example, a teacher may consider implementing PBL as important for his/her professional growth (value) but in the meantime is concerned about the extra time and effort that he/she will have to put into it (cost). Both the value and cost factor will play a role in determining the overall value of implementing PBL to this teacher.

There are three dimensions of cost: perceived effort, opportunity cost, and psychological cost of failure (Eccles et al., 1983). Perceived effort is described as the minimal amount of effort needed to succeed on a task, given the individual's estimate of his/her ability and the difficulty of the task. Effort cost would be considered high if the anticipated benefit is not perceived to be worth the effort. Opportunity cost means the loss of valued alternatives caused by an individual's engagement in a particular task. Finally, psychological cost of failure is described as the anxiety related to the potential of failure at the task (Eccles et al., 1983).

Expectancy and value were used to predict individuals' achievement-related behaviors. Using EVT as the theoretical construct to examine students' motivation has a long history in education research (Wigfield & Cambria, 2010). Expectancy for success and value positively predicted students' choice of activities, retention intentions, and performance. (Abraham & Barker, 2014; Durik, Vida, & Eccles, 2006; Foley, 2011; Guo et al., 2015; Meece et al., 1990; Trautwein et al., 2012; Wang, 2012). Studies indicated that students' expectancy for success and subjective task values they placed on the activity are positively correlated (Abraham & Barker, 2014; Meece et al., 1990; Trautwein et al., 2012; Wigfield & Eccles, 1992). In addition to being positively correlated, expectancy for success and subjective task values interact with each other and the multiplicative term Expectancy x Value plays a role in predicting achievement-related behaviors (Guo et al., 2015; Nagengast et al., 2011; Trautwein et al., 2012).

Furthermore, studies have found that students' expectancy and value beliefs have long term consequences. Durik, Vida, and Eccles (2006) reported that self-concept of ability and task importance, a combination construct of attainment and utility values that students gave to reading in 4th grade, predicted the number of language arts courses they took in high school. Students' interest in reading measured in 4th grade also predicted (indirectly, through interest measured in 10th grade) their high school leisure time reading and the number of language arts courses taken by them (Durik, et al., 2006). Simpkins, Davis-Kean, and Eccles (2006) also found that students' self-concept of ability in math and science while they were in 6th grade positively predicted their grade in math and science when they were in 10th grade.

Adding cost to the equation. Despite the theoretical importance of cost in the EVT model, historically it has been the least studied value component of empirical research within the expectancy-value framework (Wigfield & Cambria, 2010). Recently, more studies have incorporated cost as a negative value component in the task value construct (Anderson & Ward, 2014; Conley, 2012; Chiang, Byrd, & Molin, 2011; Trautwein et al., 2012). Data also revealed that cost deserved to be an individual factor, which was distinct from the other value scales (Chiang et al., 2011; Conley, 2012). The equation from the study by Wozney, Venkatesh, and Abrami (2006) described the relationship between the three elements of EVT: (expectancy) + (value) – (cost) = achievement-related behaviors.

Two studies (Flake, Barron, Hulleman, McCoach, & Welsh, 2015; Perez, Cromley, & Kaplan, 2014) specifically examined the cost construct in depth. The study by Perez, Cromley, and Kaplan (2014) investigated the impact of the three variables—competence beliefs, value, and cost—on college student's STEM retention intentions. Students' perceived cost influenced their STEM retention intentions above and beyond their competence and value beliefs. Additionally, the three cost variables (effort, opportunity, and psychological) also differentially affected their retention intentions, thus supporting the multidimensional nature of the construct. Finally, Flake, Barron, Hulleman, McCoach, and Welsh (2015) developed an EVT-based survey instrument which included a multi-dimensional cost component. Data from factor analysis showed that the cost subscales were highly correlated with one another. Also, each of the three subscales of cost had a significantly negative correlation with expectancy and value (Flake et al., 2015).

Self-Determination Theory

Intrinsic and extrinsic motivation. The self-determination theory (SDT) by Ryan and Deci (2000b) assumes that humans are by nature motivated to develop "an ever more elaborated and unified sense of self" (Ryan & Deci, 2002, p.5). That is, people are innately curious, eager to learn, and seek coherence in one's knowledge and values (Niemiec & Ryan, 2009). Through this process of personality development and behavioral self-regulation, people connect with other individuals in their social worlds and fulfill their fundamental psychological needs. However, motivation is not a unitary phenomenon. People not only have different amounts, but also different kinds of motivation, and the type of motivation is generally more important than the amount in predicting life's important outcomes (Deci & Ryan, 2008).

The most basic distinction of motivation is between intrinsic and extrinsic (Ryan & Deci, 2000a). When intrinsically motivated, people engage in activities because they find the activities interesting or enjoyable, and experience positive feelings from doing the activities even when there are no external rewards attached. To the contrary, extrinsically motivated individuals perform an action because it leads to a certain consequence, such as to obtain a tangible reward or to avoid a punishment. From the time of birth, children are intrinsically motivated to explore the environment and this natural inclination is essential to cognitive, social, and physical development, and an individual's well-being. Compared with people who are externally controlled for an action, individuals whose motivation is intrinsic typically have more interest and confidence in the task, which in turn is manifested as enhanced performance (Hayenga & Corpus, 2010), engagement (Walker, Greene, & Mansell, 2006), persistence (Duncan, Hall, Wilson, & Jenny, 2010), and creativity (Ryan & Deci, 2000b; Zhang & Bartol, 2010).

Deci, Koestner, and Ryan (1999) conducted a meta-analysis that examined the effects of extrinsic rewards on intrinsic motivation. Rewards that were contingent upon people engaging in, completing, or performing well on tasks tended to undermine people's intrinsic motivation for those tasks. The researchers postulated that the potential controlling effects of extrinsic rewards could have forestalled people taking responsibility for self-regulation and had negative impacts on individual's feeling of autonomy, a fundamental psychological need, therefore reducing their interest in the activity. However, most of the activities people participate in are not intrinsically motivated. This is particularly true as people grow from children to adults and are required to perform non-intrinsically interesting tasks in order to fulfill responsibilities or adapt to the social norms (Ryan & Deci, 2000a). The division of motivation into a dichotomy as intrinsic or extrinsic does not fully explain why people place various values and self-regulate for different activities.

Internalization of extrinsic motivations. Based on SDT, the real question lies in how much choice or self-determination people have when they are motivated to perform certain activities. People can feel autonomous while being extrinsically motivated, provided they have internalized and integrated the motivation within themselves (Deci & Ryan, 2008). SDT proposes three levels of internalized extrinsic motivation and the least effective type of internalization is referred to as *introjection*. It involves people taking in an external demand or regulation but not accepting it as their own. The second type of internalization is *identification.* When people identify with an external demand, they recognize the importance and value of the behavior and willingly accept responsibility for regulating the behavior. Finally, the fullest type of internalization is called *integration* in which people bring the identified extrinsic motivation into congruence with their other values and needs, and transform the regulation into their own (Deci & Ryan, 2008; Ryan & Deci, 2000a). At the integration level, people experience self-determination or autonomy similar to what they experience when doing an intrinsically motivated activity.

SDT proposes that between intrinsic motivation (autonomous) and extrinsic motivation (controlled) there lies a continuum of internalized extrinsic motivation types reflecting various degrees of self-determination. The concept of internalization in SDT shifted motivation from a dichotomy of intrinsic versus extrinsic to a more dynamic and fluid construct that examines motivation from the lens of self-determination (Deci & Ryan, 2008; Ryan & Deci, 2000a). For example, a teacher could be motivated to perform an uninteresting activity such as adopting an educational innovation if he/she is given a reason (an extrinsic motivation) for conducting this activity along with freedom of choice and support for his/her sense of self-determination.

Social contexts that maintain intrinsic motivation and promote internalization. Humans are endowed with intrinsic motivations to seek out novelty and challenges, to explore and to learn. However, these motivations can be either facilitated or undermined by social and environmental factors (Ryan & Deci, 2000a, 2000b, 2002). SDT postulates that humans have three fundamental psychological needs: the need for autonomy, competence, and relatedness (Ryan & Deci, 2000a, 2000b, 2002). Social environments that facilitate satisfaction of these basic needs are crucial for an individual maintaining intrinsic motivation. Additionally, social contextual conditions that cultivate individuals' feelings of competence, autonomy, and relatedness will also facilitate the internalization and integration of extrinsic motivations and promote positive psychological, developmental, and behavioral outcomes (Ryan & Deci, 2000a, 2000b, 2002). In contrast, social climates that thwart satisfaction of these needs undermine intrinsic motivation and internalization of extrinsic motivation, and negatively affect people's behavior and development (Ryan & Deci, 2000a, 2000b, 2002).

Using SDT to understand teachers' motivations to initiate innovations. Researchers have used SDT as the theoretical framework to examine what motivates teachers to initiate innovations. Gorozidis and Papaioannou (2014) investigated 218 high school teachers' motivation and intentions to participate in a non-mandatory training and teaching of an innovative academic subject. The motivation instrument consisted of four subscales: intrinsic, identified, introjected, and external motivation. Results showed a strong correlation between intrinsic motivation and identified regulation and they were grouped together as "autonomous motivation". The introjected regulation and external regulation were also significantly related and thus grouped as "controlled motivation" (Gorozidis & Papaioannou, 2014).

It was found from this study that only teachers' autonomous motivation to participate in the training program significantly predicted their intention to attend training seminars and teach the subject in the future. This finding is significant because of the role that "identified regulation" played on teachers' motivation to receive training and initiate innovation in the classroom. As discussed earlier, when people identify with an external demand, they recognize the importance and value of the behavior and willingly accept responsibility for regulating the behavior.

In this study, identified regulation was addressed by questions such as "I consider my training important for the academic success of my students" (Gorozidis & Papaioannou, 2014, p. 4) and interview statements like "The main reason is personal development, to be able to respond in the best possible way to teach this course" (Gorozidis & Papaioannou, 2014, p. 6). These results indicate that teachers feel autonomously motivated when they recognize the importance of an innovation. In other words, they feel motivated when they see the attainment value of the action, whether they are intrinsically interested in it or not.

The study conducted by Sørebø, Halvari, Gulli, and Kristiansen (2009) also used SDT as the framework to examine what motivated a group of 430 teachers to continue the use of e-learning technology. They assessed teachers' perceived autonomy, competence, relatedness, intrinsic motivation, identified extrinsic regulation, and intention to continue the use of e-learning. Identified extrinsic regulation was addressed by questions that specified the usefulness of e-learning such as "Overall, e-learning is useful in my educational work" and "Using e-learning increases my productivity as a teacher" (Sørebø, Halvari, Gulli, & Kristiansen, 2009, p. 1182).

What they found was (1) Teachers' perceived autonomy had a positive impact on their intrinsic motivation toward the use of e-learning, but did not influence their perceptions of the usefulness of e-learning, (2) Teachers' perceived competence had a positive impact on their level of perceived usefulness and intrinsic motivation to continue the use of e-learning, and (3) Teachers' perceived relatedness neither influenced their level of perceived usefulness nor their level of intrinsic motivation toward the use of e-learning. These results indicate that teachers' perceived competence enhanced their intrinsic motivation and facilitated the internalization of their extrinsic motivation to use e-learning. However, teachers' perceived autonomy had a positive impact only on their intrinsic motivation while teachers' perceived relatedness neither influenced their intrinsic nor their extrinsic motivation to use e-learning.

In addition, teachers' level of intrinsic motivation and their perceptions of the usefulness of e-learning had a significant positive correlation with their level of satisfaction with and intention to continue the e-learning usage (Sørebø et al., 2009). If we interpret this with the terminology of EVT, it suggests that the intrinsic value and utility value that teachers place on e-learning significantly predict their intention to continue using this innovative pedagogy.

Personal factors such as congruence between the innovation and teachers' perceived value (attainment, intrinsic, and utility) of the innovation play a big role in teachers' motivation to initiate an innovation, as described by the two studies above. In addition, school environment can also enhance or hamper teachers' motivation, depending on whether the environment supports teachers' innate needs for autonomy, competence, and relatedness. In order to assess the influence of school support on teachers' motivation to persist in project-based learning, an innovative pedagogy, Lam, Cheng, and Choy (2010) conducted a study. They investigated 182 teachers' perceived school support, motivation, and their willingness to continue with project-based learning in their schools.

This study used two inventories; one was for the measurement of school support and the other one was used to assess teachers' motivation (Lam, Cheng, & Choy, 2010). The school support inventory included three subscales: competence support, autonomy support, and collegial support. The motivation inventory consists of four subscales: external regulation, introjected regulation, identified regulation, and intrinsic motivation. Data revealed a positive correlation between teachers' intention to persist in doing project-based learning and high self-determined motivation (intrinsic and identified), and teachers with a high level of external motivation had a negative attitude toward using project-based learning in the future.

Teachers' willingness to continue with project-based learning was also influenced by their perceived school support, both directly and indirectly. When teachers perceived their schools as being strong in collegiality and supportive of their autonomy and competence, they were more willing to continue with project-based learning in their schools. School support also indirectly facilitated teachers' desire to continue with project-based learning through its positive influence on teacher motivation. As teachers' motivation is essential for the implementation of educational innovations, these findings are valuable to school administrators in terms of what to do to promote teachers' willingness to be part of the innovation.

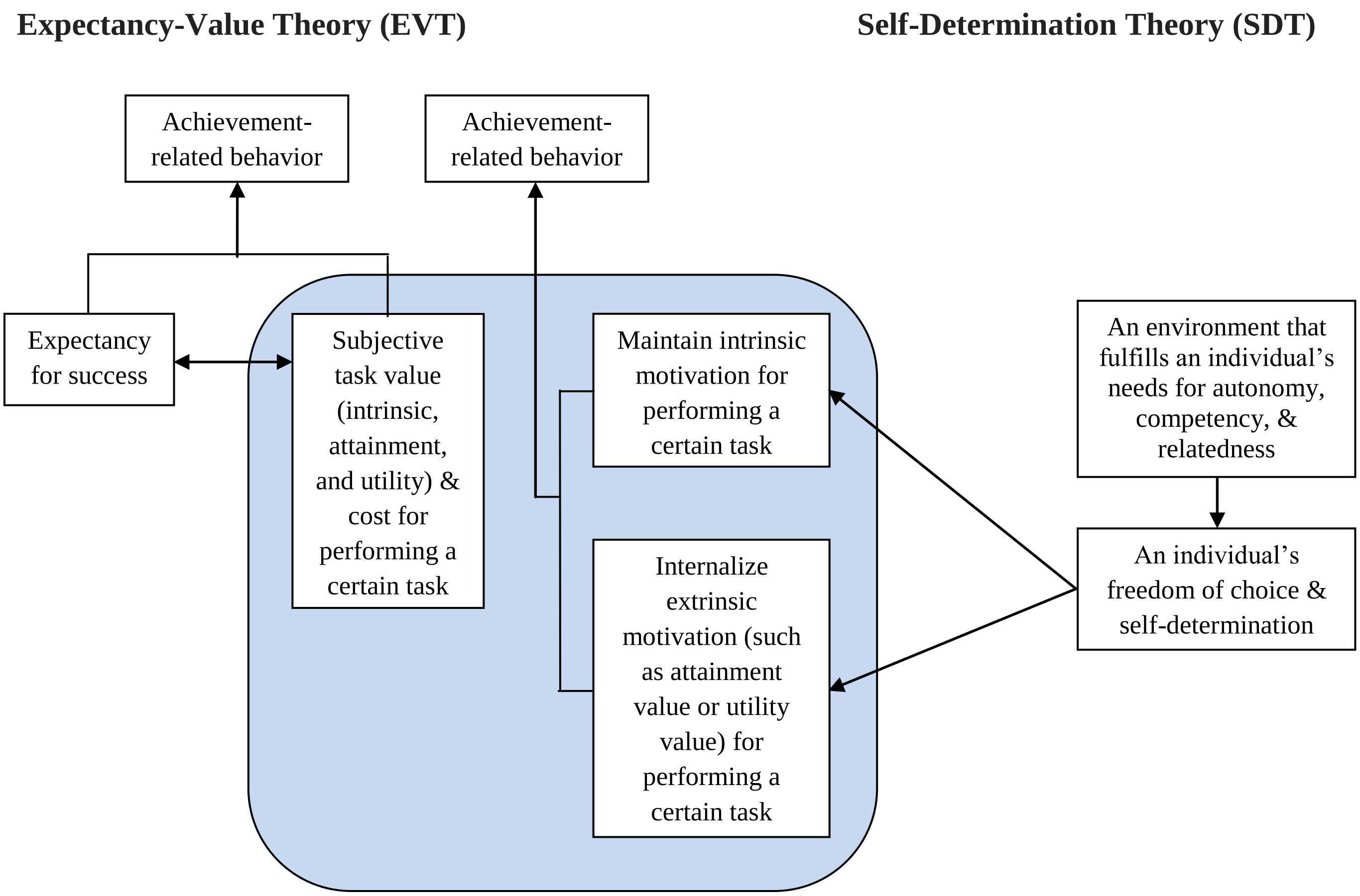

Figure 2.1. Expectancy-value theory and self-determination theory complement each other.

As shown in Figure 2.1, EVT postulates that individuals are motivated to participate in a certain task if the individual is interested in performing the activity (intrinsic value), or perceives the accomplishment of this task is either important (attainment value) or useful (utility value) to him/her. Based on SDT, these values belong to two categories, intrinsic and extrinsic (attainment & utility value). A task which has only extrinsic value to an individual can still be motivating if the individual is empowered with self-determination to choose to work on this task, through a process called "internalization." SDT also proposes that people are inclined to maintain their intrinsic motivation and internalize their extrinsic motivation in an environment that satisfies people's innate needs for autonomy, competence, and relatedness. Therefore, SDT brings another important factor, an environment that facilitates people's self-determination, into the complex picture of motivation.

Summary

In order to enhance students' long-term interest in learning science and engaging in science-related issues, science education curricula needs to provide students opportunities to actively participate in authentic activities. That is, for participants to be involved in collaboratively setting the goals of their activities and the division of labor, decide the strategy, and choose tools to construct knowledge. The goal is to enable students not only to acquire scientific knowledge, but also be able to appreciate the usefulness of science to life, through active participation in authentic science-related activities. Based on this concern, alternative science education instructional methods have been developed, one of which is problem-based learning (PBL), which uses an authentic problem to initiate and anchor a student-directed, active learning process.

PBL is radically different from traditional teaching in which students passively receive information from teachers. In order to cultivate students' ability in problem-solving and self-directed learning, PBL requires teachers to design relevant and authentic problems that trigger students' interest and promote their higher-order thinking skills. In PBL, teachers function as facilitators who provide scaffolding to students and guide them in analyzing problems, identifying research strategies, critiquing the information credibility, and working collaboratively with peers. The assessment is particularly challenging because not only do teachers need to evaluate students' progress in all of the essential PBL learning components as mentioned above, they are also required to assess students' learning of content knowledge according to state and district standards. After all, teachers are accountable for students' performance on high-stake standardized tests.

It is clear that a key factor for success of PBL is to have motivated teachers who are eager to learn and practice the pedagogy. The question is: What motivates teachers to take the challenge of getting trained for and implementing PBL?   Motivation is a complex construct and multiple theories about it have been developed by investigators and supported by research data. Two theories that have been used to examine and understand people's motivation, EVT and SDT, will form the theoretical framework for the current study.

EVT is described as a "…theory [that] incorporates both a consideration of personal motives and personality disposition to demonstrate how identity shapes values, goals, and subsequent behaviors and decisions" (Magidson, Roberts, Collado-Rodriguez, & Lejuez, 2014, p. 1446).   EVT provides three constructs to predict individuals' motivation and behavioral choices. The first two are expectancy for success and the value individuals associate with certain tasks. The third one is cost, which historically has been viewed as a negative-value component. However, based on more recent findings, cost will be considered as a separate construct in the present study. Empirical studies have demonstrated that expectancy for success and value (attainment, intrinsic, and utility) are positively related and interact with each other, thus predicting individuals' performance, intention, choice of activity, and other achievement-related behaviors, synergistically. On the other hand, the cost component is negatively correlated to expectancy, value, and motivation.

SDT proposes that human beings are naturally inclined to learn from exploring and interacting with the environment and this intrinsic motivation is essential for our cognitive, psychological, and physical development. Even when the intrinsic motivation is absent, people tend to internalize the extrinsic motivations if they recognize the importance or usefulness of certain action and act on it, if they are provided with the freedom of choice and self-determination. This is an important concept and provides a perspective for why people are motivated to perform certain activities that carry attainment or utility value but are not necessarily intrinsically motivating to them. SDT also emphasizes the importance of the social context where people live. An environment that meets people's need for autonomy, competence, and relatedness will enhance their intrinsic motivation and internalization of their extrinsic motivations. On the other hand, an environment that thwarts those needs will have a dampening effect on these motivations.

Utilizing the expectancy-value theory and self-determination theory model helps researchers to gather knowledge about what motivates individuals to engage in or stay away from certain behaviors in a specific context, such as teachers' implementation of PBL in secondary education classrooms. This knowledge has potentially important applications in building an environment which provides administrative and collegial support to teachers and fulfills their needs for autonomy and competence, and ultimately enhances teachers' desire to participate and persist in implementing PBL.

The literature review disclosed the nature of PBL, its implementation in different educational settings and the positive changes it could bring to learning and teaching. We also see the various implementation issues that have to be dealt with if teachers want to adopt this innovative, promising, yet challenging pedagogy. Knowledge about what motivates teachers to invest their resources in implementing PBL will help administrators to develop strategies to support teachers in this endeavor. However, there is a shortage of this sort of study in the literature. This study will make a contribution, by providing educators and administrators useful information that can be used to promote PBL implementation.

CHAPTER THREE

METHODS: DEVELOPMENT AND VALIDATION OF THE SURVEY

The goal of this quantitative study is to find out secondary teachers' perceptions of problem-based learning (PBL) and what factors motivate them to adopt, or not to adopt, this innovative pedagogy.

Overview of Survey Development

This study sought a quantitative approach to investigate motivational factors that mediated secondary education teachers' implementation of PBL. First, a literature review about the use of PBL in secondary education classrooms was conducted in order to understand teachers' implementation of PBL, its impact on students' learning, and the issues that teachers had to overcome in classroom context. Information from this review helped to develop questions that measured teachers' conceptions and concerns about PBL implementation. Next, research studies grounded in expectancy-value theory (EVT) and self-determination theory (SDT) were reviewed. The survey questions used in some of those studies (e.g., Eccles & Wigfield, 1995; Lam et al., 2010; Wozney et al., 2006) provided examples for incorporating the relevant aspects of the EVT and the SDT into the survey instrument, such as expectancy for success, value, cost, autonomy and support, into the instrument.

The initial version of the instrument was first validated with content experts, revised, and then piloted with a small number (n = 6) of teachers (secondary science, mathematics, social studies, and elementary). One content expert recommended that a definition of problem-based learning in the instrument be included as a reference for respondents. Another expert suggested to consistently use first-person questions for all items, as the original version employed a mixture of first-person and second-person questions. After edits were made, the survey was then administered to the study participants who taught middle or high schools in the targeted southeastern state. Teacher participants were asked to respond to questions that assessed their conceptions of PBL, expectancy for success, value, cost, autonomy, competence, and collegial support that they associated with implementing PBL. In addition, a few open-ended questions were included in this instrument to acquire in-depth information about teachers' experience of and training needs for PBL. The results were statistically analyzed to examine whether that teachers' conceptions impacted their intention to practice PBL.

Participants

There were two groups of participants. The first group included middle and high school teachers in a southeastern state of the US. Although there was high interest by the researcher in the teachers of science and their use of PBL, the participants of this study were not limited to science teachers for the following two reasons: (1) PBL is interdisciplinary because the problems used are relevant to many disciplines and real life applications, and (2) A wide range of subjects are well suited to use PBL, which has a strong focus on language, and limiting the study to science only could keep us from fully understanding its broader use by teachers of many disciplines (Edens, 2000; Hung, 2011). The second group of participants included middle and high school administrators from the same geographical areas as those of the teachers.

Development of the Instrument

Questions from surveys based on EVT or SDT were compiled (Eccles & Wigfield, 1995; Flake et al., 2015; Lam et al., 2010; sdt: Self-Determination Theory, n.d.; Wozney et al., 2006) and used as references for survey development. The following are some example items from the reviewed articles:

1. Survey item regarding perceived competence: "I feel able to meet the challenge of performing well in this course" (sdt: Self-Determination Theory, n.d.)

2. Survey item regarding intrinsic value: “In general, I find working on math assignments (very boring, very interesting)” (Eccles & Wigfield, 1995).
3. Survey item regarding attainment/utility value: “The use of computer technology in the classroom enhances my professional development” (Wonzey et al., 2006)
4. Survey item regarding effort cost: “This class demands too much of my time” (Flake et al., 2015).
5. Survey item regarding autonomy: “I feel that my manager provides me choices and options” (sdt: Self-Determination Theory, n.d.).
6. Survey item regarding support from peers: “Many colleagues cared about the difficulties I faced in the process” (Lam et al., 2010).

In addition, one science and one social studies teacher at a local high school that encouraged teachers’ use of PBL were interviewed in order to get first-hand information about teachers’ experience of implementing PBL, and their input was also incorporated into the instrument. The survey question “I have sufficient resources (e.g., technology, materials, or examples of PBL in my subject area) for implementing PBL” reflected the concern of the social studies teacher, who had very few reference cases to go by when she was developing PBL in her teaching of American History (L. James, personal communication, March 31, 2015).

Expert review. A total of six experts reviewed the initial instrument. Three reviewers were experts in science education and the use of reform based teaching methods in college and grade 6-12 classrooms. One educational psychologist with measurement expertise and two science education doctoral students with middle and high school teaching experience also reviewed the items. In addition to assessing the content validity, the reviewers also commented on items that were unclear or confusing and suggested alternative wording.

Six teachers from one major participating school district of the current study also took the survey—three middle school teachers, one high school teacher, and two elementary school teachers. One of the middle school teachers taught science, one taught English/language art, and the third one taught social studies.   The high school teacher taught science, one elementary school teacher taught STEM courses, and the other teacher taught English/language arts, mathematics, science, and social studies.

Instrumentation. The survey for this study contained multiple parts and was grounded in expectancy-value theory (Eccles et al., 1983) and self-determination theory (Ryan & Deci, 2002). The first part of the survey collected participants' demographic information and teaching background, such as gender, ethnicity, teaching subjects and years of teaching. (Refer to Appendix A for final survey) Teaching subject options included: English/language arts, mathematics, science, and social studies. There was an option for "other" if the subjects that a survey participant taught did not fall in the provided choices.

Following that, a brief definition about PBL was provided to participants to avoid ambiguity around the meaning of this pedagogy. In this survey, PBL was defined as "…a type of pedagogy in which students direct their own learning under the guidance and facilitation of a teacher. With a PBL approach, students are first presented with a problem, followed by making inquiries into how to solve the problem, recognizing relevant facts from the initial problem scenario, generating hypotheses, and identifying the necessary information that they need to acquire in order to solve the problem. Through self-directed learning and guidance from the teacher/facilitator, students acquire new knowledge and apply it to develop viable solutions for the problem." In addition, participants were instructed that "problem-based learning" and "project-based learning" were considered equivalent in this study.

The second part of the survey gathered information about teachers' training and experience in teaching with PBL, and their intention of implementing PBL during the coming school year. The third part of the survey was to understand teachers' conceptions and beliefs about PBL. The final part of the survey contained questions based on expectancy-value theory (EVT) and self-determination theory (SDT) in the following subscales: (1) 5 questions on teachers' expectancy for success and competence in implementing PBL, (2) 7 questions on teachers' perceived autonomy and support from their school and colleagues for PBL implementation (autonomy: 4; support: 3), (3) 12 questions on the value that teachers associated with using PBL (value to teachers: 6; value to students: 6), and (4) 9 questions on the costs that teachers associated with using PBL.

Sample items for teachers' conceptions and beliefs about PBL include:

- In a PBL classroom, the teacher functions as a facilitator and therefore no content teaching is necessary.
- PBL gives too much responsibility to students.

Sample items for the teachers' expectancy for success and competence in implementing PBL include:

- I am not sure that I can teach with PBL in ways that meet state and district standards.
- I may not persist with PBL if my students struggle.

Sample items for teachers' perceived autonomy and support from schools and colleagues for PBL implementation include:

- My school administrators provide me choices and options in terms of implementing PBL or other teaching methods.
- I feel supported by my school administration to implement PBL.
- There are not many people at work who are willing to help me with PBL.

Sample items from the value that teachers associate with using PBL:

- Teaching with PBL could be enjoyable.
- Teaching with PBL is not important for my professional growth.
- PBL promotes students' critical thinking.
- PBL enhances students' collaboration and communication skills.

Sample items from the cost that teachers associate with using PBL:

- I am concerned that PBL can lead to students missing out on learning important basic concepts.
- I worry that PBL might have a negative impact on how my students score on the end-of-course tests.
- It will be too stressful for me to cover the mandated curriculum if I implement PBL.

A six-point Likert scale was used to avoid neutral responses. For the purpose of statistical analysis, the response "strongly disagree," "disagree," "somewhat disagree," "somewhat agree," "agree," and "strongly agree" corresponded to a score of 1, 2, 3, 4, 5, and 6, respectively. For reversed-coded items, "strongly disagree" corresponded to a score of 6 and "strongly agree" corresponds to 1. Positive and negative survey items were interspersed to avoid biasing the participants toward an assumed correct response, as well as an additional check that participants were reading and responding to each of the items.

In addition to multiple choice questions, this instrument also contained three open-ended questions. One asked participants to list the advantages of implementing PBL, one asked for the challenges they experienced while implementing PBL, and the third question asked "Is there anything else that you would like to say about PBL?" These open-ended questions provided teachers an opportunity to report their perspectives and thoughts on PBL implementation in their own words, in addition to selecting one of a limited number of pre-specified evaluative descriptors relating to a statement about PBL, such as "strongly disagree" or "strongly agree." More importantly, open-ended questions enable respondents to provide reasons or background informing their selection in fixed response questions (Fielding, Fielding, & Hughes, 2013). Information from open-ended questions allows researchers to have a deeper understanding about a respondent's position on an issue (Stoneman & Sturgis, 2012). Furthermore, quantitative data from the fixed-response questions and qualitative data from open-ended questions were triangulated and hopefully would provide convergence from these different research methods (Poncheri, Lindberg, Thompson, & Surface, 2008).

Survey questions for the administrators (Appendix B) were basically the same except that they were worded as from an administrator's perspective. For example, the question "I decide whether I implement PBL or other teaching methods" in the teachers' survey was modified as "Teachers should make their own decisions whether they want to implement PBL or not" in the administrators' survey. Administrators' beliefs about PBL may affect their support for teachers' implementation of PBL. However, it was anticipated that there might not be enough administrators who would complete the survey and a statistical analysis of administrator's data might not be feasible.

Procedures

The survey was administered via Qualtrics (https://www.qualtrics.com/login/) at NCSU, which stored all responses in an online, secure format. A central office staff member of a school district in our target state, which has promoted the use of PBL and provided opportunities for professional development in PBL for teachers in the district, sent invitations to STEM coordinators at 17 middle and high schools in the school district's STEM Collaborative Network. A reminder was also sent to those STEM Coordinators by the principal investigator of this study. Administrators and all teachers in these schools were invited to participate.

In order to try to increase the number of potential respondents for the survey, the principal investigator of the study later sent invitations to 293 teachers across the state who had attended her workshops in the past. Because teachers who responded to this invitation could be from various school districts in the state, the survey for this group of respondents contained an additional item that asked for the name of the county in which the respondents taught. Those who took the survey had an opportunity to enter a drawing for $30 pre-paid gasoline cards, from a site that was not linked to the participants' data.

The survey was open for 7 weeks (from March 12 to April 30, 2016) and 194 educators began the survey. Responses that were less than 80% completion were considered incomplete and excluded from data analysis. Six (5 teachers and 1 administrator) of the 194 educators responded to the invitation sent by the school district central office staffer and 4 of them (3 teachers and the administrator) completed the survey. Response rate could not be calculated for this group because the invitation was sent to the school STEM coordinators and it was not known how many teachers and administrators received the invitation. The other 188 educators (184 teachers and 4 administrators) responded to the researcher's invitations and response rate was 64% (188/293 = 64%). Three administrators and 168 teachers from this group completed the survey. Overall, 4 administrators and 171 teachers completed the survey and the completion rate was 80% for administrators (4/5 = 80%) and 90% for teachers (171/ 189 = 90%).

The software package Statistical Package for the Social Sciences (SPSS, Version 21.0; IBM, 2012) was used for data analysis. Due to the small number of administrators (n = 4) who completed the survey, their data were excluded from the statistical analysis. Out of the 171 teachers who completed the survey, fifteen of them taught either at elementary schools or colleges, and therefore their responses were also excluded from the analysis. This left 156 teachers who were either middle or high school teachers, and 126 of them who had taught with PBL before. Only responses from these 126 middle or high school teachers with previous PBL experience were used to validate the instrument for the following reasons:

1. Exploratory factor analysis (EFA) was used to validate the instrument. In addition to identifying the latent constructs in the instrument, another important goal for conducting the EFA was to establish statistical models that could use teachers' motivational factors to predict their intention to implement PBL.
2. Teachers' intention to implement PBL was quantified as the average score of their responses to a set of survey items that measured teachers' desire to use PBL. Different survey questions were used to measure the intention of using PBL for teachers who either had previous experience or not, which meant that the intention scores for these two groups of teachers were not comparable. Therefore,

separate statistical models should be used to predict these two groups of teachers' intention to implement PBL.

3. The absolute majority (80.8%) of the 156 middle or high school teachers who completed the survey had previous PBL experience, and their responses would be more representative. Additionally, these responses were from teachers' first-hand classroom experiences instead of perception formed or inference made from observation or reading.

Assessing Construct Validity and Reliability

Using exploratory factor analysis to examine the construct validity of the instrument. Gorsuch (1983) argued that "A prime use of factor analysis has been in the development of both the theoretical constructs for an area and the operational representatives for the theoretical constructs" (p. 350). There are two basic types of factor analysis: EFA as mentioned earlier, and confirmatory factor analysis (CFA) (Pett, Lackey, & Sullivan, 2003). EFA allows researchers to explore the main dimensions of the instrument to generate a model; and has been frequently used to assess the construct validity during the development of an instrument (Fabrigar & Wegener, 2011; Hayton et al., 2004; Williams & Onsman, 2010; Worthington & Whittaker, 2006). CFA is generally intended to evaluate the extent to which the researcher's measurement model fits the hypothesized internal structure of the instrument (Behar-Horenstein & Niu, 2013; Worthington & Whittaker, 2006).

For the current study, EFA was conducted with the goal of identifying constructs that were represented by the variables in the instrument and establishing the validity of this survey instrument. Thirty-four items from this instrument were chosen for EFA and they belong to the following categories: (1) teachers' perceived competence for practicing PBL (5 items), (2) perceived value to teachers from PBL implementation (6 items), (3) perceived value to students from PBL implementation (6 items), (4) perceived cost of implementing PBL (9 items), (5) perceived autonomy for implementing PBL (4 items), and (6) perceived support from administrators and peers for implementing PBL (3 items). For the purpose of EFA, reversed-coded items were re-coded so that "strongly disagree" corresponded to a score of 6 and "strongly agree" corresponded to 1.

Test the suitability of data set for factor analysis. Before proceeding into EFA, data collected for the current study needed to be tested to establish their suitability for factor analysis. These tests included Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy and Bartlett's Test of Sphericity. The KMO should be above 0.50 and Bartlett's Test of Sphericity should be significant ($p < 0.05$) for EFA to be suitable (IBM Knowledge, n.d.; Williams, Brown, & Onsman, 2012; Yong & Pearce, 2013). The KMO for the 34 items was 0.866 and p =0.000 for the Bartlett's Test of Sphericity. Therefore, the data set was suitable for factor analysis.

Factor extraction, rotation, and retention. Two commonly used factor extraction methods are maximum likelihood (ML) and principal factor methods (Fabrigar, Wegener, MacCallum, & Strahan, 1999) which is principal axis factoring (PAF) in SPSS. ML is the method of choice when data are normally distributed. On the other hand, PAF has the advantage of requiring no distributional assumptions (Fabrigar et al., 1999; Osborne & Costello, 2005). PAF was used for current study because data did not fulfill the assumption of normal distribution, based on the results from Shapiro-Wilk test of normality.

PAF is generally followed by rotation in order to obtain a logical and easily interpretable model with the best "simple structure." Simple structure refers to solutions in which each factor is defined by a subset of variables with large loadings relative to the other measured variables, and each variable loads highly on only one of the factors (Fabrigar et al., 1999). A number of rotation methods are available and they can be classified into two categories: (1) orthogonal rotations that yield un-correlated factors and (2) oblique rotations that permit correlations among factors (Fabrigar et al., 1999; Osborne & Costello, 2005). It is rare that human behaviors function independently of one another thus oblique rotations provide more accurate and realistic representation of the constructs (Fabrigar et al., 1999; Osborne & Costello, 2005). Therefore, promax, a well-established and commonly used oblique rotation (Fabrigar et al., 1999; Yong & Pearce, 2013) was used for the current study.

Using SPSS (version 21.0), PAF was performed on the 34 items as described above, followed by promax rotation. The output included 34 factors with assigned eigenvalues and their scree plot. Five factors should be retained, based on the eigenvalue-greater-than-one-rule, the most commonly used criterion for number of factors to retain (DeVellis, 2012; Hayton, Allen, & Scarpello, 2004). However, this method tends to over-estimate the number of factors (Courtney, 2013; DeVellis, 2012; Fabrigar et al., 1999). Another widely used method is the scree test which has eigenvalues of factors plotted in descending order and visually examined for the last substantial drop in the magnitude of the eigenvalues. The scree plot for the 34 factors indicates a gradual leveling off, starting around factor 5, as seen in the scree plot in Figure 3.1.

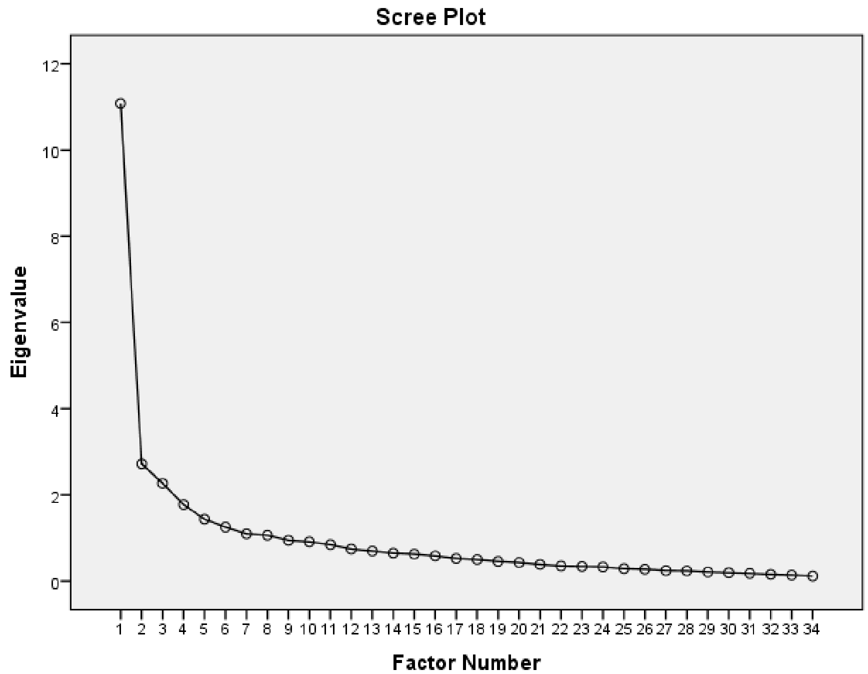

Figure 3.1. Scree plots from exploratory factor analysis with 34 items

The scree test has been criticized for its ambiguity and subjectivity (Courtney, 2013; DeVellis, 2012; Fabrigar et al., 1999). Therefore the third method, parallel analysis (PA), was also used for determining the optimal number of factors to fit the current study model. Parallel analysis is based on the rationale that eigenvalues from the sample data should be larger than those obtained from completely random data. Therefore only factors corresponding to actual eigenvalues that are greater than the parallel average random eigenvalues should be retained (Hayton et al., 2004).

Studies suggest that PA is more objective, accurate, and functions well (Courtney, 2013; Fabrigar et al., 1999; Hayton et al., 2004). SPSS syntax for parallel analysis (O'Connor, 2000) was used for the current study. Data from Parallel Analysis (PA) indicated that only the first four factors had eigenvalues greater than the random data eigenvalues generated by PA, as shown in Table 3.1. Indeed, the eigenvalue for factor 5 was 1.011 which barely exceeded the cut-off value of 1.000. Based on results from factors' eigenvalues, scree plot, and parallel analysis, a 4-factor model was adopted from the EFA.

Table 3.1

Comparison of Actual and PA Generated Random Data Eigenvalues for the 34-item Model

Factor number	Actual Eigenvalue from survey data	Average Eigenvalue From randomly generated data	95th percentile Eigenvalue from randomly generated data
1	10.718	1.506	1.678
2	2.318	1.336	1.463
3	1.842	1.202	1.324
4	1.325	1.093	1.193
5	1.011	0.993	1.083

PAF was repeated for the 34 variables with promax rotation and instruction was given to the SPSS software to extract only 4 factors. This was followed by the examination of each item's communality, defined as the proportion of each variable's variance that could be explained by the factors being extracted (Fabrigar et al., 1999). A high communality value for a variable indicates that the extracted factors represent the variables well and items with low communalities should be avoided (Fabrigar et al., 1999). The following two items were deleted based on the recommendation that items with communalities lower than 0.200 be eliminated (Yong & Pearce, 2013):

- "Teaching with PBL would require more of my time than traditional lecture-based teaching" (communality = 0.128).
- "The instructional methods that I use are driven by state standards" (communality = 0.134)

Another round of PAF with promax rotation was performed for the remaining 32 items. Based on the eigenvalue-greater-than-one rule, four factors should be retained. The scree plot of these 32 items indicates a leveling off beginning at factor 5 which also suggests a 4-factor model, as illustrated by the scree plot in Figure 3.2. Results of PA indicated that the first four factors had actual eigenvalues greater than the random data eigenvalues. However, the differences between the actual and randomly generated eigenvalues for factor 4 were relatively small, as shown in Table 3.2. Data from PAF with 3 or 4 factors would be compared before making decision about how many factors would be retained.

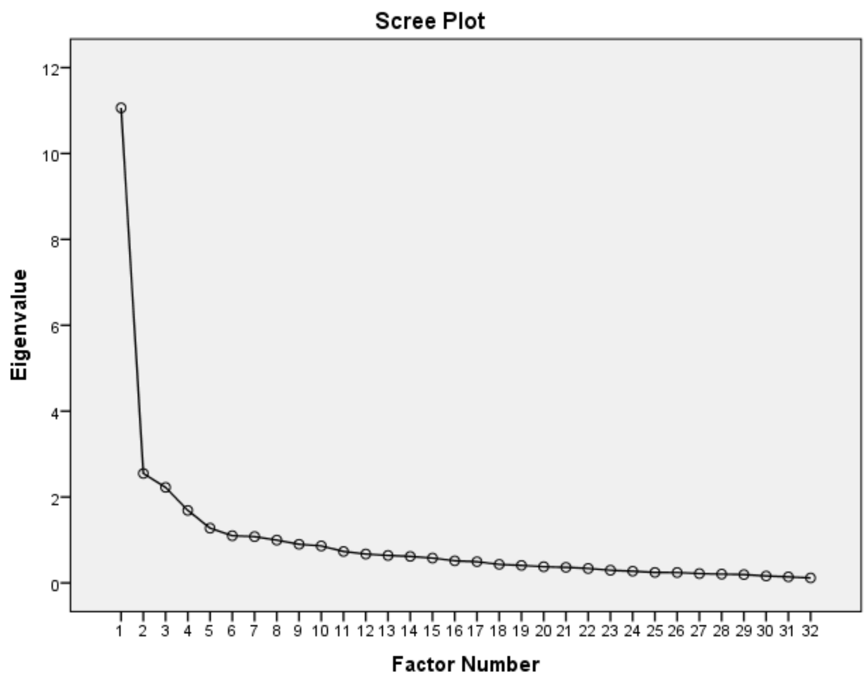

Figure 3.2. Scree plots from exploratory factor analysis with 32 items

Table 3.2

Comparison of Actual and PA Generated Random Data Eigenvalues for the 32-item Model

Factor number	Actual Eigenvalue from survey data	Average Eigenvalue From randomly generated data	95^{th} percentile Eigenvalue from randomly generated data
1	10.690	1.445	1.629
2	2.158	1.268	1.389
3	1.800	1.135	1.246
4	1.248	1.026	1.125
5	0.870	0.928	1.019

The 32-item, four-factor model. Data with 4 extracted factors showed that communalities for all 32 items exceeded 0.200. Twelve items in factor 1 had loading values greater than 0.500, an indicator for strong loaders (Osborne & Costello, 2005). One of the twelve items also loaded on factor 4 with a loading value of 0.374. It is recommended (Osborne & Costello, 2005) that an item should be deleted if it loads at 0.32 or higher on more than one factor, a phenomenon termed as "cross-loading."

Six items in factor 2 and four items in factor 3 had loading values greater than 0.500. However, the item "I have easily accessible resources for implementing PBL" cross-loaded with a loading value of 0.492 on factor 2 and 0.511 on factor 3. Only two items significantly loaded on factor 4 with loadings of 0.668 and 0.638 respectively, followed by one item with loading value of 0.374 and the other 29 loadings all less than 0.300. Furthermore, the item with loading value 0.638 on factor 4 cross-loaded on factor 3 with a value of 0.328. Elimination of this cross-loaded item left only one item in factor 4, which would not be considered a well represented factor (MacCallum, Widaman, Zhang, & Hong, 1999).

The 32-item, three-factor model. Results of the 3-factor PAF also showed that twelve items in factor 1, six items in factor 2, and five items in factor 3 had loading values greater than 0.500. The same item cross-loaded on factor 2 and 3 in the 4-factor model also cross-loaded in this model, with loading value of 0.496 on factor 2 and 0.540 on factor 3. This item was removed thus left four items in factor 3. The 3-factor model was chosen over the 4-facor model because all three factors were represented by at least four items with high loading values, a phenomenon termed "over-determination" (MacCallum et al.,1999) which had an important effect on the quality of the factor analysis. Communality data for the 32 items were also examined and items with communalities less than 0.200 were deleted. Overall, three items were removed either because of cross-loading or low communality values:

- "I have easily accessible resources (e.g., technology, materials, or examples of PBL in my subject area) for implementing PBL (cross-loaded on factor 2 and 3 with values 0.496 and 0.540 respectively).
- "I decide whether I implement PBL or other teaching methods" (communality = 0.080).
- "I feel pressured by school administrators to implement PBL (communality = 0.119).

Another round of PA was conducted on the remaining 29 items and results indicated that three factors should be retained. The actual and random data eigenvalues for the first four factors are shown in Table 3.3. The scree plot for this model, as shown in Figure 3.3, indicates a leveling off at factor 4 which also agrees with the 3-factor model. PAF of these 29 items revealed that the item "I will be able to implement PBL successfully" cross-loaded on factor 2 (loading value 0.523) and factor 3 (loading value 0.387). This item was deleted and 28 items remained for one more round of PA, and PAF followed by promax rotation.

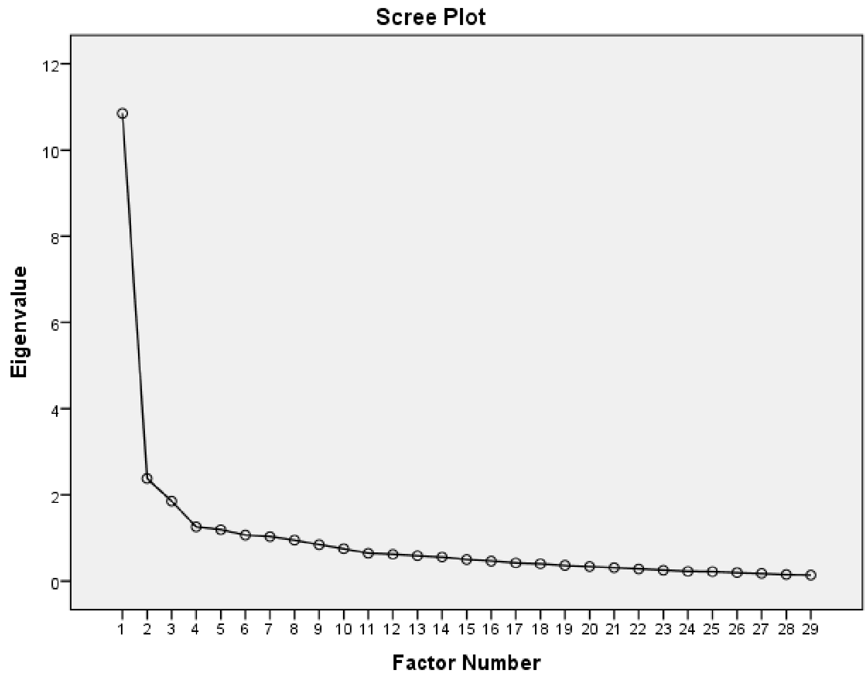

Figure 3.3. Scree plots from exploratory factor analysis with 29 items

Table 3.3

Comparison of Actual and PA Generated Random Data Eigenvalues for the 29-item Model

Factor number	Actual Eigenvalue from survey data	Average Eigenvalue From randomly generated data	95th percentile Eigenvalue from randomly generated data
1	10.464	1.332	1.507
2	1.982	1.159	1.299
3	1.427	1.034	1.155
4	0.875	0.927	1.029

The Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy for the 28-item, 3-factor model was 0.886 and p =0.000 for the Bartlett's Test of Sphericity, thus established the suitability of EFA for the data set. The communalities for the 28 items were moderate, ranging from 0.301 to 0.648, with seven variables from 0.30 to less than 0.40, eleven variables from 0.40 to less than 0.50, nine variables from 0.50 to less than 0.60, and one greater than 0.60. The factor correlation matrix indicated that the correlation was 0.594 between factor 1 and 2, 0.634

between factor 1 and 3, and 0.453 between factor 2 and 3. Indeed the three factors were correlated and using promax, an oblique rotation, was the right choice. Twenty items had loading values greater than 0.500, eleven were in factor 1, five were in factor 2, and four were in factor 3. The scree plot in Figure 3.4 was for this 3-factor model with 28 items showed a clear leveling off beginning at factor 4. Data from PA for the 28 items also indicated that three factors should be retained, as shown in Table 3.4.

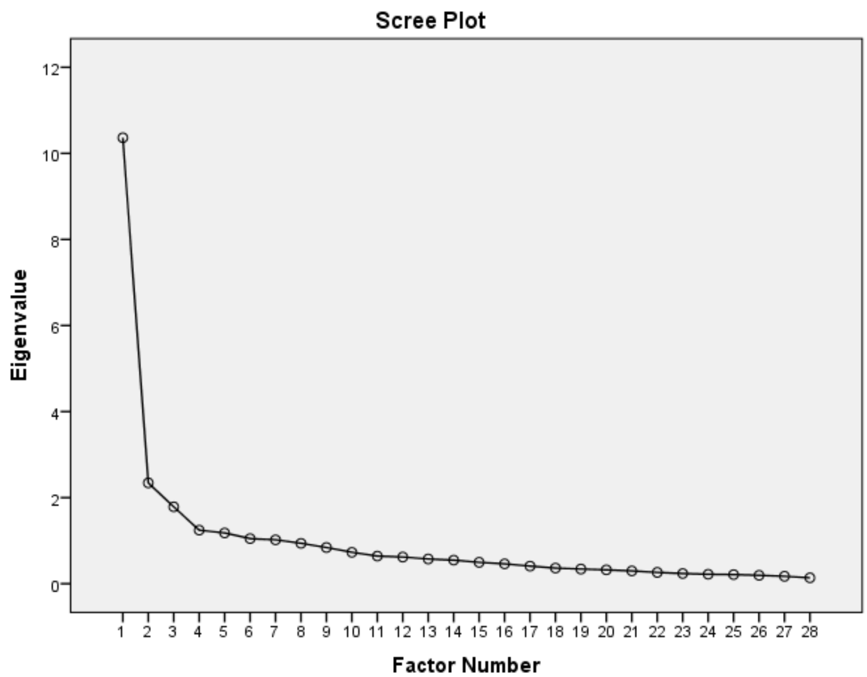

Figure 3.4. Scree plots from exploratory factor analysis with 28 items

Table 3.4

Comparison of Actual and PA Generated Random Data Eigenvalues for the 28-item Model

Factor number	Actual Eigenvalue from survey data	Average Eigenvalue From randomly generated data	95^{th} percentile Eigenvalue from randomly generated data
1	9.960	1.290	1.455
2	1.930	1.115	1.248
3	1.346	0.992	1.104
4	0.856	0.885	0.985

Is sample size adequate for the factor analysis? Another factor that needs to be examined is whether the sample size for this factor analysis is adequate. The appropriate sample size for factor analysis has been stated in terms of either the minimum necessary sample size, or the minimum ratio of the number of research subjects to the number of variables (Gorsuch, 1983; McCallum et al., 1999; Velicer & Fava, 1998). The review article by Velicer and Fava (1998) showed a wide range of subjects to variables ratio from 2:1 to 20:1, and a minimum sample size of 100 or 200. They concluded that there were neither rigorous theoretical nor empirical rules provided for those suggestions (Velicer & Fa, 1998). For the current study, responses from 126 teachers were used for EFA that employed 28 items, and the subject to variable ratio was 4.5.

Using blanket sample-size recommendations tends to overlook two important characteristics of the data which play a role in determining adequate sample size: (1) the extent to which factors are overdetermined and (2) the level of the communalities of the measured variables (Kahn, 2006; MacCallum et al., 1999). Factors are highly overdetermined when they are represented by at least three or four measured variables with high loadings (MacCallum et al., 1999). Communalities indicate the proportion of each variable's variance that can be explained by the factors. A communality of zero means the variable has no correlation with any other variable in the model. On the other hand, a communality value of 1.0 indicates the variance is perfectly accounted for by the set of factors underlying the model (Gorsuch, 1983). MacCallum, Widaman, Zhang, and Hong (1999) demonstrated mathematically and empirically that sample size requirements were contingent upon items' communality values and the degree of overdetermination of the factor structure.

Quality of factor analysis solutions improves as overdetermination of factors and communalities of variables increase (MacCallum et al., 1999). The study by MacCallum et al.

(1999) found that good estimate of factors was achieved with sample size of only 60, variables-to-factors ratio of 10:3 and high communalities (all greater than 0.6), or variables-to-factors ratio of 20:3 and wide communality (from 0.2 to 0.8). They also found that a sample size of 100 was adequate for variables to factors ratio of 20:3 and low communality (0.2, 0.3, and 0.4).

The communalities of all variables in the final EFA model of the current study are moderate and range from 0.301 to 0.648. All three factors are represented by four or more items with loading values of 0.500 or higher, thus meeting the criterion for overdetermination (MacCallum et al., 1999). There is no cross-loading which is defined as an item that loads at 0.32 or higher on more than one factor (Osborne & Costello, 2005). Overall, the 3-factor model fulfills the requirement for overdetermination and includes variables with moderate communalities, and the sample size of 126 for factor analysis of the current study is adequate.

Factor interpretation. Factor 1 explains 35.13% of the total variance and includes eleven items that all belong to the "value" category. There are six questions in this instrument that measure the value of PBL to students and five of them load on factor 1 with loading values ranging from 0.567 to 0.846. The only item from the "value of PBL to students" category that is not in factor 1 is "Using PBL causes students to have negative attitudes toward learning" with a loading value of 0.488 which is not far from the cut-off point of 0.500. Six of the seven items in the instrument that assess the value of PBL to teachers also load on factor 1 with loading values range from 0.556 to 0.762. Out of the six questions, two belong to the "attainment value" sub-category, two belong to the "intrinsic value" sub-category, and two belong to the "utility value" sub-category. The only item that misses the 0.500 cut-off point is the intrinsic value item "I am not interested in implementing PBL" with a loading value of 0.468.

For interpretation clarity, Thompson and Daniel (1996) suggest that "…factors should be given names that do not invoke the labels of observed variables because the latent constructs are not observed variables themselves" (p.202). Thus, factor 1 is named "value of PBL to teachers and their students" because all eleven items in this measure either teachers' perception of the value of PBL to themselves or to their students.

Factor 2 explains 6.60% of the total variance. It includes two items that measure teachers' perceived competence and three items that measure perceived cost in implementing PBL. Five questions in the instrument are based on the construct of expectancy for success (in EVT) and competence (in SDT). Item "I am not sure that I can teach with PBL in ways that meet state and district standards" and item "I may not persist with PBL if my students struggle" load on factor 2 with loading values 0.870 and 0.508, respectively.

The three "perceived cost" items have loading values ranging from 0.656 to 0.786. Specifically, they belong to the sub-category "psychological cost of failure," because they reflect the anxiety related to the potential of failure at the task, such as, "I worry that PBL might have a negative impact on how my students score on the end-of-course tests." Two items belonging to the "effort cost" sub-category load on factor 2, with loading values 0.475 and 0.442 respectively, and miss the 0.500 cut-off point. Factor 2 is labeled, "perceived competence and cost in PBL implementation."

Factor 3 explains 4.42% of the total variance. It includes four items that measure support from schools or peers, with loading values ranging from 0.623 to 0.776, and is called "school and peer support in PBL implementation." Two out of these four items refer to support from peers, with loading values 0.717 and 0.659, respectively. The other two items measure support from administration. One measures teachers' perception of overall school support, with a loading value of 0.776. The other one assesses teachers' perceived school support for autonomy in implementing PBL, with a loading value of 0.623. These findings agree with the results of a study by Lam, Cheng, and Choy (2010), which indicates that teachers' motivation and persistence in implementing PBL are positively correlated with their perception of school support for autonomy and competence, and collegial support.

The cumulative percentage of variance explained by the three factors is 46.15%. In other words, close to half of the differences among survey answers from teachers can be explained by the variation in their perceived value, competence and cost, and support from schools and peers in implementing PBL. Adding more factors into the model negligibly increases the total variance explained at the cost of losing the simple structure of the model. Table 3.5 lists the items included in each of the three factors extracted and retained, their communalities, and the total variance explained by each factor.

Table 3.5

Factor Loadings for Principal Axis Factoring with Promax Rotation of Teachers' Perceptions of PBL Scale

Total Variance explained	Item	Communalities	Factor loadings 1	2	3
35.13%	Factor 1: Value of PBL to teachers and their students				
	PBL stimulates students' creativity.	0.568	**0.846**	-0.105	-0.059
	PBL professional development will make me a better teacher.	0.583	**0.762**	-0.203	0.155
	PBL does not help students to obtain a deeper understanding of the content knowledge than they do in a traditional classroom.	0.407	**0.688**	0.107	-0.222
	PBL promotes students' critical thinking.	0.387	**0.685**	0.079	-0.208
	Teaching with PBL is not important for my professional growth.	0.523	**0.670**	-0.047	0.118
	PBL enhances students' collaboration and communication skills.	0.516	**0.670**	-0.055	0.117
	I enjoyed using the PBL approach with my students.	0.462	**0.653**	0.084	-0.042
	The skills that I gain by implementing PBL may be useful beyond the classroom.	0.385	**0.649**	0.040	-0.089
	Teaching with PBL could be enjoyable.	0.485	**0.569**	0.009	0.172
	In PBL, students engage in issues relevant to their lives/communities.	0.342	**0.567**	0.079	-0.053
	Teaching well with PBL is important for my career.	0.500	**0.556**	-0.030	0.231
6.60%	Factor 2: Perceived competence and cost in PBL implementation				
	I am not sure that I can teach with PBL in ways that meet state and district standards.	0.648	-0.206	**0.870**	0.097
	It will be too stressful for me to cover the mandated curriculum if I implement PBL.	0.588	0.099	**0.786**	-0.209
	I worry that PBL might have a negative impact on how my students score on the end-of-course tests.	0.414	-0.094	**0.732**	-0.113
	I am concerned that PBL can lead to students missing out on learning important basic concepts.	0.493	0.209	**0.656**	-0.227
	I may not persist with PBL if my students struggle.	0.443	0.090	**0.508**	0.165
4.42%	Factor 3: School and peer support in PBL implementation				
	I feel supported by my school administration to implement PBL.	0.594	-0.053	0.058	**0.776**
	People at work care about my experience with PBL.	0.513	0.086	-0.143	**0.717**
	There are not many people at work who are willing to help me with implementing PBL.	0.356	-0.166	0.069	**0.659**

(continued)

Total Variance explained	Item	Communalities	Factor loadings		
			1	2	3
	My school administrators provide me choices and options in terms of implementing PBL or other teaching methods.	0.369	0.074	-0.172	**0.623**

Note. Factor loadings > 0.500 are in bold

Reliability of the instrument. Using Cronbach's (1951) own words, reliability of a measurement indicates its "accuracy or dependability" (p. 297). Reliability of an instrument refers to its ability to consistently measure an attribute and Cronbach's α has been the most widely used indicator of the reliability of an instrument (Davenport, Davison, Liou, & Love, 2015; DeVon et al., 2007; Streiner, 2003). However, Cronbach's α is affected by the length of the scale (Nunnally & Bernstein, 1994). Two commonly used strategies to improve Cronbach's α are (1) increasing the number of related items and (2) deleting items with lower inter-item correlations (Cho & Kim, 2015). These strategies could lead to "alpha inflation" in which the sample-level alpha is higher than the population-level alpha (Cho & Kim, 2015). It is recommended not to judge the instrument's reliability solely by Cronbach's α and multiple methods should be used (Clark & Watson, 1995; Nunnaly & Bernstein, 1994). Therefore, the reliability of the instrument in the current study was assessed by three indicators: Cronbach's α, mean inter-item correlation, and corrected item-total correlation.

Cronbach's α. According to DeVellis (2012), an alpha coefficient between 0.80 and 0.90 is "very good," 0.70 to 0.80" is "respectable," 0.65 to 0.70 is minimally acceptable, 0.60 to 0.65 is undesirable, and below 0.60 is "unacceptable." Cronbach's α coefficients for the three factors in the current study range from 0.768 to 0.891 and fit in either the "respectable" or "very good" category. Cronbach's α for the 11 items in factor 1 is 0.891, for the five items in factor 2 is 0.837, and is 0.768 for the four items in factor 3. Deleting items from any of the factors would only decrease the Cronbach's α, as shown in Table 3.5.

Corrected item-total correlations. Corrected item-total correlations are correlations between each item and the sum of the remaining items in the scale. They indicate the extent to which each item relates to the construct measured by the whole instrument. It is suggested that these values should be at least 0.30 (Nunnaly & Bernstein, 1994, p.304) or 0.40 (Mattick & Clarke, 1998). The corrected-item-total correlation values for all 20 items included in the final 3-factor model range from 0.497 to 0.723, as shown in Table 3.6, which offer more evidence for the instrument's strong reliability.

Table 3.6

Cronbach's α Coefficients and Corrected Item-total Correlation for Each Item

Factors	Item	Corrected item-total correlation	Cronbach's α if item deleted
Value of PBL to teachers and students (Cronbach's α =0.891)	PBL stimulates students' creativity.	0.690	0.880
	PBL professional development will make me a better teacher.	0.693	0.877
	PBL does not help students to obtain a deeper understanding of the content knowledge than they do in a traditional classroom.	0.583	0.885
	PBL promotes students' critical thinking.	0.565	0.885
	Teaching with PBL is not important for my professional growth.	0.705	0.876
	PBL enhances students' collaboration and communication skills.	0.631	0.882
	I enjoyed using the PBL approach with my students	0.605	0.882
	The skills that I gain by implementing PBL may be useful beyond the classroom.	0.599	0.883
	Teaching with PBL could be enjoyable.	0.646	0.881
	In PBL, students engage in issues relevant to their lives/communities.	0.545	0.886
	Teaching well with PBL is important for my career.	0.642	0.882
Perceived competence and psychological cost of failure (Cronbach's α =0.837)	I am not sure that I can teach with PBL in ways that meet state and district standards.	0.700	0.786
	It will be too stressful for me to cover the mandated curriculum if I implement PBL.	0.723	0.781
	I worry that PBL might have a negative impact on how my students score on the end-of-course tests.	0.588	0.821
	I am concerned that PBL can lead to students missing out on learning important basic concepts.	0.646	0.801
	I may not persist with PBL if my students struggle.	0.551	0.826
School and peer support in PBL implementation (Cronbach's α =0.768)	I feel supported by my school administration to implement PBL.	0.666	0.666
	People at work care about my experiences with PBL.	0.609	0.692
	There are not many people at work who are willing to help me with implementing PBL.	0.519	0.739
	My school administrators provide me choices and options in terms of implementing PBL or other teaching	0.497	0.750

Mean inter-item correlations. Inter-item correlations indicate the extent to which the individual items of a scale are related. They are not influenced by scale length; thus they serve as a clearer measure of item homogeneity (Briggs & Cheek, 1986). Eisen, Ware, Donald, and Brook (1979) recommend that the mean inter-item correlation should exceed 0.30. Briggs and

Cheek (1986) propose that the optimal level of homogeneity exists when the mean inter-item correlation is in the 0.20 to 0.40 range, and a value higher than 0.50 suggests that the measurement might be too specific and redundant. Clark and Watson (1995) believe that a desirable range for mean inter-item correlation should be from 0.15 to 0.50, depending on the specificity of the construct. Mean inter-item correlations for items in factor 1, 2, and 3 are 0.45, 0.51, and 0.46, respectively which provide further evidence for the instrument's reliability. Tables 3.7, 3.8, and 3.9 show inter-item correlations for items in each factor.

Table 3.7

Inter-item Correlation among the Eleven Items in Factor 1

Item #*	1	2	3	4	5	6	7	8	9	10	11
1	1.000										
2	0.518	1.000									
3	0.505	0.396	1.000								
4	0.454	0.398	0.396	1.000							
5	0.435	0.568	0.407	0.397	1.000						
6	0.580	0.573	0.388	0.445	0.446	1.000					
7	0.472	0.475	0.282	0.578	0.502	0.390	1.000				
8	0.473	0.626	0.485	0.407	0.387	0.432	0.337	1.000			
9	0.543	0.498	0.483	0.324	0.539	0.495	0.484	0.325	1.000		
10	0.478	0.304	0.527	0.330	0.404	0.433	0.333	0.391	0.341	1.000	
11	0.445	0.517	0.348	0.328	0.748	0.366	0.484	0.389	0.508	0.360	1.000

Note.*Item # is based on descending loading values for each factor, as indicated in Table 3.5.

Table 3.8

Inter-item Correlation among the Five Items in Factor 2

Item #*	1	2	3	4	5
1	1.000				
2	0.574	1.000			
3	0.517	0.602	1.000		
4	0.580	0.570	0.447	1.000	
5	0.524	0.497	0.325	0.461	1.000

Note.*Item # is based on descending loading values for each factor, as indicated in Table 3.5.

Table 3.9

Inter-item Correlation among the Four Items in Factor 3

Item #*	1	2	3	4
1	1.000			
2	0.537	1.000		
3	0.473	0.499	1.000	
4	0.539	0.405	0.287	1.000

Note.*Item # is based on descending loading values for each factor, as indicated in Table 3.5.

Summary

The validity and reliability of the instrument were examined and results are summarized as follows:

- EFA was performed on the measurements of 34 items after they passed the suitability test for EFA.
- PAF followed by promax rotation was used to identify the latent constructs of the instrument.
- Items were retained only if they had moderate communality values and did not cross-load. Six out of the 34 items were deleted based on these criteria and 28 items left for PAF.
- Based on items' eigenvalues, scree plot, and data provided by parallel analysis, three factors were extracted and retained.
- EFA yielded 3 factors: factor 1included eleven items related to the perceived value of PBL to teachers and their students; factor 2 included five items related to teachers' perceived competence and cost in implementing PBL; and factor 3 included four items related to school support for autonomy and peers' support to implement PBL.

- Cronbach's α coefficients, inter-item correlations, and corrected item-total correlations of the 20 items included in the three factors were examined. Data indicated a strong reliability of the instrument.

The instrument developed for the current study is reliable and valid, as demonstrated by results from statistical analyses. Cronbach's α coefficients, mean inter-item correlations, and corrected item-total correlations of items all indicated good reliability for the instrument. EFA developed a clear and parsimonious model with three factors: value of PBL to teachers and their students, perceived competence and cost, and support from school and peers in implementing PBL. All three factors were overdetermined (MacCallum et al., 1999) by multiple items with good loading values and no cross-loading. The factors align very well with the theoretical framework of the current study: the expectancy-value theory by Eccles (1983) and the self-determination theory by Ryan and Deci (2000b).

In this chapter we discussed the development and validation of the survey. Data demonstrated that the current study has successfully employed a particular theoretical model to organize the seemingly disparate reasons why teachers implement PBL. The next three chapters will cover other findings from the statistical and qualitative data analyses, discussion of the findings, and conclusions and implications from the current study.

CHAPTER FOUR

FINDINGS

In this chapter, the findings from the survey data analyses will be presented, beginning with the demographic information of the respondents. The group of teachers with previous PBL experience will be compared and contrasted with the group of teachers who never practiced PBL before, in their conceptions and motivations about PBL. Results from statistical analyses, that use teachers' composite factor scores to predict their intention to implement PBL, will also be presented. Finally, the qualitative data collected from teachers' responses to the open-ended questions in the survey are presented, followed by the summary of responses from administrators who completed the survey.

Descriptive Statistics

Table 4.1 lists the demographics of the 156 respondents. These 156 teachers were further divided into two groups based on whether they had previous experience in implementing PBL or not. The two groups were designated as "PBL" and "non-PBL." Eighty-one percent of the respondents (126 out of 156) had previous experience teaching with PBL and were assigned to the "PBL" group, and 30 respondents belonged to the "non-PBL" group. It should be noted that sixty-one of the 126 teachers in the PBL group are from a school district that strongly promotes PBL. Demographics also were compiled for the PBL and non-PBL groups.

Table 4.1

Demographics of the Middle and High School Teachers Who Completed the Survey

Demographics		Overall (*n* = 156)	PBL[1] (*n* = 126)	non-PBL[2] (*n* = 30)
Gender	Female	125 (80.1%)	103 (81.7%)	22 (73.3%)
	Male	31 (19.9%)	23 (18.3%)	8 (26.7%)
Ethnicity	Black or African American	9 (5.8%)	9 (7.1%)	0
	White, non-Hispanic/non-Latino	139 (89.1%)	109 (86.5%)	30 (100%)
	Asian or Pacific Islander	1 (0.6%)	1 (0.8%)	0
	Hispanic/Latino	3 (1.9%)	3 (2.4%)	0
	Other	4 (2.6%)	4 (3.2%)	0
Age (ranges from 23 to 78)	23—30	24 (15.5%)	21 (16.7%)	3 (10.0%)
	31—40	28 (18.1%)	23 (18.2%)	5 (16.7%)
	41—50	49 (31.6%)	38 (30.2%)	11 (36.7%)
	51—60	35 (22.6%)	29 (23.0%)	6 (20.2%)
	61—70	18 (11.6%)	14 (11.1%)	4 (13.3%)
	71—78	1 (0.6%)	0	1 (3.3%)
Years of teaching	0—less than 10	65 (41.7%)	49 (38.9%)	16 (53.3%)
	10—less than 20	49 (31.4%)	41 (32.5%)	8 (26.7%)
	20—less than 30	33 (21.2%)	27 (21.4%)	6 (20.0%)
	30—less than 40	6 (3.8%)	6 (4.8%)	
	40 years or more	3 (1.9%)	3 (2.4%)	
Type of schools currently teach	Middle school	37 (23.7%)	30 (23.8%)	7 (23.3%)
	High school	119 (76.3%)	96 (76.2%)	23 (76.7%)
Teaching subjects[3]	English/Language Arts	15 (9.6%)	14 (11.1%)	1 (3.3%)
	Mathematics	18 (11.5%)	13 (10.3%)	5 (16.7%)
	Science	99 (63.5%)	80 (63.5%)	19 (63.3%)
	Social Studies	10 (6.4%)	9 (7.1%)	1 (3.3%)
	Other	29 (18.6%)	22 (17.5%)	7 (23.3%)

Note. [1] "PBL" indicates teachers who had experience in implementing PBL. [2] "non-PBL" indicates teachers who did not have experience in implementing PBL. [3] The total percentage exceeded 100% because some teachers taught more than one subject.

Teachers' demographics. Eighty percent of the respondents were female and close to 90% were ethnically White, non-Hispanic/non-Latino. The age of teachers ranged from 23 to 78 with an average age of 45.3. Approximately one third (31.6%) of the teachers were from 41 to 50 years old, which constituted the largest group of respondents. Years of teaching also covered a wide range, from less than a year to more than 40 years— and the biggest group was teachers who had taught for less than 10 years (41.7%). Close to three quarters of the 156 respondents (73.1%) had between 0 and 20 years of teaching experience and the mean years of teaching was 13.4.

More than three quarters (76.3%) of the respondents were high school teachers. Science teachers accounted for 63.5% of the respondents, followed by a distant second of 11.5% mathematics teachers. Several respondents taught both science and mathematics. English/Language Arts and social studies teachers constituted 9.6% and 6.4% of the respondents, respectively. In addition, 18.6% of the respondents listed the subjects they taught as “other,” which included Career and Technical Education, Physical Education, Theatre Arts, Special Education, Agricultural Education, Media, and Seminar.

Teachers’ training and use of PBL. Out of the 156 respondents, most of them (90.4%) had training in PBL, either informal or formal, and close to half (43.6%) had both informal and formal training. In terms of formal PBL training, 26.9% of the teachers had from 2 to 5 days of professional development (PD), followed by 14.1% with more than 2 weeks of PD in PBL, 10.3% with 6 to 10 days, and 6.4% with 1 day or less PD. PBL training data were also compiled for the “PBL” and “non-PBL” groups, as shown in Table 4.2.

Table 4.2

Teachers' Training and Use of PBL

Teachers' training and use of PBL	Overall (n = 156)	PBL (n = 126)	non-PBL (n = 30)
Teachers' training for PBL			
No training at all	15 (9.6%)	6 (4.8%)	9 (30.0%)
Informal training only	51 (32.7%)	39 (31.0%)	12 (40.0%)
Formal training only	22 (14.1%)	17 (13.5%)	5 (16.7%)
Both informal and formal training	68 (43.6%)	64 (50.8%)	4 (13.3%)
Amount of formal training received			
1 day or less	10 (6.4%)	8 (6.3%)	2 (6.7%)
2—5 days	42 (26.9%)	35 (27.8%)	7 (23.3%)
6—10 days	16 (10.3%)	16 (12.7%)	
More than 2 weeks	22 (14.1%)	22 (17.5%)	
Desired PBL training[1]			
Classroom management	57 (36.6%)	43 (34.1%)	14 (46.7%)
Change from direct instruction to facilitating	64 (41.0%)	48 (38.1%)	16 (53.3%)
Designing/structuring PBL lessons and units	118 (75.6%)	91 (72.2%)	27 (90.0%)
Assessment (formative and/or summative)	83 (53.2%)	67 (53.2%)	16 (53.3%)
Other (e.g., prepare students for standardized tests)	7 (4.5%)	6 (4.8%)	1 (3.3%)
I do not want training on PBL	16 (10.3%)	13 (10.3%)	3 (10.0%)
Current use of PBL			
Currently not using PBL		2 (1.6%)	
Use PBL for 1 or 2 lesson units for a course		57 (45.2%)	
Use PBL for up to 25% of teaching		37 (29.4%)	
Use PBL for up to 50% of teaching		20 (15.9%)	
Use PBL for most of the teaching		10 (7.9%)	
Reason for not practicing PBL[1]			
Lack of professional training			14 (46.7%)
Lack of interest			1 (3.3%)
Don't believe the importance of PBL			1 (3.3%)
Lack of perceived competence			9 (30.0%)
Other (e.g., lack of time, do not know how)			7 (23.3%)

Note. [1] The total percentage exceeded 100% because some teachers made more than one choice.

Teachers also expressed their desire to receive PBL training in four categories: classroom management, change from direct instruction to facilitating, designing/structuring PBL lessons and units and assessment (formative and/or summative). Designing/structuring PBL lessons was brought up by 118 teachers (75.6%), followed by assessment; 83 teachers (53.2%) desired training in this regard. Sixty-four teachers (41.0%) wanted to learn more about changing from direct instruction to facilitating, and 57(36.6%) asked for additional preparation in classroom management. Seven teachers (4.5%) requested more preparation—beyond what was listed in the choices, such as preparing students for standardized tests.

In terms of their current use of PBL, most of the teachers who had previous PBL experience (98.4%) were using PBL at the time of completing the survey. Close to half of the teachers (45.2%) practiced PBL for 1 or 2 lesson units of a course, followed by 29.4% of the teachers who used it for up to one-fourth of their teaching. There were 15.9% of the PBL-group teachers who used this pedagogy for up to half of their teaching and 7.9% of the teachers used PBL for most of their teaching.

Teachers who had never used PBL in the past were also asked to select reason(s) for not using this pedagogy. The most prevalent reason provided was the lack of professional training (46.7%), followed by lack of perceived competence (30.0%). One teacher was not interested and another did not consider PBL implementation important. Seven teachers chose "other" and offered reasons, such as lack of time or did not know how to implement PBL. Table 4.2 lists PBL training received and desired PBL training for all respondents (n = 156), teachers in the PBL group (n = 126), and non-PBL group (n = 30), respectively. Also included in Table 4.2 are PBL group teachers' current use of PBL and non-PBL group teachers' reasons for not practicing PBL.

Comparisons between Teachers Who Had and Teachers Who Did Not Have PBL Experience

Responses of 43 items from teachers who either had PBL experience or did not were compared and results are listed in Table 4.3. Comparisons were made by the nonparametric Mann-Whitney U tests because results of the Shapiro-Wilk normality test indicated that data from the current study were not normally distributed. In addition, Levens's test for equality of variances showed that six out of the total 43 variables had unequal variances, which also disqualified the use of a parametric test. For the purpose of these analyses, the response "strongly disagree," "disagree," "somewhat disagree," "somewhat agree," "agree," and "strongly agree" correspond to a score of 1, 2, 3, 4, 5, and 6, respectively.

Three items measured either years of teaching or PBL training received and 7 items were used to assess teachers' general conceptions of PBL. The rest of the 33 items were categorized into six groups based on the theoretical framework of this instrument: (1) teachers' perceived competence in practicing PBL, (2) value of PBL implementation to teachers, (3) value of PBL implementation to their students, (4) cost of implementing PBL, (5) teachers' perceived autonomy in implementing PBL, and (6) teachers' perceived support for their PBL implementation.

Table 4.3

Comparison between Teachers with and without PBL Experiences

Category	Survey item	*M*	*SD*	*p*
Years of teaching	The number of years that I have been a school teacher is	PBL: 13.8 non-PBL: 11.8	9.77 10.29	0.237
Types of PBL training	The following statement best describes my training for PBL	PBL: 3.10 non-PBL: 2.13	1.003 1.008	0.000**
Amount of formal PBL training	I have had the following amount of formal PBL training (e.g., professional development):	PBL: 2.64 non-PBL: 1.78	0.991 0.441	0.011*
Teachers' general concept about PBL	PBL should use open-ended driving questions that allow students to develop more than one reasonable, complex answer.	PBL: 5.20 non-PBL: 5.00	0.670 0.643	0.107
	With PBL, it's totally up to the teacher to give students feedback about the quality of their work-in-progress.	PBL: 3.05 non-PBL: 3.14	1.264 1.432	0.721
	In a PBL classroom, the teacher functions as a facilitator and therefore no content teaching is necessary.	PBL: 2.05 non-PBL: 2.50	0.987 1.196	0.040*
	I believe PBL is a pedagogy that is more appropriate for motivated students.	PBL: 3.54 non-PBL: 4.00	1.423 1.232	0.129
	PBL gives too much responsibility to students.	PBL: 2.32 non-PBL: 2.77	0.952 0.898	0.010*
	PBL is especially effective for students with low ability.	PBL: 3.48 non-PBL: 2.97	1.225 0.999	0.044*
	Students with limited English language skills have trouble with PBL.	PBL: 3.44 non-PBL: 3.62	1.177 1.147	0.498
Teachers' perceived competence in practicing PBL	I will be able to implement PBL successfully.	PBL: 4.86 non-PBL: 3.70	0.914 0.877	0.000**
	I do not feel competent to teach with a PBL approach.	PBL: 2.25 non-PBL: 4.00	1.045 1.313	0.000**
	I may not persist with PBL if my students struggle.	PBL: 2.96 non-PBL: 3.80	1.169 0.997	0.000**
	I feel confident that I can successfully assess students' learning progress in a PBL setting.	PBL: 4.67 non-PBL: 3.97	1.110 0.964	0.000**
	I am not sure that I can teach with PBL in ways that meet state and district standards.	PBL: 2.71 non-PBL: 3.80	1.326 0.925	0.000**
Perceived value of PBL to teachers	I am not interested in implementing PBL.	PBL: 1.88 non-PBL: 2.93	1.005 1.337	0.000**
	Teaching with PBL could be enjoyable.	PBL: 5.25 non-PBL: 4.60	0.726 1.037	0.000**
	Teaching well with PBL is important for my career.	PBL: 4.44 non-PBL: 3.67	1.243 1.124	0.001**
	Teaching with PBL is not important for my professional growth.	PBL: 2.21 non-PBL: 2.93	0.994 1.258	0.002**

(continued)

Category	Survey item	*M*	*SD*	*p*
	PBL professional development will make me a better teacher.	PBL: 4.85 non-PBL: 4.67	0.992 1.093	0.456
	The skills that I gain by implementing PBL may be useful beyond the classroom.	PBL: 4.93 non-PBL: 4.57	0.981 0.858	0.019*
Perceived value of PBL to students	PBL does not help students to obtain a deeper understanding of the content knowledge than they do in a traditional classroom.	PBL: 2.09 non-PBL: 2.53	1.122 1.137	0.030*
	Using PBL causes students to have negative attitudes toward learning.	PBL: 2.06 non-PBL: 2.47	0.940 0.937	0.027*
	In PBL, students engage in issues relevant to their lives/communities.	PBL: 4.99 non-PBL: 4.60	0.847 0.621	0.007**
	PBL stimulates students' creativity.	PBL: 5.40 non-PBL: 5.00	0.707 0.743	0.005**
	PBL enhances students' collaboration and communication skills.	PBL: 5.39 non-PBL: 4.93	0.704 0.740	0.002**
	PBL promotes students' critical thinking.	PBL: 5.39 non-PBL: 5.03	0.771 0.765	0.009**
Perceived cost of implementing PBL	I am concerned that PBL can lead to students missing out on learning important basic	PBL: 2.90 non-PBL: 3.63	1.255 1.426	0.010*
	Teaching with PBL would require more of my time than traditional lecture-based teaching.	PBL: 4.06 non-PBL: 3.93	1.337 1.388	0.599
	Preparing to implement PBL would require too much of my time.	PBL: 3.21 non-PBL: 4.30	1.254 1.368	0.000**
	I have easily accessible resources (e.g., technology, materials, or examples of PBL in my subject area) for implementing PBL.	PBL: 3.66 non-PBL: 3.37	1.540 1.520	0.360
	Implementing PBL will make classroom management more difficult.	PBL: 2.75 non-PBL: 3.43	1.166 1.305	0.011*
	It will be too stressful for me to cover the mandated curriculum if I implement PBL.	PBL: 2.91 non-PBL: 3.77	1.207 1.104	0.000**
	I worry that PBL might have a negative impact on how my students score on the end-	PBL: 3.22 non-PBL: 3.97	1.436 1.426	0.016*
	I am concerned that implementing PBL might have a negative impact on my teaching evaluation.	PBL: 2.28 non-PBL: 2.80	1.136 1.157	0.019*
	I believe that the overall benefits from implementing PBL would outweigh the costs.	PBL: 4.60 non-PBL: 4.00	1.150 1.145	0.006**
Perceived autonomy in implementing PBL	I decide whether I implement PBL or other teaching methods.	PBL: 4.81 non-PBL: 4.80	1.071 0.847	0.541
	I feel pressured by school administrators to implement PBL.	PBL: 2.65 non-PBL: 2.50	1.261 1.196	0.543
	My school administrators provide me choices and options in terms of implementing PBL or other teaching methods.	PBL: 4.52 non-PBL: 4.70	1.239 0.794	0.821
	The instructional methods that I use are driven by state standards.	PBL: 4.79 non-PBL: 4.80	1.121 0.761	0.617

(continued)

Category	Survey item	*M*	*SD*	*p*
Perceived support in implementing PBL	I feel supported by my school administration to implement PBL.	PBL: 4.79 non-PBL: 4.57	1.182 1.135	0.342
	People at work care about my experience with PBL.	PBL: 3.82 non-PBL: 3.48	1.403 1.153	0.175
	There are not many people at work who are willing to help me with implementing PBL.	PBL: 2.97 non-PBL: 3.70	1.258 1.442	0.010*

Note. *Significant $p < .05$; **highly significant $p < .01$

Significant differences in types of PBL training (informal or formal) and amount of formal PBL training (days of professional development) existed between teachers with PBL experience (the PBL group) and without PBL experience (the non-PBL group). Ordinal scales were used for both items. For items that asked for teachers' training for PBL, "no training" was assigned a value of 1and "informal training only" was assigned a value of 2, 3 was assigned to "formal training only" and 4 was assigned to "both informal and formal training". For items that measured teachers' amount of formal PBL training, the choices of "1 day or less," "2-5 days," "6-10 days," and "more than 2 weeks," were assigned as 1, 2, 3, and 4, respectively.

For the seven questions that measured teachers' general conceptions of PBL, significant differences between the average responses from the PBL and non-PBL group existed in three of them. There also were seven items in the category of "perceived support and autonomy" and responses for one item exhibited significant difference between the PBL and non-PBL groups. However, responses to all five items in the "perceived competence" category, eleven out of the twelve items that measured perceived value, and seven out of nine items in the "perceived cost" category indicated significant differences between the teachers with or without PBL experiences.

One-sample Wilcoxan signed rank test, the non-parametric equivalent of the one-sample *t*-test, was conducted to evaluate the collective difference between the value of PBL to teachers and to their students, for both PBL and non-PBL groups. Results indicated significance difference existed between these two types of value for PBL group—mean for all student value items was 5.21and mean for all teacher value items were 4.87 ($p < 0.01$). The same pattern was observed in the non-PBL group— the mean for all student items was 4.76 and the mean for teacher value items was 4.27 ($p < 0.05$). One-sample Wilcoxan signed rank test also was performed to differentiate the two types of cost, the effort cost and the psychological cost of failure. For the PBL group, the mean values for the effort cost and psychological cost were 3.66 and 4.17, respectively ($p < 0.01$). For the non-PBL group, the mean values for the effort cost and psychological cost were 3.18 and 3.46, respectively ($p < 0.05$)

Underlying Factors that Predict Teachers' Perceptions of PBL and Intention to Practice PBL

Using teachers' factor scores to predict their intention to continue implementing PBL. Multiple linear regression was used to evaluate whether the three factors from the EFA significantly predicted teachers' intention to continue implementing PBL. The independent variables of the regression were teacher's factor scores. Factor scores are weighted composite variables and items with higher factor loadings will have a greater impact on the scores. There are different methods to calculate factor scores; the regression method (DiStefano, Zhu, & Mindrila, 2009), which is the default method of SPSS, was chosen. Using the regression method, the computed factor scores are standardized to a mean of zero and a standard deviation of 1 (DiStefano et al., 2009). A respondent with a positive score for a certain factor indicates that he/she places higher than average value on the particular factor.

The dependent variable of the regression analysis was teachers' intention to continue their PBL practice, which was measured by averaging their responses to the following three questions: (1) I plan to increase the level of PBL I use this year; (2) I plan to continue using PBL in some capacity this year, and (3) I doubt that I will implement PBL this year as much as I have in the past. Responses to question number 3 were reverse coded. These three questions were available only to respondents who answered “yes” to the question “I have experience teaching with PBL;” therefore, only responses from teachers in the PBL group were included in these analyses. This new variable was called “Intention” and its average for the 126 teachers in the PBL group was 4.65.

Different combinations of the three factor scores were used in order to obtain the best-fitting and most parsimonious model. Factor 1 (F1) alone predicted 46.3% of the variance in teachers’ intentions, as indicated by the r^2 value of the regression model. Adding factor 2 (F2) to the equation increased r^2 from 0.463 to 0.471 and only factor 1 was a significant predictor. Adding factor 3 (F3) to the equation increased r^2 from 0.463 to 0.481 and both F1 and F3 were significant predictors. The r^2 for the multiple linear regression model that included all three factors was 0.485. However, F2 was not a significant predictor when all three factors were included in the regression model. Data also indicated that F2 and F3, whether individually or combined, significantly predicted teachers’ intention to implement PBL, as shown in Table 4.4.

Table 4.4

Multiple Linear Regression Analyses: Using the 3 Factors to Predict Teachers' Intention to Implement PBL

Model number	r^2	Constant	F1 b_1*	F2 b_2*	F3 b_3*	p
1	0.463	4.70	0.684	N/A	N/A	0.000[b]
2	0.270	4.70	N/A	0.526	N/A	0.000[b]
3	0.339	4.70	N/A	N/A	0.587	0.000[b]
4	0.471	4.70	0.591		N/A	0.000[b]
				0.143		0.107
5	0.481	4.70	0.536	N/A		0.000[b]
					0.209	0.028[a]
6	0.403	4.70	N/A	0.305		0.000[b]
					0.431	0.000[b]
7	0.485	4.70	0.466			0.000[b]
				0.124		0.158
					0.195	0.040[a]

Note. [a]Significant $p < .05$; [b]Highly significant $p < .01$

Examining differences in teachers' intentions to continue, and perceptions of competence, value and cost about PBL implementation. Mann-Whitney U test and Kruskal-Wallis test, the non-parametric equivalents of *t*-test and ANOVA, were used because data were not normally distributed, as indicated by the results from Shapiro-Wilk test of normality. Teachers' intention to implement PBL, the "Intention" scores, or respective composite scores for the three factors were compared against different genders, type of school (middle or high school), teaching subjects (STEM vs. non-STEM), years of teaching, current practice of PBL, and types and amount of formal PBL training received.

Originally there were five choices for teaching subjects—English/language arts, mathematics, science, social studies, and other. Some respondents taught more than one subject and therefore belonged to more than one group. This phenomenon violated the independent samples requirement of Kruskal-Wallis test. Therefore, respondents were grouped into "STEM" for science and mathematics vs. "non-STEM" for English/language arts and social studies. Respondents who chose "other" category were assigned into the "STEM" group if they stated that they taught technology, engineering, or health science. They were assigned to the "non-STEM" group if they taught physical education, special education, theatre arts, media, or seminar. This reduced the original five groups to two groups and therefore Mann-Whitney U test was used to compare their respective mean value for each variable.

Teachers' years of teaching, which was originally measured on an interval scale, was transformed into an ordinal scale with three levels: less than 10 years, from 10 to less than 20 years, and 20 or more years. Kruskal-Wallis test was used to investigate whether there were differences among the three groups in terms of their intention to implement PBL, perceived value, self-efficacy and cost, and support in implementing PBL as measured by "Intention" score and three factor scores.

Finally, the "Intention" score and three factor scores were compared according to teachers' current practice of PBL, type of PBL training received, and amount of formal PBL training received. Teachers were divided into five groups based on their current use of PBL: not using PBL at all, use PBL for no more than one or two lesson units for a particular course, use PBL for about 25% of teaching, use PBL for about 50% of teaching, and use PBL for most of teaching. There were four groups for type of training received: no training, informal training only, formal training only, and both informal and formal training. In terms of amount of formal training, teachers chose one from the following four categories: one day or less, 2-5 days, 6-10 days, or more than 2 weeks. Kruskal-Wallis tests were performed and when the results indicated a significant difference among all the groups in a variable, *post-hoc* pairwise comparisons were then conducted to identify which specific groups differed. Results are displayed in Table 4.5.

Table 4.5

The Effects of Different Factors on Teachers' Intention to Implement PBL and Three Factor Scores

Dependent variable	Independent variable	*M*	*p*
Intention	Gender	Female(n = 103, M = 4.47) Male (n = 23, M = 4.52)	0.990
	Type of school	Middle school (n = 31, M = 4.40) High school (n = 95, M = 4.50)	0.596
	Teaching subjects	STEM (n = 93, M = 4.39) Non-STEM (n = 33 , M = 4.73)	0.092
	Years of teaching	Less than 10 years (n = 49, M = 4.61) Ten to less than 20 years (n = 41 , M = 4.57) More than 20 years (n = 36, M = 4.20)	0.149
	Current practice of PBL	Group 1: currently not using PBL (n = 2, M = 4.00) Group 2: one or 2 lesson units for a course (n = 57, M = 4.13) Group 3: about 1/4 teaching is done by PBL (n = 37, M = 4.65) Group 4: about 1/2 teaching is done by PBL (n = 20, M = 4.82) Group 5: most of teaching is done by PBL (n = 10, M = 5.25)	0.002** between group 2 & group 5. Others all $\geq$ 0.050
	Type of PBL training received	Group 1: no PBL training (n = 6 , M = 4.00) Group 2: informal training only (n = 39, M = 4.24) Group 3: formal training only (n = 17, M = 4.65) Group 4: both informal & formal training (n = 64, M = 4.62)	0.033* between group 2 & group 4. Others all $\geq$ 0.050
	Amount of formal PBL training received	Group 1: one day or less (n = 8 , M = 4.19) Group 2; two to five days (n = 35 , M = 4.46) Group 3: six to 10 days (n = 16, M = 5.16) Group 4: more than 2 weeks (n = 22, M = 4.68)	0.034* between group 2 & group 3. Others all $\geq$ 0.050
Factor 1 score	Gender	Female(n = 103, M = -0.019) Male (n = 23, M = 0.084)	0.917
	Type of school	Middle school (n = 31, M = 0.168) High school (n = 95, M = -0.050)	0.345
	Teaching subjects	Science (n = 93, M = -0.090) Non-Science (n = 33 , M = 0.251)	0.051
	Years of teaching	Less than 10 years (n = 49, M = 0.138) Ten to less than 20 years (n = 41 , M = 0.055) More than 20 years (n = 36, M = -0.236)	0.392
	Current practice of PBL	Group 1: currently not using PBL (n = 2, M = 0.585) Group 2: one or 2 lesson units for a course (n = 57, M = -0.399) Group 3: about 1/4 teaching is done by PBL (n = 37, M = 0.155) Group 4: about 1/2 teaching is done by PBL (n = 20, M = 0.339) Group 5: most of teaching is done by PBL (n = 10, M = 0.797)	0.000** between group 2 & group 5. Others all $\geq$ 0.050
	Type of PBL training received	Group 1: no PBL training (n = 6 , M = -0.730) Group 2: informal training only (n = 39, M = -0.188) Group 3: formal training only (n = 17, M = 0.154) Group 4: both informal & formal training (n = 64, M = 0.112)	0.062

(continued)

Dependent variable	Independent variable	*M*	*p*
	Amount of formal PBL training received	Group 1: one day or less (n = 8 , M = -0.923) Group 2; two to five days (n = 35 , M = 0.051) Group 3: six to 10 days (n = 16, M = 0.464) Group 4: more than 2 weeks (n = 22, M = 0.367)	0.028* between group 1 & group 4. Others all $\geq$ 0.050
Factor 2 score	Gender	Female(n = 103, M = -0.026) Male (n = 23, M = 0.114)	0.756
	Type of school	Middle school (n = 31, M = -0.114) High school (n = 95, M = 0.034)	0.679
	Teaching subjects	Science (n = 93, M = -0.102) Non-Science (n = 33 , M = 0.286)	0.067
	Years of teaching	Less than 10 years (n = 49, M = 0.031) Ten to less than 20 years (n = 41 , M = -0.048) More than 20 years (n = 36, M = -0.003)	0.923
	Current practice of PBL	Group 1: currently not using PBL (n = 2, M = -0.236) Group 2: one or 2 lesson units for a course (n = 57, M = -0.470) Group 3: about 1/4 teaching is done by PBL (n = 37, M = 0.195) Group 4: about 1/2 teaching is done by PBL (n = 20, M = 0.550) Group 5: most of teaching is done by PBL (n = 10, M = 0.687)	0.018* between group 2 & 3; 0.000** between group 2 & 4; 0.006** between group 2 & 5. Others all $\geq$ 0.050
	Type of PBL training received	Group 1: no PBL training (n = 6 , M = -0.009) Group 2: informal training only (n = 39, M = -0.443) Group 3: formal training only (n = 17, M = 0.381) Group 4: both informal & formal training (n = 64, M = 0.150)	0.007** between group 2 & 3; 0.015* between group 2 & 4. Others all $\geq$ 0.050
	Amount of formal PBL training received	Group 1: one day or less (n = 8 , M = -0.468) Group 2; two to five days (n = 35 , M = 0.101) Group 3: six to 10 days (n = 16, M = 0.340) Group 4: more than 2 weeks (n = 22, M = 0.495)	0.059
Factor 3 score	Gender	Female(n = 103, M = -0.042) Male (n = 23, M = 0.183)	0.351
	Type of school	Middle school (n = 31, M = 0.036) High school (n = 95, M = -0.011)	0.835
	Teaching subjects	Science (n = 93, M = -0.060) Non-Science (n = 33 , M = 0.169)	0.148
	Years of teaching	Less than 10 years (n = 49, M = 0.028) Ten to less than 20 years (n = 41 , M = 0.040) More than 20 years (n = 36, M = -0.113)	0.878
	Current practice of PBL	Group 1: currently not using PBL (n = 2, M = 0.573) Group 2: one or 2 lesson units for a course (n = 57, M = -0.423) Group 3: about 1/4 teaching is done by PBL (n = 37, M = 0.129) Group 4: about 1/2 teaching is done by PBL (n = 20, M = 0.538) Group 5: most of teaching is done by PBL (n = 10, M = 0.613)	0.001** between group 2 & 4; 0.007** between group 2 & 5. Others all $\geq$ 0.050

(continued)

Dependent variable	Independent variable	*M*	*p*
	Type of PBL training received	Group 1: no PBL training (*n* = 6 , *M* = -0.080) Group 2: informal training only (*n* = 39, *M* = -0.314) Group 3: formal training only (*n* = 17, *M* = 0.373) Group 4: both informal & formal training (*n* = 64, *M* = 0.085)	0.065
	Amount of formal PBL training received	Group 1: one day or less (*n* = 8 , *M* = -0.695) Group 2; two to five days (*n* = 35 , *M* = 0.083) Group 3: six to 10 days (*n* = 16, *M* = 0.456) Group 4: more than 2 weeks (*n* = 22, *M* = 0.320)	0.083

Note. *Significant $p < .05$; **highly significant $p < .01$

There were no significant differences in teachers' perceptions of and intention for PBL implementation associated with differences in teachers' gender, teaching subjects, years of teaching, and type of school they teach. A trend of more positive perceptions of competence, value, autonomy, support and less cost associated with PBL implementation was observed as teachers practiced PBL more frequently, and received formal training. Receiving informal training in addition to formal training did not have any additional effect on teachers' intention and perception of PBL implementation, compared with those of teachers who only had formal training. Additionally, a positive trend in teachers' intention and perceptions of PBL was observed as the length of formal training increased.

Significant increase of factor 2 score was observed between teachers who used PBL occasionally and teachers who used PBL for 25%, 50%, or most of their teaching. Therefore, a more fine-grained analysis was performed to decipher the influence of teachers' perceived competence and cost, the two major constructs in factor 2, on their frequency of PBL use. Cost was further divided into effort cost and psychological cost of failure. Significant increase in perceived competence was observed between teachers who used PBL occasionally and who used PBL at every other level ($p < 0.01$). Teachers who practiced PBL occasionally and teachers who used PBL for most of their teaching differed significantly in their perceived effort cost for implementing PBL ($p < 0.05$). Statistical analyses also indicated significant difference in teachers' psychological cost of failure between teachers who used PBL occasionally and who used PBL at every other level ($p < 0.05$).

Using teachers' current level of practice and training in PBL to predict their perception of and intention for PBL implementation. Multiple linear regression was performed to evaluate whether teachers' current level of practice and training in PBL significantly predicted teachers' perceptions of and intention for PBL implementation. The dependent variables were either teachers' intention or one of the three factor scores. The independent variables were teachers' current level of PBL practice, type of training, amount of formal training, or various combinations of these variables.

Table 4.6

Multiple Regression Analyses: Using Teachers' Current Levels of Practice and Training in PBL to Predict Their Perceptions of and Intention for PBL Implementation

Dependent variable	r^2	Constant	Current level of PBL use b_1*	Amount of formal training b_2*	p
Intention	0.202	3.53	0.457	N/A	0.000[b]
Factor 1 score	0.137	-1.07	0.380	N/A	0.000[b]
Factor 1 score	0.086	-0.72	N/A	0.313	0.005[b]
Factor 1 score	0.187	-1.49	0.340 	 0.235	0.002[b] 0.028[a]
Factor 2 score	0.199	-1.25	0.454	N/A	0.000[b]
Factor 2 score	0.065	-0.50	N/A	0.278	0.013[a]
Factor 3 score	0.161	-1.11	0.410	N/A	0.000[b]
Factor 3 score	0.057	-0.52	N/A	0.263	0.019[a]

Note. [a]Significant $p < .05$; [b]Highly significant $p < .01$

Teachers' current level of PBL practice significantly predicted their perceptions of and intention in PBL implementation. Types of training had no significant effects on teachers' perceptions of and intention in PBL implementation. The amount of formal training did, although its predictive power was lower than that of teachers' current level of PBL practice. Table 4.6 lists regression models in which teachers' current level of PBL practice and/or the amount of formal PBL training they received significantly predicted their perceptions of and intention for PBL implementation.

Qualitative Data Analysis of the Open-ended Question Responses

The instrument for the current study contained several open-ended questions, such as: "The advantages of implementing PBL in my classroom are;" "The challenges of implementing PBL in my classroom are;" and, "Is there anything else that you would like to say about PBL?" Only teachers who had previously taught with PBL were routed to answer these questions. Teachers' responses to the open-ended questions ranged from a couple of words to a short paragraph. They were read thoroughly multiple times to comprehend these qualitative data in their entirety. An inductive approach was then used for the qualitative data analysis (i.e., no preconceived codes/keywords existed). After carefully reading the responses, the researcher:

1. Identified key words or phrases in teachers' comments. For example: words or phrases that described PBL improved students' learning which reflected the value of PBL.
2. Established word "categories" according to the theoretical constructs of the current study. For example: value and cost of PBL implementation, perceived competence and autonomy in implementing PBL.
3. Added up the count for each word/phrase and the count of all the words/phrases in each category, and finally, calculated the total word count for this question. The percentage of the word count of each category in the total word count was computed.

4. Used a finer-grained approach in which the 126 teachers who were directed to this question were divided into three groups according to their frequency of using PBL, and the percentage of each word count for each group was calculated.
5. Created levels according to PBL use. Level 1 included teachers who were not using PBL at the time of completing the survey or who used PBL for no more than 1 or 2 lesson units for a course and they accounted for 46.8% of the 126 teachers. Teachers in level 2 used PBL for about 25% or 50% of their teaching, and they accounted for 45.3% of the126 teachers. The rest (7.9%) were level 3 teachers who used PBL for most of their teaching.

What teachers perceived as the advantages of implementing PBL. One hundred and twenty out of the 126 middle and high school teachers responded to the question "The advantages of implementing PBL in my classroom are:" and 37 keywords were identified from their answers. There were a total of 252 word counts, although frequency of the keywords mentioned by respondents varied greatly, from 2 time for terms like "independence" and "increased responsibility," to 30 times for "critical thinking." Upon further examination, related words such as "interested" and "enjoyment" were combined. Table 4.7 lists the keyword categories, the words and phrases that are assigned into each category, and the percentage of each word/phrase being used by teachers who practice PBL at different levels:

Table 4.7

Teachers' Perceived Advantages of Implementing PBL Grouped Based on Their Current Levels of Practice

Keywords/phrases	Count (%)[1] level 1	Count (%)[1] level 2	Count (%)[1] level 3	Total count (%)[2]
Value to students				
Critical thinking	15 (50.0%)	14 (46.7%)	1 (3.3%)	30
Student engagement	10 (40.0%)	12 (48.0%)	3 (12.0%)	25
Real life relevance	8 (34.8%)	12 (52.2%)	3 (13.0%)	23
Student-centered approach	8 (38.1%)	11 (52.4%)	2 (9.5%)	21
Knowledge retention & application	8 (42.1%)	11 (57.9%)	0	19
Improved learning	10 (55.6%)	8 (44.4%)	0	18
Collaboration	9 (60.0%)	6 (40.0%)	0	15
Ownership & participation	6 (40.0%)	8 (53.3%)	1 (6.7%)	15
Problem solving skills	8 (57.1%)	6 (42.9%)	0	14
Interest & enjoyment	6 (50.0%)	6 (50.0%)	0	12
Creativity	6 (60.0%)	3 (30.0%)	1 (10.0%)	10
Differentiated learning	2 (25.0%)	5 (62.5%)	1 (12.5%)	8
Hands-on experience	4 (66.7%)	2 (33.3%)	0	6
Communication	2 (40.0%)	3 (60.0%)	0	5
Increased motivation	2 (50.0%)	2 (50.0%)	0	4
Improved self-esteem	1 (25.0%)	3 (75.0%)	0	4
Independence	2 (100%)	0	0	2
Provide challenge & choice	2 (100%)	0	0	2
Increased responsibility	1 (50.0%)	1 (50.0%)	0	2
21^{st} century skills	0	1 (100%)	0	1
Skill development (technology, time management, life-long learning, etc.)	1 (33.3%)	2 (66.7%)	0	3
"Value to students" total	111(46.4%)	116 (48.5%)	12 (5.0%)	239 (94.8%)[2]
Value to teachers				
Ease for frequent formative assessment	2 (40.0%)	3 (60.0%)	0	5
Improved teacher-student relationship	2 (66.7%)	1 (33.3%)	0	3
Practice NGSS	1 (50.0%)	1 (50.0%)	0	2
Practice different teaching skills (e.g., facilitation)	2 (100%)	0	0	2
Classroom management	0	1 (100%)	0	1
"Value to teachers" total	7 (53.8%)	6 (46.2%)	0	13 (5.2%)
Total	118 (46.8%)	122 (48.4%)	12 (4.8%)	252 (100%)

Note. [1].% of occurrence = total count for a specific keyword/phrase from participants in certain level / total count from a specific keyword/phrase from participants in all levels. [2].% of occurrence = total keyword counts in the category / total keyword counts

Teachers consider the value of PBL to their students the most dominant advantage for implementing this pedagogy. Data showed that teachers considered the value of PBL to their students the main advantage of implementing this pedagogy. One hundred and eleven out of the 120 teachers (92.5%) who answered this question brought up a variety of values that their students would receive from PBL. This category accounted for 94.8% of all keyword counts gathered from all of the responses to this open-ended question. Many keywords/phrases are included in this category and presented below are teachers' comments that contain those keywords/phrases.

PBL employs a student-centered approach which improves students' learning. "*Active learning*," "*student-directed/driven*," "*ownership*," and "*improved learning*" together were mentioned 54 times which was 21.4% of the total keyword counts. The following are comments from teachers: "*Student driven learning (intrinsically motivated to acquire knowledge)*," "*Student involvement and ownership of lessons*," "*Students get to direct the pace of their learning*," and "*Students are personally invested in the outcome of their learning, and they are able to be more creative in their learning. Additionally, students are able to individualize their work towards their personal interests*."

PBL improves the affective components of students' learning. Teachers saw a higher level of student engagement, enjoyment, and motivation in a PBL classroom, as evidenced by the following statements:

> *It is very engaging. Students connect science concepts with the problem in a more meaningful way and seem to retain the concepts longer. Students tend to ask more questions and explore ideas related to or ancillary to the problem and often explore more on their own.*

More teachers' statements expressed similar ideas: "*It's a student-centered approach. Typically students find it more enjoyable and satisfying. It encourages greater* *understanding….PBL develops lifelong learning skills,*" "*Students are usually engaged and directing their own learning in something of interest to them,*" "[PBL] *increased interest and motivation*," "*Students feel a level of control and self motivation*."

PBL promotes students' 21st century skills. Teachers also believed that PBL provided students the opportunity to improve their 21st century skills, such as problem solving and the 4Cs: communication, collaboration, critical thinking, and collaboration, which were mentioned 75 times and accounted for 29.8% of the total word counts. Here is the response from one teacher, "*By implementing PBL, the students are able to incorporate the 4Cs organically. They don't even realize that they are using all four!"* There were other similar statements, such as, "*Students work together and solve real world problems using critical thinking skills*," "*It allows students to be creative and apply earlier skills and concepts taught," "PBL increases innovation," and "Students enjoy teaching and helping each other*."

PBL provides differentiated and interdisciplinary learning opportunities and improves students' perceived competence. Learning was differentiated and integrated in a PBL context, as stated by these respondents: "*Students are learning at their own style and pace…differentiation is automatically implemented keeping the students engaged*," "*Connection between subject areas help students retain information*," and "*Cross curricular units create more relevant teaching for students*." Furthermore, teachers observed an increase in students' perceived competence as they commented that, "*Students with PBL experience rate their abilities higher*" and "*PBL improves self-esteem and increases participation*."

Teachers appreciated the "real-life" relevance of PBL. Teachers valued the real-life applicability of PBL, as illustrated by their comments: "*Science is an applied field. PBL is what makes it connected with real world scenarios*," "*It gives the chance for students to experience* *real life situations in which they can use the problem solving skills generated by PBL*," and "*It* [PBL] *gives real-life application to concepts*."

***PBL improves students' knowledge retention and application*.** Teachers associated PBL with improved students' knowledge retention and application and these were their statements: "[PBL] *Improved student learning and retention*," "[PBL] *increases the enjoyment for learning and promotes long-term retention of information*," "*Students tend to remember the information longer and are more able to apply the material in novel ways*," and "*It* [PBL] *allows students to be creative and apply earlier skills and concepts taught*."

Teachers also perceive value to themselves from implementing PBL. Several teachers liked the opportunity to perform frequent formative assessments that PBL offered. As one teacher said, "*I can perform informal assessments as I walk around*" and another said, "*Frequent assessments can be done at any time*." PBL also provided teachers a platform to incorporate NGSS into their teaching. Moreover, teachers and students developed stronger relationships in a PBL context. One teacher described it as the "*collaboration among teachers and students*." It was also illustrated in another teacher's statement:

> *My students are challenged according to their needs and I feel I can reach them more easily. The inquiry is meaningful for them and I feel I relate to their world better. Also, it opens the opportunity to a new teacher-student relationship in the classroom*.

What teachers perceive as the challenges of implementing PBL. The question "The challenges of implementing PBL in my classroom are:" received 119 responses out of the total 126 middle and high school teachers, and 42 keywords/phrases were identified from their answers. There were a total of 205 word counts and frequency of the keywords mentioned by respondents varied from 35 times for "additional time requirement" to 1 time for words like "support from peers" and "provide an open-learning classroom environment." Upon further examination, words that had similar meanings such as students' accountability and students' responsibility were combined.

Similar to the question about the advantages of PBL implementation, word categories that fit a construct in the expectancy-value theory (EVT) or self-determination theory (SDT) were established. For example, the category "effort cost to teachers" includes the following words and phrases: PBL requires more of teachers' time, scaffolding students, problem design, classroom management, and more. The category "teachers' autonomy" includes words/phrases such as covering mandated curriculum, standardized tests, state standards, and pacing guides. Occurrence of each keyword/phrase was also divided according to teachers' current use of PBL, similar to what was done for the "advantages of PBL implementation." Table 4.8 lists the categories, the words and phrases that are assigned into each category and the respective % of occurrence for teachers in different PBL practice levels:

Table 4.8

Teachers' Perceived Challenges of Implementing PBL Grouped Based on Their Current Levels of Practice

Keywords/phrases	Count (%)[1] level 1	Count (%)[1] level 2	Count (%)[1] level 3	Total count (%)[2]
Effort cost to teachers				
Additional teachers' time required	13 (37.1%)	19 (54.3%)	3 (8.6%)	35
Not enough classroom time	5 (45.5%)	4 (36.4%)	2 (18.2%)	11
Planning	2 (18.2%)	7 (63.6%)	2 (18.2%)	11
Students were not ready for PBL	7 (77.8%)	2 (22.2%)	0	9
Students' resistance to PBL	4 (50.0%)	4 (50.0%)	0	8
Problem design	4 (57.1%)	3 (42.9%)	0	7
Difficulties with summative assessment	3 (42.9%)	3 (42.9%)	1 (14.3%)	7
Students lack of motivation	5 (71.4%)	2 (28.6%)	0	7
Students lack of focus	5 (71.4%)	2 (28.6%)	0	7
Students' group work issues	3 (42.9%)	4 (57.1%)	0	7
Monitor students' progress (lack of persistence)	3 (50.0%)	3 (50.0%)	0	6
Scaffolding students	3 (50.0%)	3 (50.0%)	0	6

(continued)

Keywords/phrases	Count (%)[1] level 1	Count (%)[1] level 2	Count (%)[1] level 3	Total count (%)[2]
Students' attendance issues	2 (40.0%)	3 (60.0%)	0	5
Work with students with different abilities & paces	1 (25.0%)	3 (75.0%)	0	4
Classroom management	2 (50.0%)	0	2 (50.0%)	4
Students' frustration	3 (75.0%)	1 (25.0%)	0	4
Students' engagement issues	2 (66.7%)	1 (33.3%)	0	3
To make PBL work in a large class	1 (33.3%)	2 (66.7%)	0	3
Students' accountability & responsibility	1 (33.3%)	1 (33.3%)	1 (33.3%)	3
Provide an open-learning environment	0	1 (100%)	0	1
Dealing with students' anxiety	1 (100%)	0	0	1
"Effort cost to teachers" total	70 (47.0%)	68 (45.6%)	11 (7.4%)	149(72.7%)
Issues related to support for teachers				
Lack of resources	5 (41.7%)	6 (50.0%)	1 (8.3%)	12
Access to technology	2 (25.0%)	5 (62.5%)	1 (12.5%)	8
Collaboration with other teachers	1 (25.0%)	3 (75.0%)	0	4
Training for teachers	2 (66.7%)	1 (33.3%)	0	3
Equipment	0	3 (100%)	0	3
Space	0	2 (66.7%)	1 (33.3%)	3
Funding	2 (100%)	0	0	2
Support from administrators	1 (100%)	0	0	1
Support from peers	0	1 (100%)	0	1
"Support for teachers" total	13 (35.1%)	21 (56.8%)	3 (8.1%)	37(18.0%)
Issues related to teachers' autonomy				
Cover mandated curriculum & follow state standards	7 (53.8%)	6 (46.2%)	0	13
Pacing guides	0	2 (100%)	0	2
Prepare students for standardized tests	2 (50.0%)	2 (50.0%)	0	4
"Teachers' autonomy" total	9 (47.4%)	10 (52.6%)	0	19 (9.3%)
Total	92 (44.9%)	99 (48.3%)	14 (6.8%)	205 (100%)

Note. [1].% of occurrence = total count for a specific keyword/phrase from participants in certain level / total count from a specific keyword/phrase from participants in all levels. [2].% of occurrence = total keyword counts in the category / total keyword counts

"Effort cost to teachers" is the number one challenge for teachers' implementation of PBL. Teachers recognized that PBL implementation required additional effort from them. Various kinds of effort cost to teachers were brought up by 97 teachers out of the 119 (81.5%) respondents to this question. The major kinds are: time requirement, working with students who are not ready for or resistant to PBL, scaffolding students, and planning and problem design.

PBL requires extra time. Thirty-five respondents brought up the issue that PBL required more of teachers' time than teaching with the traditional lecture-based method, and it was the most frequently mentioned challenge. One teacher said PBL "*planning and prep time are huge for the teacher*." Interestingly, another teacher said "*It does take more time but a carefully written problem can cover multiple learning objectives at a time*."

To find enough class time to implement PBL also concerned some teachers, as one described PBL as "*...needing to allow more time for the students to assimilate the information as opposed to giving them the information*." Another teacher also faced the issue of not having enough class time to implement PBL, although the reason for lack of time was different. This teacher said "*Seems like there is never enough time to allow students to get through projects. Not because they are slow but because they are engaged & want to explore & continue projects.*" Regardless of the teachers' reasons that caused shortage of classroom time, they probably faced the same consequence, which was noted by another teacher, "*Problem-based learning is time consuming in that it is often difficult for me to embed ALL the concepts and content that I am expected to cover*."

Planning and problem design are not easy tasks. One teacher said "*Most of the planning for PBL is up front. Sometimes it is difficult to plan for contingencies*." Another teacher said, "*Creating suitable problem scenarios is difficult*," which reflected the challenge of developing problems or lesson plans that would provide students great learning experiences. Furthermore, the statement, "*My curriculum doesn't always lend itself to PBL structure*" from an English/Language Arts teacher suggested that teachers of certain subjects might face additional challenges in terms of designing a PBL unit.

Students' lack of readiness, resistance to PBL, and need for intense scaffolding. Teachers perceived that not all students were ready for PBL, as described by the following statements: "*The functioning level of my learners is a challenge, along with their independence to utilize and express their learning*," and "*Lacking foundation of solid education in previous years of my students' academic lives*." In addition to lacking the readiness for PBL, some students showed resistance, "*Some students don't want to engage in the higher level thinking because it does involve more effort on their part. They can also get frustrated if the problem is drawn out for too many days*." Resistance to PBL was not limited to students who were struggling academically; some advanced students also did not embrace PBL.

Students also needed guidance to evaluate the credibility of information, as described by this teacher's comment:

> *Keeping students on track, assuring their use of appropriate resources - just because it's on the internet doesn't mean it's accurate or useful information - training them in the use of techniques for direction and discovery. Helping them to process the information…. distilling the salient features, etc.*

It's clear that scaffolding is essential for students' learning in a PBL context, as one respondent reported the challenge for implementing PBL was "*The need to scaffold intensively for standard students*."

Teachers' effort is required to maintain productive group-working dynamics among students in an open and collaborative environment. Working in small groups was a common practice of PBL and it was an issue that teachers needed to pay attention to as described by one teacher; "*Group dynamics issues may require faculty intervention*." This teacher figured out a way to deal with the problem and she said, "*The biggest challenge to PBL is getting all the* *students to work as a group. In many cases, some students are content to try to let their partner do all the work. I have managed to minimize that problem through the use of rubrics that contain group components and individual components*." Teachers could also create an open and collaborative classroom environment to encourage students working in groups, as stated by another teacher.

The collaborative nature of PBL also involved difficulties caused by students' attendance issues. One teacher commented, "*Student absences affect groups who work on projects together*." The other one said *"It is difficult to help students who are absent due to illness or sports to catch up*." In addition, maintaining students' engagement and focus in a PBL context could also be challenging.

How to assess students' progress in a PBL context. Teachers were confronted with two difficulties in terms of making assessments for PBL. The first one was, "*...deciding how to grade it."* One teacher put it this way: "*It is difficult to measure the effectiveness of PBL. We can measure implementation but have not found a system to measure effectiveness."* Another difficulty with PBL assessment was that "*Grading is challenging when parents expect to see frequent grades and PBL lends itself to fewer summative grades*."

Teachers need more support to help them implement PBL. Teachers' responses indicated that they did not have all of the materials and equipment for conducting PBL. They also did not always have the support from administrators to implement PBL for different reasons, such as, "*Students don't want to learn this way. They would rather be spoon fed, and their pushback causes administration to not be supportive of this type of pedagogy*," and "*...lack of support from administrators in the county because there is little evidence about the impact on test scores*." In addition, four teachers stated that "…*having coworkers with whom to* *collaborate is not easy*," although they estimated that between 50% and 100% of the teachers in their schools used PBL. The challenges reported by them included "…*finding time to collaborate*" and "*Colleagues that are not flexible/fixed mind sets."*

Issues with teachers' autonomy to implement PBL. Teachers' independence and the decision of implement PBL was complicated by the fact that they needed to cover the mandated curriculum as specified in state standards and prepare students for the high-stakes standardized tests. There was one response which contained only the acronym "*EOC* [End of Course]" as the challenge for implementing PBL. The following were two examples that illustrated teachers' effort to teach mandated curriculum: "*Fitting this* [PBL] *into the curriculum in a meaningful time frame (so it doesn't detract from other units that must be covered)" and "Covering curriculum in the very regimented pacing dictated by my county*."

Overall, teachers have positive views about PBL. The last question of the survey was an open-ended question "Is there anything else that you would like to say about PBL?" and 36 teachers responded to this question. Overall, teachers who responded felt positively about PBL, as illustrated by the following statements from three teachers:

From teacher 1:

> *I teach at a charter school that is structured around PBL, and we have been implementing it successfully for about 8 years. It has been a process, and our ideas about it are always expanding, but we have found it to provide an incredibly rich set of learning experiences for students and the entire school community. The Presentation of Learning is an important piece, and this gives students a lot of accountability in owning their work and doing it well.*

From teacher 2:

I really like the idea of students directing their learning. One student in particular shines when he is able to share what he learned. There are others who you never hear from and then when it is time to share - they have a voice and they are proud of themselves.

From teacher 3:

When designed well, students have the opportunity to see how curriculum prepares them for future career options. Additionally, it allows students to have real-life importance to their learning and working tasks that has the 4Cs embedded throughout the learning challenge presented to them.

Teachers need training for PBL implementation. Teachers also expressed their opinions about the pre-requisites they needed in order to implement PBL successfully. First of all, teachers needed to know what PBL is, as suggested by one teacher, "*I think we should definitely have professional development opportunities to let teachers know that this is a strong method for reaching all students*." They also needed professional training to learn how to do PBL, as this teacher shared his experience:

I was given the opportunity to spend a paid week planning a PBL during the summer. I was also given days within the school year to reflect with a partner and split the work in which I was compensated. I had help from outside agencies which aided in the process of implementation. Had I not been given the time, money, resources, and outside help, I would NOT have been successful what so ever in the implementation of my PBL. Nor would it have been a true real world experience. These kind of projects are phenomenal for students and educators but there is not enough time allowed during a traditional school day to complete all the work and planning that goes into [it]. *The compensation was also helpful in the entirety of the week that I spent during the summer learning and* *planning. It made the project more worthwhile and made me feel as if for once in teaching I was a professional.*

Balancing the use of PBL with other teaching methods. Teachers did not believe that PBL should totally replace traditional teaching methods. One teacher said "*I don't think it would work in every classroom or even for every lesson. I think, with all things, PBL should be used in moderation and with the instructors' discretion*."

Students need to be prepared for PBL. One teacher expressed her opinion of PBL as a "*Great idea but need to give students strong foundation skills*." One teacher suggested conditioning students with problems of smaller scale first:

> *I think it's important for students to have background knowledge prior to working on a project in the area. We start with basic projects and then move to more complex projects where students have more choices and less structure. For me, balancing non-PBL with projects works well.*

Teachers like collaboration and knowledge-sharing among peers. Teachers felt that "*It would be great to receive lessons that have worked for other teachers at a localized web site*." They also liked to have lesson plans that fit the state standards, as described by this comment, "*If I receive training, I would like to see examples with direct alignment with state standards."* Also, it would be ideal if there were a collection of PBL lesson plans for different subjects and students with special needs, as illustrated by this statement:

> *I would like to see a model and data of how this method is successful for the low incident special education population at the secondary level. I have yet to see a model that aligns with the EXTEND I common core standards using the Unique Learning System as a Problem Based Learning style/method of instruction.*

Does PBL have adverse effects on students' EOC scores? Teachers seemed to have different opinions in terms of whether PBL would have adverse effects on students' EOC scores. On the one hand, there are statements like, "*When implemented well, it works to inspire students at a MUCH deeper level. However, 100% PBL without directly teaching test taking skills can have a negative impact on standardized test scores,*" and "*Teaching 8th grade Math & Science links me to a Math 8 EOG, Math I EOC, & Science 8 EOG. I have to pick in developing their real-world skills or performing on standardized tests*." On the other hand, one teacher said the following:

> *I use it daily, and my students that range from struggling level 2's to high achieving 5's, do well both in the classroom, and on their EOC's (end of course state tests). Normally their EOC's score are the highest in the system, and often some of the highest in the state.*

Support from administrators and peers. Teachers addressed the issues about support from schools and other teachers while answering the question about the challenges they faced in implementing PBL. Here they reiterated the importance of "support" by saying "*PBL… will only work in an environment where the administration is supportive. PBL is especially tied to the school culture, so I believe it will work best if several teachers in the school are following that model*."

Summary. Findings from teachers' response to the three open-ended questions are summarized as follows:

- Teachers considered the value of PBL to their students, such as students' improved understanding, learning engagement, knowledge transfer, and 21st century skills as the main advantages of PBL implementation.

- Teachers also benefited from PBL implementation, such as improved teacher-student relationships.
- The extra time required to prepare and implement was the main challenge that teachers faced in implementing PBL.
- It required extra effort from teachers to follow the pacing guides and cover mandated curriculum while incorporating PBL into their teaching.
- Teachers sometimes had to deal with students' lack of readiness and/or resistance to PBL.
- Teachers needed professional training to learn the "What," "Why," and "How" of PBL.
- Teachers needed to develop a balance between the use of PBL and direct teaching so students could benefit from PBL and their performance on EOC would not be negatively affected.
- It would be beneficial if teachers would share their PBL lesson plans that worked well for them with other teachers.
- Support from school administrators and other teachers was essential for a successful PBL implementation.

Data from Administrators

Four administrators completed the survey. Their average score for each item was calculated and compared with those of teachers', as shown in Table 4.9. No statistical analyses were conducted due to the small sample size.

Table 4.9

Comparison of Administrators' Responses with Teachers' Responses

	Survey item	*M* Administrators *n* = 4	*M* PBL group *n* = 126	*M* non-PBL group *n* = 30
General concept about PBL	PBL should use open-ended driving questions that allow students to develop more than one reasonable, complex answer.	5.50	5.20	5.00
	With PBL, it is totally up to the teacher to give students feedback about the quality of their work-in-progress.	2.50	3.05	3.14
	In a PBL classroom, the teacher functions as a facilitator and therefore no content teaching is necessary.	1.75	2.05	2.50
	I believe PBL is a pedagogy that is more appropriate for motivated students.	2.25	3.54	4.00
	PBL gives too much responsibility to students.	2.00	2.32	2.77
	PBL is especially effective for students with low ability.	4.25	3.48	2.97
	Students with limited English language skills have trouble with PBL.	3.00	3.44	3.62
Perceived competence in practicing PBL	I feel confident that teachers can successfully assess students' learning progress in a PBL setting.	5.25		
	I feel confident that I can successfully assess students' learning progress in a PBL setting.		4.67	3.97
	I am not sure that teachers can teach with PBL in ways that meet state and district standards.	2.00		
	I am not sure that I can teach with PBL in ways that meet state and district standards.		2.71	3.80
Value of PBL to students	PBL does not help students to obtain a deeper understanding of the content knowledge than they do in a traditional classroom.	1.50	2.09	2.53
	Using PBL causes students to have negative attitudes toward learning.	1.50	2.06	2.47
	In PBL, students engage in issues relevant to their lives/communities.	5.25	4.99	4.60
	PBL stimulates students' creativity.	5.75	5.40	5.00
	PBL enhances students' collaboration and communication skills.	5.50	5.39	4.93
	PBL promotes students' critical thinking.	5.75	5.39	5.03
Perceived cost in practicing PBL	I am concerned that PBL can lead to students missing out on learning important basic concepts.	1.50	2.90	3.63

(continued)

	Survey item	*M* Administrators *n* = 4	*M* PBL group *n* = 126	*M* non-PBL group *n* = 30
	Teaching with PBL would require more of teachers’ time than traditional lecture-based teaching.	4.75	4.06	3.93
	Preparing to implement PBL would require too much of teachers’ time.	3.00		
	Preparing to implement PBL would require too much of my time.		3.21	4.30
	Teachers have easily accessible resources (e.g., technology, materials, or examples of PBL in their subject areas) for implementing PBL.	3.75		
	I have easily accessible resources (e.g., technology, materials, or examples of PBL in my subject areas) for implementing PBL.		3.66	3.37
	Implementing PBL will make classroom management more difficult.	2.25	2.75	3.43
	It will be too stressful for teachers to cover the mandated curriculum if they implement PBL.	2.00		
	It will be too stressful for me to cover the mandated curriculum if I implement PBL.		2.91	3.77
	I worry that PBL might have a negative impact on how students score on the end-of-course tests.	2.00	3.22	3.97
	I am concerned that implementing PBL at my school might have a negative impact on my administrative evaluation.	1.50		
	I am concerned that implementing PBL at my school might have a negative impact on my teaching evaluation.		2.28	2.80
	I believe that the overall benefits from implementing PBL would outweigh the costs.	5.25	4.60	4.00
Perceived autonomy in implementing PBL	Teachers should make their own decisions whether they want to implement PBL or not.	2.75		
	I decide whether I implement PBL or other teaching methods.		4.81	4.80
	My school does not pressure teachers to implement PBL.	3.75		
	I feel pressured by school administrators to implement PBL.		2.65	2.50
	I provide teachers choices and options in terms of implementing PBL or other teaching methods.	4.25		
	My school administrators provide me choices and options in terms of implementing PBL or other teaching methods.		4.52	4.70

(continued)

	Survey item	*M* Administrators *n* = 4	*M* PBL group *n* = 126	*M* non-PBL group *n* = 30
Perceived support in Implementing PBL	The instructional methods that teachers use are driven by state standards.	3.50		
	The instructional methods that I use are driven by state standards.		4.79	4.80
	I feel that as an administrator I support teachers to implement PBL.	5.00		
	I feel supported by my school administration to implement PBL.		4.79	4.57
	People at work care about my experiences with PBL.	3.50	3.82	3.48
	There are not many people at work who are willing to help teachers with implementing PBL.	3.25	2.97	3.70

The four administrators felt confident that their teachers could teach PBL and meet state and district standards, and assess students' learning progress in a PBL setting. They agreed with the values that PBL would bring to students in their schools, and they did not perceive the "psychological cost of failure" associated with PBL implementation. They recognized themselves being supportive to their teachers for PBL implementation, and they agreed that teaching with PBL would require more of teacher's time than traditional lecture-based teaching. The administrators sent mixed signal in terms of teachers' autonomy in implementing PBL—they responded to item "My school does not pressure teachers to implement PBL" with "somewhat agree;" however, their response to item "Teachers should make their own decisions whether they want to implement PBL or not" was "somewhat disagree."

Administrators would like teachers to receive training for PBL implementation. All four administrators expressed their desire for teachers to receive training for designing/structuring PBL lessons and units, and assessments (formative and/or summative). Three out of four administrators would like to see teachers obtain training in changing from direct instruction to facilitating. Finally, two out of four administrators would like to see teachers receive training in classroom management for PBL implementation.

What are administrators' perceived advantages and challenges of implementing PBL in their schools? The most frequently mentioned advantages were the 21st century skills: communication, collaboration, creativity, critical thinking and problem solving. In terms of challenges, "time" was mentioned by all four administrators, followed by resources/funding by two administrators, teacher training by one administrator, and preparing students for this innovative pedagogy by one administrator.

Summary

In this chapter, quantitative data from the survey instrument were compiled and analyzed. Data presented include teachers' demographics, their training and use of PBL, comparisons of teachers with or without PBL experience in terms of their conceptions of PBL, and various factors that might influence teachers' perception of and motivation for PBL implementation. Qualitative data collected from teachers' responses to the open-ended questions were also compiled, summarized, and presented.

Data indicated that teachers with PBL experience had significantly higher levels of perceived competence, value, and cost in implementing PBL than teachers who did not have PBL experience. Further analysis of teachers with PBL experience revealed the influence of teachers' PBL training on their intention to implement and their perceived competence, value, and cost of this pedagogy. Results from the multiple linear regression also revealed that teachers' composite factor scores predicted their intention to continue practicing PBL, with factor 1, the "value" factor, being the strongest predictor.

Qualitative data from the open-ended survey questions also fit the theoretical framework of the instrument and triangulated well with the quantitative data. The value of PBL to teachers and their students was identified from the qualitative data as the major and only advantage of PBL. Effort cost to teachers, issues related to support for teachers, and teachers' autonomy were the major challenges for PBL implementation. Finally, responses from four administrators who completed the survey were compiled and presented in this chapter. No statistical analysis was performed on the administrators' data due to the small sample size. In Chapter five, results from the current study will be discussed and inferences will be made from the findings. Finally, conclusions and implications will be drawn in Chapter six.

CHAPTER FIVE

DISCUSSION

The goal of the current study was to examine factors that could potentially motivate secondary teachers to implement PBL. These elements are grounded in expectancy-value theory (EVT) by Eccles et al. (1983) and self-determination theory (SDT) by Ryan and Deci (2000b), two well established theories to examine the motivations underlying human behaviors. Survey responses were analyzed and yielded a 3-factor model. This affirmed that the survey items measured teachers' motivation to implement PBL, based on constructs of EVT and SDT—teachers' perceived competence, value, cost, autonomy, and their perceived support from administration and peers. Statistical analysis was performed to compare the perceptions between teachers who had taught with PBL (the PBL group) and teachers who never used PBL (the non-PBL group). Any significant differences in these conceptions between the two groups of teachers would indicate that teachers' perceived competence, value, cost, autonomy, and support from administration and peers in practicing PBL are associated with their use of this pedagogy. In this chapter, the quantitative and qualitative data will be triangulated and the findings presented in Chapter Four will be discussed.

Differences between PBL and Non-PBL Teachers

The PBL and non-PBL group teachers were compared in order to answer the first research question "Are there differences between teachers with and teachers without PBL experience in terms of their perceptions of PBL, training, perceived ability, and motivation in implementing this pedagogy?" There were significant differences between the PBL and non-PBL group of teachers for all five items in the instrument's subscale of teachers' expectancy for success/perceived competence in implementing PBL. Overall, teachers with PBL experience felt competent and expected to succeed in implementing PBL. On the other hand, teachers who had never taught with PBL did not feel competent, and questioned their ability to overcome issues such as students struggling with this pedagogy and meeting rigid state requirements. Actually, close to one-third (30.0%) of teachers in the non-PBL group attributed not practicing PBL to their lack of perceived competence. These findings are consistent with the theoretical motivational models, expectancy-value theory and self-determination theory which state that individuals are more motivated to engage in certain activities if they perceive themselves to be competent and likely to succeed in the endeavor (Eccles et al., 1983; Ryan & Deci, 2000b).

Both groups of teachers agreed that students will benefit from PBL, such as obtaining a deeper understanding of the content knowledge and building their 21st century skills, although the agreement level was significantly higher among the PBL group teachers. Also, both groups of teachers recognized the usefulness of PBL; however, there were significant differences in the intrinsic and attainment values each group placed on PBL. Indeed, the item that measured teachers' interest in implementing PBL has the largest difference between the two groups of teachers.

Teachers with PBL and teachers without PBL experience both recognized the cost associated with implementing this pedagogy, although the non-PBL group teachers had significantly higher levels of anxiety and concerns about the effort required for this pedagogy. Both groups of teachers agreed that PBL would require more of teachers' time than traditional lecture-based teaching. However, they did not agree in terms of whether they felt this time requirement was too demanding, and teachers in the PBL group were more willing to invest their time in this instructional method. Actually, this "PBL requires too much of my time" question elicited the greatest difference between the two groups of teachers among all items in the "cost" category. This finding suggests that the PBL group teachers were aware that teaching with PBL required more time than the traditional teaching. However, they were willing to invest their time because they believed that the overall benefits from implementing PBL would outweigh the costs.

The comparison between the PBL and non-PBL groups demonstrated that teachers with PBL experience felt more competent, placed higher value and less cost on PBL implementation. This is what would be predicted using the EVT frameworks; teachers who feel competent and whose value outweighs the cost are more likely to choose PBL (Tollefson, 2000). These findings are consistent with studies that investigated individuals' motivation for achievement-related behaviors, ranging from teachers implementing computer technologies in the classrooms to students' intent to stay in their STEM major (Perez et al., 2014; Peters & Daly, 2013; Wozney et al., 2006),

Teachers in both groups believed that they had the autonomy to implement PBL or not. Autonomy is important because, according to the SDT model, in addition to the feelings of competence, people must experience their behavior as self-determined in order for them to sense the intrinsic motivation for that behavior (Ryan & Deci, 2000b). Both groups also felt supported by school administration to implement PBL. However, teachers did not perceive support from peers as strongly as that from administration and this was particularly true for teachers belonging to the non-PBL group. There were no data collected during the current study that would help us to understand why teachers with no PBL experience were less likely to feel supported by peers than did teachers with PBL experience. It might be that there was not a collaborative and supportive culture in the schools of the non-PBL teachers. It is also possible that teachers in the non-PBL group were generally from schools in which peer teachers' understanding about and implementation of PBL were limited, thus they did not feel comfortable to help their peers in practicing this innovative pedagogy.

What Factors Affect Teachers' Perceived Competence, Value, Cost, Autonomy, Support, and Their Intention in Implementing PBL?

After organizing multiple variables into a model represented by factors in EVT and SDT, these factors were used to answer the second research question, "Are there underlying factors that predict teachers' perceptions of PBL and their intention to implement it?" Multiple linear regression established two parsimonious models as follows:

Intention = 4.70 + 0.684 x Factor 1 score (r^2 = 0.463)

Intention = 4.70 + 0.305 x Factor 2 score + 0.431 x Factor 3 score (r^2 = 0.403)

These results suggested that teachers' perceived value, competence, cost, support, and autonomy all could be significant predictors of their intention to implement PBL. However, two regression models were established because factor 1, the "value" factor, had the most dominating impact on teachers' intention to implement PBL. Adding factor 2 and/or 3 to the regression model in addition to factor 1 only minimally increased the proportion of the variance in teachers' intention that was predictable from the independent variables. That is, teachers' valuing of PBL was the greatest predictor of their use of PBL. The way this worked is similar to what happened in the study by Sheingold and Sheingold (2013), which used a social capital survey instrument to measure the nursing work environment and predict workers' job satisfaction. The social capital of nursing (SCON) instrument had five factors were extracted by exploratory factor analysis. Composite scores for each factor were calculated and used as independent variables for regression analysis to predict employees' job satisfaction and intention to stay. Although all of 5 factors were significant and positively associated with job satisfaction; factor 1(external trust, solidarity and empowerment) had the most impact and was the only subscale that significantly predicted workers' job satisfaction and intention to stay (Sheingold & Sheingold, 2013).

In the PBL study, variations in teachers' PBL training were also associated with differences in their intention to implement PBL. There were two kinds of variations: the type of training (formal and/or informal) and the length of the formal training. Examples of informal training included learning from peers or self-taught; and attending professional development workshops was an example of formal training. A trend was observed: teachers who had received formal training had higher levels of perceived value, competence, autonomy, support, and intention in implementing PBL than teachers who only had informal training. However, teachers with both informal and formal training had similar intentions and factor 1 scores as the "formal training only" group, and their factor 2 and factor 3 scores were lower than the "formal training only" group. These two groups had a comparable amount of formal training, thus these differences were not attributable to the amount of formal training that teachers received. It is unclear why informal training had a negative impact on teachers' perceived competence, cost, autonomy, and support about PBL, instead of having an additive or even synergistic effect on formal training, as may have been expected.

Not only did having formal training improve teachers' perception of and intention for PBL implementation, the amount of formal training also mattered. Data showed a general trend that teachers' intention to implement PBL and their factor scores increased as their formal PBL training lengthened. Teachers with six to ten days of formal training had significantly higher intention to implement PBL than teachers with two to five days of training did. Regression analysis results also indicated that the amount of formal training positively predicted teachers' perceptions of PBL implementation. However, the improvement for intention, factor 1(value), and factor 3 (autonomy and support) scores all plateaued at 6-10 days of training; receiving more than 2 weeks of formal training only showed a positive impact on teachers' factor 2 (competence and cost) score.

Insufficient professional training is one of the most frequently cited barriers for pedagogical change (Brownell & Tanner, 2012; Owston, 2007). The international study by Owston (2007) examined the factors that sustained an innovative pedagogy involving technology use in 174 schools in 28 countries, and sustainability was defined as "the innovation having carried on for a period of more than 2 years without extra fiscal resources" (p. 67). This study found that teacher professional development was essential for the sustainability of an innovative pedagogy and a solid professional development program was found in all 59 schools that past the criterion of sustainability for the new pedagogy.

Another study that demonstrated the importance of professional development is the Local Systemic Change (LSC). LSC was a National Science Foundation funded initiative which included 88 projects that provided up to 130 hours of professional training around mathematics, science, and technology education to 70,000 primary and secondary teachers between 1995 and 2002 (Banilower, Boyd, Pasley, & Weiss, 2006; Weiss & Pasley, 2006). The evaluation of this project (Banilower et al., 2006) found that teachers with 60 or more hours of professional development were more likely to report positive outcomes than teachers with less than 60 hours of training. However, most of these positive changes occurred in the first 80 hours of professional development and three seemed to be a limited impact beyond 80 hours of training (Banilower et al., 2006). Findings from the current PBL study also suggest that the positive impact from PBL formal training seemed to level-off around two weeks.

Findings also indicated that teachers' current level of PBL practice positively predicted their perceived competence, value, autonomy, support, and intention for PBL implementation. Bandura (1977) stated that performance accomplishment was a major source of information for self-efficacy. Individuals' performance accomplishment is based on personal mastery experiences, thus it makes sense that more frequent practice of PBL increased teachers' perceived competence in using this pedagogy. It is reasonable to infer that teachers continue using PBL when they perceive the overall benefits from this pedagogy outweigh the total costs. The overall benefits have many aspects, ranging from value to teachers and their students to the feeling of competence and relatedness among peers. This highlights the importance of providing an environment that supports and cultivates teachers' perceptions of competence, value, autonomy, and lessened anxiety for PBL, so they will persist in practicing this innovative pedagogy. However, one issue that deserves special attention is that teachers who occasionally practice PBL have significantly lower level of perceived competence and higher level of anxiety in implementing PBL, compared with teachers who practice PBL on a regular basis. It will be worthwhile to develop strategies that would help teachers who value PBL but hesitate to use it regularly to overcome their anxiety and lack of competence in using this pedagogy.

Summary.

- Two regression models were developed that evaluated the predictive power of teachers' perception about PBL on their intention to practice it.
- Teachers' perceived value of PBL was the strongest predictor and positively predicted their intention to implement PBL.

- Teachers who received formal training in using PBL had higher levels of perceived value, competence, support, autonomy, and intention to implement PBL than teachers who only had informal training.
- The amount of formal training that teachers received positively predicted their perceived value, competence, support, autonomy, and intention to implement PBL. However, this impact seemed to level off around 2 weeks of training.
- Teachers' frequencies of practicing PBL positively predicted their perceived value, competence, support, autonomy, and intention in implementing PBL.

Teachers Perceived Advantages and Challenges, and Their Overall Views of Implementing PBL

Several open-ended questions were included in the instrument to ask respondents to report their perspectives and thoughts on PBL implementation in their own words. Open-ended questions enabled respondents to provide reasons or background information informing their selection of fixed response questions (Fielding, Fielding, & Hughes, 2013). Open-ended questions also allow researchers to have a deeper understanding about a respondent's position on an issue (Stoneman & Sturgis, 2012). Furthermore, quantitative data from the fixed-response questions and qualitative data from open-ended questions are often triangulated and hopefully obtain convergence from different research methods (Poncheri, Lindberg, Thompson, & Surface, 2008). Data collected from teachers' responses to these open-ended questions were used to answer the third research question "What are teachers' perceptions of the advantages and challenges for implementing PBL?

Teachers perceived the value of PBL to their students as the major advantage for implementing this pedagogy. A high percentage (95.2%) of the participants responded to the question which asked them to state the advantages of implementing PBL. Only teachers who had PBL experience had access to this question, so all responses were from teachers' first-hand classroom experiences instead of perceptions formed from observation or reading. Value of PBL implementation to their students were most frequently mentioned in teachers' responses to this question, and 111 out of the 120 teachers (92.5%) who answered this question brought up a variety of values that their students would receive from PBL. Based on the frequency of word count, almost all responses (94.8%) related to certain aspects of value that their students would receive from PBL implementation. This is different from the quantitative data, in which both the value of PBL to teachers and value of PBL to their students were considered important motivational factors for teachers' intention to implement PBL. Actually, the eleven items in the "value" factor were about equally distributed between these two kinds of value.

The average score for all survey items in "value for students" was compared with that of all items in "value for teachers." The results indicated that although teachers agreed that PBL was valuable to themselves and to their students, they placed a higher level of agreement on the value of this pedagogy for their students. This could partially explain why teachers' responses to the open-ended question were skewed towards "value of PBL to their students." It is also plausible that due to the wording of the open-ended question, teachers put more emphasis on the value of PBL to their students when they read the item that asked them to state the "advantages" of implementing PBL in their classrooms.

Teachers strongly appreciated the value of PBL for improving their students' 21st century skills. Overall, words like communication, collaboration, critical thinking, creativity, and problem solving were all in this category and 29.8% of the word count fell under this group. This is consistent with teachers' responses to items that measured their perceived value of PBL to their students. These results are in line with what researchers have found in the past. PBL has been shown to have a positive effect on students' higher-order thinking skills (Jerzembek & Murphy, 2013; Liu et al., 2012; Tarhan et al., 2008; Wong & Day, 2009), abilities in problem solving (Becerra-Labra et al., 2012; Stanley & Marsden, 2012), and collaboration (Becerra-Labra et al., 2012; Stanley & Marsden, 2012).

Student-centered active learning and related concepts such as knowledge application, and ownership/responsibility accounted for 22.2% of the word counts in this category. Previous studies have shown that implementing PBL in secondary education classrooms improved students' self-regulated learning (English& Kitsantas, 2013, Filcik et al., 2012; Jerzembek & Murphy, 2013; Sungur & Tekkaya, 2006), enhanced knowledge retention and application (Becerra-Labra et al., 2012; Jones, 2008; Wong & Day, 2009), and increased conceptual learning (Vasconcelos, 2012). Findings from the current research are consistent with the results of previous studies.

Words related to students' affective domain of learning were mentioned 45 times, which accounted for 19.9% of all keywords mentioned. Responses from the current study demonstrated that teachers believe that PBL improved students' interest in learning, in line with the findings from previous studies (Liu et al., 2012; Marle et al., 2014). Teachers also believed that PBL enhanced students' engagement, similar to other research findings (Armbruster et al., 2009; Muehlenkamp et al., 2015), and that PBL motivated students, as illustrated by earlier studies (Liu et al., 2012; Marle et al., 2014). However, the current study is based on data from teachers who practice PBL, which is different from earlier studies that mainly examined students in a PBL context.

The phrase “relevant to real life” received 23 counts, close to one-tenth (9.1%) of the total count of how teachers described benefits of PBL to their students. Similar to solving well-structured problems that students typically receive in the classrooms, solving real-life, interdisciplinary ill-structured problems requires domain knowledge and justification skills to support the problem solution (Chin & Chia, 2006). Additionally, Chin and Chia (2006) explain that solving ill-structured problems requires skills in regulating cognition, such as planning, monitoring and evaluating progress, and modifying goals when necessary. The “real-life” focus of PBL problems also motivates students to learn and retain knowledge thus improves the quality of learning (Chin & Chia, 2006; Vardi & Ciccarelli, 2008). This study documents that PBL teachers are aware, through firsthand experience, of benefits to students that have been documented in studies focusing on students.

Finally, it was encouraging to see that teachers believed that PBL improved students’ self-esteem and confidence in learning, which was demonstrated in the study on middle school students by Liu, Hsieh, Cho, and Schallert (2006). Teachers in the current study also appreciated that PBL provided a context for students developing learning styles according to their abilities and interest. However, it is important to recognize that the appropriate types and amount of scaffolding, and students’ use of these scaffoldings are required for successful differentiated learning (Simons & Klein, 2007). PBL teachers in this study understood this concept and they provided scaffolding to their students in the PBL classroom according to the students’ needs, as reported in teachers’ responses to the survey question.

Value to teachers from implementing PBL was a relatively minor component in their total responses and it only accounted for 5.2% of all the keywords/phrases count. Quite a few teachers felt that in a PBL context they could do frequent formative assessment. This was a beneficial practice, as teachers could use information gathered from formative assessment to make instructional decisions that supported students' needs at that time. In other words, teachers could use formative assessment as "assessment *for* learning, not assessment *of* learning" (Trauth-Nare & Buck, 2011). No teachers mentioned any advantage for summative assessments in a PBL classroom. This is not surprising, as assessment has been one of the most controversial issues in PBL (Savin-Baden, 2004; Pedersen et al., 2009). Overall, this is an area in which that teachers need more support, as more than half (53.2%) of the teachers indicated assessment, whether formative or summative, as what they desired more training in.

Several teachers mentioned that PBL helped them relate to their students better and how the "collaboration" between the teacher and students in a PBL context facilitated the development of relationships with students. A meta-analysis by Roorda, Koomen, Spilt, and Oort (2011) revealed positive associations between healthy teacher-student relationships and both student engagement and achievement. In addition, Spilt, Koomen, and Thijs (2011) suggested in their review paper that teacher-student relationships might affect teachers' wellbeing, on both personal and professional levels.

Effort cost to teachers is the major challenge to implement PBL. The survey item "The challenges of implementing PBL in my classroom are" also had a high response rate (94.4%). Various kinds of effort cost to teachers were brought up by 97 teachers out of the 119 (81.5%) respondents to this question. Based on the frequency of word count, close to three quarters (72.7%) of the keywords/phrases mentioned were related to certain kinds of effort, be it the additional time required, planning and designing problems, or classroom management. Two types of cost items were included in the survey instrument to measure teachers' perceived cost about using PBL; one was the effort cost and the other one was the psychological costs of failure.

Teachers were significantly less likely to be concerned with issues resulting from failures in implementing PBL, such as a negative impact on their teaching evaluation, compared to their concerns about the effort required by this pedagogy, such as the extra time needed for PBL.

These findings demonstrate the multi-dimensional nature of the "cost" construct and are in line with the work by other researchers (Flake et al., 2015; Perez et al., 2014). The study by Perez, Cromley, and Kaplan (2014) examined motivational factors for college students' intention to remain in a STEM major, using EVT as the theoretical framework. Their results showed that while students who perceived the STEM major as requiring too much effort or as requiring them to forego other valued activities were more likely to intend to leave the major, psychological cost was not related to their intent to leave the STEM major. The differential relation of the three cost variables to students' retention intentions supported the multi-dimensionality of the cost construct (Perez et al., 2014).

Out of all of the effort costs, teachers most frequently responded that PBL required more of teachers' time and classroom time, which were challenges for practicing this pedagogy. Together, these two types of time as costs accounted for 22.4% of all words teachers included in the "effort cost to teachers" category. Previous PBL studies have also shown that one challenge teachers had to face was the amount of time it took to plan for and implement PBL (Ertmer & Simons, 2006; Ribeiro, 2011).

Planning and problem design were also brought up as challenges for teachers in implementing PBL. One teacher reported that "*Lots of planning required on the front end*" was a challenge to her when using PBL. Planning for PBL is very different from preparing traditional lessons. Teachers need to anticipate the many different paths students will take to solve the problem and prepare the relevant resources required (Ertmer et al., 2009). Ertmer et al.

(2009) asserted that this is more involved and difficult than preparing for traditional lessons, in which teachers direct learning activities and exercise higher level of control in terms of what resources are needed.

One teacher reported the challenge of "*Coming up with real to life scenarios*" for the problem design. Designing good problems does require effort from teachers, but they are important. Good problems should lead students to achieve the learning goals as intended by the curriculum (Sockalingam, Rotgans, & Schmidt, 2012). In order to accomplish this goal, a problem should interest students, be sufficiently clear, and be of appropriate difficulty level in addition to being able to stimulate students' critical thinking, and relevant and enable application which are the essence of PBL (Sockalingam & Schmidt, 2011). Teachers in this study described how difficult this can be. Hung (2006) came up with a 3C3R problem designing model which used researching, reasoning, and reflecting (3Rs) to design problems that were connected and taught appropriate contents in an authentic context (3Cs). However, there was no evidence that teachers were familiar with the 3Cs and/or the 3Rs, based on their responses to the survey questions.

It is important to recognize that the teachers in this study followed state standards whether they practice PBL or not. Meeting state standards includes covering the mandated curriculum, following a rigid pacing guide, and preparing students for high-stakes standardized tests of which students' performance is still used to measure students', even teachers' accomplishment. PBL is not known for helping students gain content knowledge through the process of doing and making inquiries, as demonstrated by students' performance on tests that measure their content knowledge (Albanese & Mitchell, 1993; Berkson, 1993; Nandi, Chan,

Chan, Chan, & Chan, 2000; Vernon & Blake, 1993). Yet, 15% of the PBL teachers believed that students not only gained content knowledge through PBL, but also retained it.

One way to integrate inquiry and active-learning of PBL with content knowledge acquisition is to directly reinforce the content and learning goals through lecturing, although it is generally not an endorsed practice in PBL (Ertmer & Simons, 2006). One PBL teacher in the study said it well in the "overall comments" about PBL:

> *It* [PBL] *is one of many tools in our teaching tool box. It is important to use the tools that are most effective for our course and the students in that course….The wisdom is in knowing when to use the PBL approach and when to use the traditional approach, and everything in between.*

Another effort that challenged PBL teachers' implementation of PBL related to their perceptions of students' lack of readiness and resistance to PBL. They described how the transition from the traditional passive learning to self-directed learning in PBL can be discomforting to students. Students felt uncertain about their roles and how they would be evaluated in a PBL context. Similar to earlier studies that reported issues related to managing group work in PBL (Ertmer et al., 2009; Hung et al., 2008), teachers in the current study also faced challenges in student group functioning. The study by Vardi and Ciccarelli (2008) found the following strategies quantitatively and qualitatively improved group discussion: (1) providing students clear guidelines for discussion, (2) having them practice group discussion according to the guidelines, and (3) aligning these discussions with assessment. Data from the Vardi and Ciccarelli study (2008) showed that 72.8% of the students reported the discussion helped in their problem solving most or all of the time. In the current study, different strategies were used by teachers to mitigate the problem; one teacher developed rubrics that contained both individual and group components, and another teacher chose to monitor students' group dynamics and intervene when necessary.

Students' resistance to PBL could be due to their lack of self-directed learning skills or lack of academic readiness such as reading and/or math, as suggested by one teacher. Interestingly, one teacher stated that many of his advanced students resisted PBL. The reason given by him was that those students preferred traditional learning in which they could memorize lots of information and facts.

It is plausible those advanced students wanted to maintain their high GPAs, and memorizing facts provided better chance to perform well in high-stakes standardized tests than solving problems in PBL would. After all, students' scores on standardized tests do play a significant role in college admission in today's education system (Buchmann, Condron, & Roscigno, 2010). This will probably remain as an issue for PBL implementation until one day educators and researchers successfully integrate problem-solving into the main curriculum and design assessments that evaluate whether students meet the learning objectives of the PBL process—and in the meantime measure students' readiness for standardized tests.

As discussed in the previous session, the transition from passive learning to self-directed learning can be challenging and this ability does not come naturally or easily for many students. As Miflin (2004) argued, it is flawed to assume that leaving control of the learning to students will inevitably lead to the development of their self-directed learning ability. Instead, it is cultivated through teachers' scaffolding in a supportive environment (English & Kitsantas, 2013) which was described by one teacher in the current study as "…*an open learning environment for students to feel comfortable questioning in classrooms.*"

Based on PBL teachers' responses, the scaffoldings that they provided were not limited to support in gathering/evaluating information, and solving problems. They also guided students in collaborating and communicating with their peers, and time management. Not only did those scaffoldings help students acquire important learning and life skills, they also maintained students' motivation and learning interest throughout the process. As one teacher stated "*…helping students sustain energy through the completion of a project and maintain focus."*

Teachers reported various support-related issues for implementing PBL. "*Lack of resources*" appeared most often (12 times) in this category and the second frequently mentioned issue (8 times) was "*not enough access to technology*". The use of technology and computers is gaining popularity in education and there is no exception in PBL. More and more PBL lessons are delivered as hypermedia units (Linn, Clark, & Slotta, 2003; Liu et al., 2012; Ravitz & Blazevski, 2014; Simons & Klein, 2007) and require the use of online resources for various purposes such as searching for information. Therefore, not enough access to technology can be a serious handicap for teachers who are interested in practicing PBL but only have limited computer access for their students.

Three teachers pleaded for more support for teachers' training. As discussed earlier, PD training for PBL was positively associated with teachers' perception of competence, increased the value and decreased the cost they placed on PBL implementation, and their intention to implement PBL in the future. Finally, four teachers specifically talked about the difficulties of having colleagues with whom to collaborate. All four teachers taught in schools where they estimated at least 50% of the teachers used PBL. Therefore, the difficulties in collaboration were probably not due to lack of teachers who practiced PBL. Indeed, the reasons those four teachers gave for lack of collaboration were lack of time and peers' lack of flexibility and fixed mind sets.

In contrast to the findings of this study, a study by Nariman and Chrispeels (2016) suggested that collaboration among teachers led to time-saving in implementing PBL.

The potential adverse impact of the challenges on teachers' self-efficacy in implementing PBL. No PBL teachers explicitly commented on their perceived competence in their responses to the open-ended questions. Based on discussions above, teachers did face situations that had potential to challenge their self-efficacy in implementing PBL, such as difficulties in connecting PBL with mandated curriculum and standardized tests and shortage of resources. van Dinther, Dochy, and Segers (2011) pointed out in their review that repeated strong negative mastery experiences would probably decrease individuals' levels of self-efficacy. It is plausible to suggest that there is a potential for teachers' perceived competence in practicing PBL to be adversely affected by a continual exposure to issues that demand extra effort and resolution of these issues were beyond teachers' reach.

Examining teachers' challenges for PBL implementation through the lens of teachers' PBL practice frequency. The overall keywords count for teachers is in line with the proportion of teachers in each level of practice frequency. However, a fine-grained look of the keyword count revealed that teachers in level 1, who taught PBL occasionally, encountered proportionally more issues with students' readiness for PBL. Issues with students' readiness for PBL were brought up by 9 teachers. Seven (77.8%) were from level 1 teachers, and the other two were from level 2 teachers, who used PBL for up to 25% or 50% of their teaching. Students' lack of motivation was brought up by 7 teachers, five of them (71.4%) were teachers from level 1 and two were from level 2. This was also the case for "students' lack of focus". Furthermore, no teacher from level 3, who used PBL for most of their teaching, reported any issues related to students' readiness, resistance, motivation, or focus.

One plausible explanation for this phenomenon is that as students gain more opportunities to practice PBL, they feel more comfortable with it and gradually acquire skills for self-directed active learning. It is also probable that as teachers gain experience in practicing PBL they develop better strategies to scaffold and facilitate their students for this pedagogy. Therefore teachers who use PBL occasionally might have to deal with proportionally more issues related to students' lack of readiness for this innovative pedagogy.

A similar scenario also occurred with teachers' autonomy-related issues, such as following state standards and preparing students for standardized tests, which were brought up by 19 teachers. Nine of them were from level 1 and the other10 teachers belonged to level 2. None of the teachers in level 3 mentioned concerns in this regard. Perhaps very frequent practice helped teachers develop the skill to integrate traditional teaching with PBL. Therefore, these teachers could follow state standards and prepare their students for standardized tests while engaging them in active learning. As one level 3 teacher declared "…*my students*…*do well both in the classroom, and on their EOC's*…. *their* [students'] *EOC's score are the highest in the system, and often some of the highest in the state.*"

The study by Ertmer et al. (2009) examined the PBL implementation of five middle school teachers with at least 4 years of PBL experience. The teachers employed such strategies as using short PBL units based on past teaching, providing plenty of supporting information for students, using mini-lessons to reinforce content, creating websites to link to relevant resources, giving students clear rubric, and implementing daily checks. Results from this study described all five participating teachers as being able to meet academic standards and provide students with problem-solving experiences in the learning process, thus sustaining their intention to continue using PBL.

Summary. The qualitative data collected from the three open-ended questions provided deeper insight of various factors that either motivated or challenged teachers in practicing PBL. They fit the theoretical framework of the instrument and triangulate well with the quantitative data, discussed as follows:

Teachers value PBL. All advantages that teachers mentioned belong to the category "value of PBL," particularly the value of PBL to their students. Teachers believed that PBL provided an authentic environment for students to practice student-centered active learning and ultimately improved their 21st century skills.

Teachers recognize the extra effort required for implementing PBL. "Effort cost to teachers" was the number one challenge that teachers faced in practicing PBL. The effort cost covered a wide spectrum, from extra time required for PBL planning and implementation to provide an open-learning classroom environment. Teachers might want to start with "post-hole" units and move into more comprehensive PBL lesson units after they become more familiar and comfortable with this pedagogy.

Challenges in implementing PBL might dampen teachers' perceived competence in implementing PBL. Although no issues concerning self-efficacy about PBL implementation were mentioned in teachers' responses to the open-ended questions, research indicates the potential for teachers' self-efficacy to be reduced by continual exposure to issues that demand extra effort and feeling that they have little power to resolve these challenges (van Dinther, Dochy, & Segers, 2011). After all, individuals' mastery experiences are very influential on their self-efficacy (Bandura, 1977). The sustainability of PBL practice might be curtailed if these issues persist.

Issues related to teachers' autonomy in implementing PBL. Although teachers felt they decided whether to implement PBL or not, they had little leeway in terms what to teach and the pace of teaching it. Furthermore, the pressure of having their students perform well in high stakes standardized tests seemed inevitable. One strategy that PBL teachers in this study developed was to integrate PBL and traditional lecture-based teaching and used this combined pedagogy accordingly.

What Do Administrators Think of PBL?

Although responses from administrators were not statistically analyzed due to the small sample size (n = 4), they were compared and contrasted to the teachers' responses for items that measured the same concepts. Overall, administrators and teachers shared similar beliefs about PBL, as demonstrated by the comparable average scores for various items. This was particularly true for administrators and teachers with PBL experience.

Administrators valued PBL and considered themselves supportive of teachers who wanted to implement this pedagogy. They feel confident that their teachers were able to implement PBL successfully. Administrators also indicated a lower level of "psychological cost of failure" associated with PBL implementation than did teachers. One plausible explanation is that these four administrators worked with teachers who had low levels of psychological cost about PBL. It is also possible that their schools were in the very early phase of PBL implementation and these administrators' responses were based on their beliefs instead of data collected from teachers' practice. Judging by the fact that only four administrators participated in the current study, it is difficult to conclude whether there is really a gap between administrators' and teachers' beliefs.

Summary

In this chapter, findings from the current study were discussed and inferences were made from the research findings. Quantitative and qualitative data were examined against the theoretical framework for the current study, the expectancy-value theory and self-determination theory. Both sets of data converged and fit into the various constructs of the theoretical framework. Regression models were established which used teachers' perceived competence, value, cost, autonomy, and support to predict their intention to implement PBL. Teachers' levels of current PBL practice and their formal training in PBL were also examined for their potential influence on teachers' perceptions of and intention to implement this pedagogy. The next chapter will be dedicated to the conclusions of the current study and its implications in PBL implementation.

CHAPTER SIX

CONCLUSIONS AND IMPLICATIONS

Half a century has passed since the inauguration of PBL and its application has been expanded from medical school education to higher and secondary education classrooms. Research studies (Allen et al., 2011; Dochy et al., 2003; Strobel, & van Barneveld, 2009) have associated the use of PBL with development of students' higher order thinking skills, enhanced knowledge application, and improved affective components of learning. However, the open-ended nature of PBL inevitably raises concerns and issues about the implementation of this pedagogy, as reported by various studies (Ertmer et al., 2009; Nariman & Chrispeels, 2016; Pecore & Bohan, 2012). Teachers' motivation is pivotal for the successful implementation of pedagogical innovations (Gorozidis et al., 2014; Lam et al., 2010). However, an extensive literature review conducted by the researcher revealed that there are limited number of studies that focused on teachers' beliefs about PBL, their reported use of PBL, and underlying motivations. Most of the PBL studies examined this pedagogy through students' lens.

In order to investigate teachers' beliefs, practices and motivations for PBL use, a survey instrument was developed for the current study. The expectancy-value theory (EVT) of Eccles et al. (1983) and the self-determination theory (SDT) by Ryan and Deci (2000b) were guiding theoretical frameworks. Exploratory factor analysis of the survey responses from the teachers with prior PBL experience revealed three major motivational constructs: (1) the value of PBL to teachers and their students, (2) teachers' perceived competence and cost in implementing PBL, and (3) perceived support from schools for teachers' perceived autonomy and support from peers for perceived relatedness. Out of the three factors, the value of PBL was the most dominant one.

Multiple methods were used to assess the internal consistency of items in each factor and they all provided satisfactory results, thus confirming the reliability of the instrument. Multiple methods established the construct validity of the survey instrument. Furthermore, regression models were established which used teachers' perceived value, competence, cost, and support from administrations and peers in implementing PBL to significantly predict their intention of using this pedagogy. Therefore, the first conclusion of this study is that the survey developed for the current study is a reliable and valid instrument to measure secondary school teachers' perception of their ability and motivation to implement PBL. The second conclusion is that the value of PBL to teachers and their students was the strongest predictor for teachers' intention to use PBL.

Teachers who completed this survey shared some basic conceptions about PBL, whether they had previous PBL experience or not. Teachers who taught with PBL before felt competent and expected success in implementing PBL. However, this level of perceived competence was not observed in the group of teachers who never practiced PBL before. All respondents recognized the value and cost associated with implementing PBL, although the PBL group teachers had significantly higher level of perceived value and less concern of the cost than the non-PBL group teachers did. The third conclusion is that teachers who practiced PBL valued it more highly, felt more competent, and anticipated greater success with this pedagogy.

Further examination of teachers with previous PBL experience indicated a general trend of increasing intention for implementation, perceived competence and support, and reduced concern of cost as the frequency of PBL practice increased. A fourth conclusion is that implementing PBL enhances teachers' perceived competence, value, and lessens their anxiety about this pedagogy, and this improvement is positively associated with teachers' frequency of using PBL.

Teachers who practiced PBL before reported having significant more formal training than their non-PBL counterpart. In addition, close to half of the teachers who never practiced PBL before in the current study cited lack of professional training as their reason for not using PBL, further emphasizing the impact of formal training on teachers' implementation of PBL. Furthermore, a positive correlation was observed between the amount of PBL formal training that teachers received and their perceived competence, value, cost, autonomy, support, and intention in implementing PBL. This positive impact plateaued between six and ten days of formal training. The fifth conclusion is that PBL professional development that last between one and two weeks led to higher levels of teachers' perceived competence, value, autonomy, support, intention, and reduced levels of perceived costs of implementing PBL.

Qualitative data collected from teachers' responses to the open-ended questions in the instrument fit the theoretical framework and triangulate well with the quantitative data of the current study. The sixth conclusion is that convergence is obtained from different research methods employed in the current study. Similar to what was found in the quantitative data, "value" is the most dominant and only one advantage revealed by the qualitative data. The qualitative data provided more in-depth information about the challenges that teachers face in implementing PBL, such as the extra time requirement and following the rigid state standards. Teachers also voiced their desire for support from school administrators and colleagues such as providing formal PBL training and opportunities for collaboration among peers. Overall, teachers recognized and appreciated all the benefits that they and students would receive from PBL. They were aware of the effort required for teaching with PBL; however, they were willing to invest the extra time and effort associated with the planning and implementing this innovative pedagogy as they considered the overall benefits outweighed the costs. The final conclusion is that PBL teachers found the time and effort to implement PBL as worthwhile because of its value to students' learning.

Implications

Findings from this study demonstrated what motivates teachers and what challenges them to implement PBL. To practice PBL is time-consuming and can be a daunting task, as reported by teachers in this study. Therefore, teachers might consider starting PBL with "post-hole" problems, which are short problems that can be used when teachers don't want to design their entire course around PBL (Stepien & Gallagher, 1993). These kinds of smaller units offer teachers a more manageable entry into the process, and expand the scale after they master the time-management skills required in PBL (Ertmer & Simons, 2006).

Design good problems also challenged teachers. Actually, there are great resources for teachers who are interested in practicing PBL such as the multiple online libraries which collect well designed problems for teachers to use:

- WISE (Web-based Inquiry Science Environment) at https://wise.berkeley.edu/
- Wake Forest School of Medicine and the University of Texas at Dallas Problem-based Learning (WAKE/UTD PBL) at https://www.wake-utd.org/resources
- National Center for Case Study Teaching in Science (University of Buffalo) at http://ublib.buffalo.edu/libraries/projects/cases/case.html

University of Delaware PBL Clearinghouse (http://www1.udel.edu/pblc/) also has a good collection of different investigative cases. However, they are geared toward undergraduate students and need to be modified for secondary education students. It will be worthwhile to make a concerted effort among teachers to choose lesson units from these sites, modify them to meet their particular needs, try the units in their classrooms, and share their experiences with other teachers. Schools or school districts can take the lead to establish a repository to collect the PBL units that have been tried out and work well, and provide this resource to all teachers who are interested in using it.

Another concern that PBL teachers share is the coherence of PBL with curricular mandates and standardized testing. Teachers who implement PBL are still held accountable to state-mandated standards and assessments, and this was a particular concern for teachers who did not use PBL frequently. Researchers and educators are aware of this issue and have been working on developing methods which help students make the connection between their inquiry activities and the content.

For example, the developers of WISE use the term “making thinking visible” in reference to strategies that reveal what and how students are thinking within a specific content domain (Linn, Clark, & Slotta, 2003). The information provided by students serves as a valuable insight for teachers to adjust activities to better connect with content knowledge or mandated curriculum (Linn et al., 2003). Ultimately teachers can customize projects in the WISE curriculum library to fit their school context and support their state standards. It will be very beneficial to teachers if schools set up a mechanism so relevant information and/or useful products obtained from PBL research, such as this WISE product, can be efficiently disseminated to teachers.

Another challenging issue for PBL implementation is to prepare students for this innovative pedagogy that requires students to be in charge of their learning. Vardi and Ciccarelli (2008) proposed several strategies to better prepare students in allied health courses for PBL which are worth of considering:

- Students were required to identify issues and search the literature prior to the class.
- Students were provided with a list of online resources relevant to the problems.
- Each class was started with students' discussing a key conceptual question arising out of the problem.

Study results indicated that 82.8% of the students felt adequately prepared "most of the time" or "all of the time" (Vardi & Ciccarelli, 2008). Although this study was administered on a group of undergraduate students, similar strategies could be adapted to help middle or high school students to benefit from PBL.

Hall and Hord (2011) said, "Change cannot occur without professional learning" (p.53). Findings from the current study clearly indicate the importance of professional development trainings for teachers' perception/understanding of and desire to implement PBL. Not only is the formal training important for teachers' motivation to implement PBL, the amount of the formal training also matters. This is illustrated by the trend of higher intention for implementation, value, competence, perceived autonomy, and lower anxiety for using PBL, as the amount of formal training increases. However, this increase plateaus between one and two weeks of training, which suggests that perhaps administrators should aim at professional development trainings for teachers that range from six to ten days. Based on findings from the current study that teachers' specific value beliefs about PBL most powerfully predict their intention for PBL implementation, professional development trainings will be more effective if they are designed to explicitly target teachers' value beliefs, focusing on the values addressed in this study.

The review by Walton (2014) recognized the importance of collective participation in professional development trainings. Collective participation means that a cohort of teachers from the same school or grade attend the professional development experience to facilitate “interaction and discourse, which can be a powerful form of teacher learning.” (Desimone, 2009, p. 184). This kind of interaction might facilitate collaboration among teachers, which was valued by teachers in this study. Therefore, schools might encourage teachers to take PBL professional development training as teams with members who teach different subjects, followed by interdisciplinary collaboration among those teachers. There are two advantages for using this approach: (1) It meets the interdisciplinary nature of PBL, and (2) it provides interaction among teachers that facilitates a social-professional network in which teachers find the relatedness (Emo, 2015). Ultimately this could motivate teachers’ intention to implement PBL.

In addition, teachers in this professional learning network can share their experiences in developing assessment for PBL, a challenge for PBL implementation in this study. It will be particularly helpful to develop effective summative assessments which not only evaluate students’ learning, but also their readiness for high-stakes standardized tests. It would be a good practice for teachers to approach the issues of developing assessments through the lens of PBL, which offers teachers opportunities to communicate and collaborate with each other. This is an arduous endeavor and therefore school administrators, in addition to supplying tangible resources, need to provide a collaborative school environment and facilitate the experience sharing and teamwork among teachers who are interested in PBL.

Finally, administrators who are interested in promoting PBL should evaluate the need and interest for receiving PBL professional development among teachers in their schools and districts. It might be worthwhile for schools to establish a system that tracks teachers’ PBL training, assesses their needs for further training, and provides a mechanism to help teachers obtain those training.

Significance and Limitations

As PBL is gaining attention from educators and making inroads into secondary education classrooms, researchers have started conducting studies to examine the effectiveness of this pedagogy. However, many of those studies tend to focus on the impact of PBL on students' learning such as their gain in 21st century skills: communication, collaboration, critical thinking, creativity, and problem solving. The current study takes a novel approach and examines PBL from teachers' perspectives. Findings from the current study provide a holistic view of motivational factors for teachers' intention to implement PBL, which are timely in this period of science education reforms that promote student-directed active learning.

However, there are several caveats about the current study that need to be addressed. As with all survey studies, data for this study were collected from self-report measures of teachers thus lack the objectivity of a controlled experiment. Moreover, 81% of the respondents who completed the survey (126 out of 156) taught with PBL before. Sixty-one of those 126 teachers are from a school district which strongly promotes PBL. This indicates that data of the current study are from teachers who either favor PBL themselves or work in a school system that highly encourages this pedagogy. Therefore, the resulting implications may have limited generalizability and only apply specifically to this population. Future studies should attempt to incorporate a wider range of teachers with varying backgrounds such as their experience of using PBL and their school's policy in terms of promoting PBL implementation.

It would also be worthwhile to conduct a study in which teachers take the survey developed for the current study before and after the PBL professional development training. Although these data are still based on self report, they will provide insight in terms of whether attending professional development training is positively associated with teachers' perceptions of their competence, value and cost they place on PBL, and their intention to implement this innovative pedagogy. Comparison of the pre- and post-training data will also reveal effectiveness of the professional development workshops, evaluated by their impact on teachers' beliefs in various elements of PBL. Ultimately this information will help educators design effective professional development for PBL, which in turn will equip more teachers to implement this innovative pedagogy and prepare more students for 21st century futures.

REFERENCES

Abraham, J., & Barker, K. (2014). An Expectancy-Value Model for Sustained Enrolment Intentions of Senior Secondary Physics Students. *Research in Science Education*, 1-18.

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

Allen, D. E., Donham, R. S., & Bernhardt, S. A. (2011). Problem-based learning. *New Directions for Teaching and Learning*, *2011*(128), 21-29.

American Association for the Advancement of Science (2011). Vision and change in undergraduate biology education: A call to action. Retrieved from http://visionandchange.org/files/2013/11/aaas-VISchange-web1113.pdf

Andersen, L., & Ward, T. J. (2014). Expectancy-value models for the STEM persistence plans of ninth-grade, high-ability Students: A comparison between black, Hispanic, and white students. *Science Education*, *98*(2), 216-242.

Armbruster, P., Patel, M., Johnson, E., & Weiss, M. (2009). Active learning and student-centered pedagogy improve student attitudes and performance in introductory biology. *CBE-Life Sciences Education*, *8*(3), 203-213.

Bandura, A. (1977). Self-efficacy: toward a unifying theory of behavioral change. *Psychological Review*, *84*(2), 191-215.

Banilower, E. R., Boyd, S. E., Pasley, J. D., & Weiss, I. R. (2006). *Lessons from a decade of mathematics and science reform: A capstone report for the local systemic change through teacher enhancement initiative*. Retrieved from ERIC website: http://files.eric.ed.gov/fulltext/ED518421.pdf

Barell, J. (2011). Problem-based learning: The foundation for 21st century skills. In J. A. Bellanca (Ed.), *21st century skills: Rethinking how students learn* (pp. 175-199). Bloomington, IN: Solution Tree Press.

Barrows, H. S. (1983). Problem-based, self-directed learning. *The Journal of the American Medical Association*, 250, 3077-3080.

Barrows, H. S. (1986). A taxonomy of problem-based learning methods. *Medical Education*, *20*(6), 481-486.

Barrows, H. S. (1996). Problem-based learning in medicine and beyond: A brief overview. *New Directions for Teaching and Learning*, *1996*(68), 3-12.

Battle, E. S. (1965). Motivational determinants of academic task persistence. *Journal of Personality and Social Psychology*, *2*(2), 209-218.

Battle, E. S. (1966). Motivational determinants of academic competence. *Journal of Personality and Social Psychology*, *4*(6), 634-642.

Becerra-Labra, C., Gras-Martí, A., & Torregrosa, J. M. (2012). Effects of a problem-based structure of Physics contents on conceptual learning and the ability to solve problems. *International Journal of Science Education*, *34*(8), 1235-1253.

Becker, D. F., McGlashan, T. H., & Grilo, C. M. (2006). Exploratory factor analysis of borderline personality disorder criteria in hospitalized adolescents. *Comprehensive Psychiatry*, *47*(2), 99-105.

Behar-Horenstein, L., & Niu, L. (2013). College Teachers' Instructional Practices: Exploratory and Confirmatory Factor Analyses. *The Journal of Faculty Development*, *27*(2), 38-45.

Beichner, R. J. (2014). History and evolution of active learning spaces. *New Directions for Teaching and Learning*, *2014*(137), 9-16.

Bell, T., Urhahne, D., Schanze, S., & Ploetzner, R. (2010). Collaborative inquiry learning: Models, tools, and challenges. *International Journal of Science Education*, *32*(3), 349-377.

Berkson, L. (1993). Problem-based learning: have the expectations been met?.*Academic Medicine*, *68*(10), S79-88.

Bøe, M. V. (2012). Science choices in Norwegian upper secondary school: What matters?. *Science Education*, *96*(1), 1-20.

Bøe, M. V., & Henriksen, E. K. (2013). Love it or leave it: Norwegian students' motivations and expectations for postcompulsory physics. *Science Education*,*97*(4), 550-573.

Bong, M. (2001). Role of self-efficacy and task-value in predicting college students' course performance and future enrollment intentions. *Contemporary Educational Psychology*, *26*(4), 553-570.

Bonwell, C. C., & Eison, J. A. (1991). *Active Learning: Creating Excitement in the Classroom. 1991 ASHE-ERIC Higher Education Reports*. ERIC Clearinghouse on Higher Education, The George Washington University, One DuPont Circle, Suite 630, Washington, DC 20036-1183.

Bozic, N., & Williams, H. (2011). Online problem-based and enquiry-based learning in the training of educational psychologists. *Educational Psychology in Practice*, *27*(4), 353-364.

Briggs, S. R., & Cheek, J. M. (1986). The role of factor analysis in the development and evaluation of personality scales. *Journal of personality*,*54*(1), 106-148.

Brownell, S. E., & Tanner, K. D. (2012). Barriers to faculty pedagogical change: lack of training, time, incentives, and… tensions with professional identity? *CBE-Life Sciences Education*, *11*(4), 339-346.

Buchmann, C., Condron, D. J., & Roscigno, V. J. (2010). Shadow education, American style: Test preparation, the SAT and college enrollment. *Social Forces*, *89*(2), 435-461.

Cennamo, K., Brandt, C., Scott, B., Douglas, S., McGrath, M., Reimer, Y., & Vernon, M. (2011). Managing the complexity of design problems through studio-based learning. *Interdisciplinary Journal of Problem-based Learning*, *5*(2), 12-36.

Chiang, E. S., Byrd, S. P., & Molin, A. J. (2011). Children's perceived cost for exercise: Application of an expectancy-value paradigm. *Health Education & Behavior*, *38*(2), 143-149.

Chin, C., & Chia, L. G. (2006). Problem-based learning: Using ill-structured problems in biology project work. *Science Education*, *90*(1), 44-67.

Cho, E., & Kim, S. (2015). Cronbach's coefficient alpha: Well known but poorly understood. *Organizational Research Methods*, *18*(2), 207-230.

Clark, L. A., & Watson, D. (1995). Constructing validity: Basic issues in objective scale development. *Psychological Assessment*, *7*(3), 309-319.

Conley, A. M. (2012). Patterns of motivation beliefs: Combining achievement goal and expectancy-value perspectives. *Journal of Educational Psychology*, *104*(1), 32-47.

Courtney, M. G. R. (2013). Determining the number of factors to retain in EFA: Using the SPSS R-Menu v2. 0 to make more judicious estimations. *Practical Assessment, Research & Evaluation*, *18*(8), 1-14.

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika*, *16*(3), 297-334.

Davenport, E. C., Davison, M. L., Liou, P. Y., & Love, Q. U. (2015). Reliability, dimensionality, and internal consistency as defined by Cronbach: distinct albeit related concepts. *Educational Measurement: Issues and Practice, 34*(4), 4-9.

Dawson, V., & Venville, G. J. (2009). High-school Students' Informal Reasoning and Argumentation about Biotechnology: An indicator of scientific literacy? *International Journal of Science Education*, *31*(11), 1421-1445.

Deci, E. L. (1972). The effects of contingent and noncontingent rewards and controls on intrinsic motivation. *Organizational Behavior and Human Performance*, *8*(2), 217-229.

Deci, E. L., Koestner, R., & Ryan, R. M. (1999). A meta-analytic review of experiments examining the effects of extrinsic rewards on intrinsic motivation.*Psychological Bulletin*, *125*(6), 627-668.

Deci, E. L., & Ryan, R. M. (2008). Facilitating optimal motivation and psychological well-being across life's domains. *Canadian Psychology, 49*(1), 14-23.

DeVellis, R. F. (2012). *Scale development: Theory and applications* (3rd edition). Thousand Oaks, CA: SAGE Publications, Inc.

DeVon, H. A., Block, M. E., Moyle-Wright, P., Ernst, D. M., Hayden, S. J., Lazzara, D. J., ... & Kostas-Polston, E. (2007). A psychometric toolbox for testing validity and reliability. *Journal of Nursing Scholarship, 39*(2), 155-164.

DiStefano, C., Zhu, M., & Mindrila, D. (2009). Understanding and using factor scores: Considerations for the applied researcher. *Practical Assessment, Research & Evaluation*, *14*(20), 1-11.

Dixon, R. A., & Brown, R. A. (2012). Transfer of learning: Connecting concepts during problem solving. *Journal of Technology Education*, *24*(1), 2-17.

Dochy, F., Segers, M., Van den Bossche, P., & Gijbels, D. (2003). Effects of problem-based learning: A meta-analysis. *Learning and instruction*, *13*(5), 533-568.

Drent, M., & Meelissen, M. (2008). Which factors obstruct or stimulate teacher educators to use ICT innovatively?. *Computers & Education*, *51*(1), 187-199.

Drew, V., & Mackie, L. (2011). Extending the constructs of active learning: implications for teachers' pedagogy and practice. *Curriculum Journal*, *22*(4), 451-467.

Duncan, L. R., Hall, C. R., Wilson, P. M., & Jenny, O. (2010). Exercise motivation: a cross-sectional analysis examining its relationships with frequency, intensity, and duration of exercise. *International Journal of Behavioral Nutrition and Physical Activity*, *7*(7), 1-9.

Durik, A. M., Vida, M., & Eccles, J. S. (2006). Task values and ability beliefs as predictors of high school literacy choices: A developmental analysis. *Journal of Educational Psychology*, *98*(2), 382-393.

Eccles, J. (2009). Who am I and what am I going to do with my life? Personal and collective identities as motivators of action. *Educational Psychologist*, *44*(2), 78-89.

Eccles, J. S., Adler, T. F., Futterman, R., Goff, S. B., Kaczala, C. M., Meece, J. L., & Midgley, C. (1983). *Expectancies, values and academic behaviors.* In J. T. Spence (Ed.), *Achievement and achievement motivation* (pp. 75-146). San Francisco, CA: W. H. Freeman.

Eccles, J. S., & Wigfield, A. (1995). In the mind of the actor: The structure of adolescents' achievement task values and expectancy-related beliefs. *Personality and Social Psychology Bulletin, 21*(3), 215-225.

Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology*, *53*(1), 109-132.

Edens, K. M. (2000). Preparing problem solvers for the 21st century through problem-based learning. *College Teaching*, *48*(2), 55-60.

Eisen, M., Ware Jr, J. E., Donald, C. A., & Brook, R. H. (1979). Measuring components of children's health status. *Medical care*, *17*(9), 902-921.

Ellison, W. D., & Levy, K. N. (2012). Factor structure of the primary scales of the Inventory of Personality Organization in a nonclinical sample using exploratory structural equation modeling. *Psychological Assessment*, *24*(2), 503-517.

Emo, W., (2015). Teachers' motivations for initiating innovations. *Journal of Educational Change*, *16*, 171-195.

English, M. C., & Kitsantas, A. (2013). Supporting student self-regulated learning in problem- and project-based learning. *Interdisciplinary Journal of Problem-based Learning*, *7*(2), 128-150.

Ertmer, P. A., Glazewski, K. D., Jones, D., Ottenbreit-Leftwich, A., Goktas, Y., Collins, K., & Kocaman, A. (2009). Facilitating technology-enhanced problem-based learning (PBL) in the middle school classroom: An examination of how and why teachers adapt. *Journal of Interactive Learning Research*, *20*(1), 35-54.

Ertmer, P. A., & Simons, K. D. (2006). Jumping the PBL implementation hurdle: Supporting the efforts of K–12 teachers. *Interdisciplinary Journal of Problem-based Learning*, *1*(1), 40-54.

Evans, M. A., Lopez, M., Maddox, D., Drape, T., & Duke, R. (2014). Interest-driven learning among middle school youth in an out-of-school STEM studio. *Journal of Science Education and Technology*, *23*(5), 624-640.

Fabrigar, L. R., & Wegener, D. T. (2011). Exploratory factor analysis (Understanding statistics). Retrieved from http://site.ebrary.com.prox.lib.ncsu.edu/lib/ncsu/detail.action?docID=10605698

Fabrigar, L. R., Wegener, D. T., MacCallum, R. C., & Strahan, E. J. (1999). Evaluating the use of exploratory factor analysis in psychological research.*Psychological Methods*, *4*(3), 272-299.

Fielding, J., Fielding, N., & Hughes, G. (2013). Opening up open-ended survey data using qualitative software. *Quality & Quantity*, *47*(6), 3261-3276.

Filcik, A., Bosch, K., Pederson, S., & Haugen, N. (2012). The effects of project-based learning (PBL) approach on the achievement and efficacy of high school mathematics students: A longitudinal study investigating the effects of the PBL approach in mathematics education. *Proceedings of the National Conference on Undergraduate Research.*

Flake, J. K., Barron, K. E., Hulleman, C., McCoach, B. D., & Welsh, M. E. (2015). Measuring cost: The forgotten component of expectancy-value theory. *Contemporary Educational Psychology*, *41*, 232-244.

Fleischman, H.L., Hopstock, P.J., Pelczar, M.P., and Shelley, B.E. (2010). *Highlights from PISA 2009: Performance of U.S. 15-year-old students in reading, mathematics, and science literacy in an international context* (NCES 2011-004). U.S. Department of Education, National Center for Education Statistics. Washington, DC: U.S. Government Printing Office. Retrieved from http://nces.ed.gov/pubs2011/2011004.pdf

Foley, L. S. (2011). Exploring K–3 Teachers' Implementation of Comprehension Strategy Instruction (CSI) Using Expectancy-Value Theory. *Literacy Research and Instruction*, *50*(3), 195-215.

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences*, *111*(23), 8410-8415.

Gallagher, S. A., & Gallagher, J. J. (2013). Using problem-based learning to explore unseen academic potential. *Interdisciplinary Journal of Problem-based Learning*, *7*(1), 111-131.

Gijbels, D., Dochy, F., Van den Bossche, P., & Segers, M. (2005). Effects of problem-based learning: A meta-analysis from the angle of assessment. *Review of educational research*, *75*(1), 27-61.

Gillies, R. M., & Nichols, K. (2015). How to support primary teachers' implementation of inquiry: Teachers' reflections on teaching cooperative inquiry-based science. *Research in Science Education*, *45*(2), 171-191.

Gliem, R. R., & Gliem, J. A. (2003). Calculating, interpreting, and reporting Cronbach's alpha reliability coefficient for Likert-type scales. Midwest Research-to-Practice Conference in Adult, Continuing, and Community Education.

Goh, K. (2014). What good teachers do to promote effective student learning in a problem-based learning environment. *Australian Journal of Educational & Developmental Psychology*, *14*, 159-166.

Goodnough, K., & Hung, W. (2008). Engaging teachers' pedagogical content knowledge: Adopting a nine-step problem-based learning model. *Interdisciplinary Journal of Problem-based Learning*, *2*(2), 61-90.

Gorozidis, G., & Papaioannou, A. G. (2014). Teachers' motivation to participate in training and to implement innovations. *Teaching and Teacher Education*, *39*, 1-11.

Gorsuch, R. L. (2nd ed.). (1983). *Factor analysis*. Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Grice, J. W. (2001). Computing and evaluating factor scores. *Psychological methods*, *6*(4), 430-450.

Guo, J., Marsh, H. W., Parker, P. D., Morin, A. J., & Yeung, A. S. (2015). Expectancy-value in mathematics, gender and socioeconomic background as predictors of achievement and aspirations: A multi-cohort study. *Learning and Individual Differences*, *37*, 161-168.

Hall, G. E., & Hord, S. M. (2011). Implementation: Learning Builds the Bridge between Research and Practice. *Journal of Staff Development*, *32*(4), 52-57.

Harris, M. B. (2nd Ed.) (1998). *Basic statistics for behavioral science research*. Upper Saddle River, NJ: Allyn & Bacon

Hartman, K. B., Moberg, C. R., & Lambert, J. M. (2013). Effectiveness of problem-based learning in introductory business courses. *Journal of Instructional Pedagogies*, *12*, 1-13.

Hayenga, A. O., & Corpus, J. H. (2010). Profiles of intrinsic and extrinsic motivations: A person-centered approach to motivation and achievement in middle school. *Motivation and Emotion*, *34*(4), 371-383.

Hayton, J. C., Allen, D. G., & Scarpello, V. (2004). Factor retention decisions in exploratory factor analysis: A tutorial on parallel analysis. *Organizational Research Methods*, *7*(2), 191-205.

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn?. *Educational Psychology Review*, *16*(3), 235-266.

Hmelo-Silver, C. E., & Barrows, H. S. (2006). Goals and strategies of a problem-based learning facilitator. *Interdisciplinary Journal of Problem-based Learning*, *1*(1), 21-39.

Hmelo-Silver, C. E., Duncan, R. G., & Chinn, C. A. (2007). Scaffolding and achievement in problem-based and inquiry learning: A response to Kirschner, Sweller, and Clark (2006). *Educational Psychologist*, *42*(2), 99-107.

Holden, H., & Rada, R. (2011). Understanding the influence of perceived usability and technology self-efficacy on teachers' technology acceptance. *Journal of Research on Technology in Education*, *43*(4), 343-367.

Hsu, Y. S. (2008). Learning about seasons in a technologically enhanced environment: The impact of teacher-guided and student-centered instructional approaches on the process of students' conceptual change. *Science Education*, *92*(2), 320-344.

Hsu, Y. S., Lai, T. L., & Hsu, W. H. (2015). A design model of distributed scaffolding for inquiry-based learning. *Research in Science Education*, *45*(2), 241-273.

Hung, P. H., Hwang, G. J., Lee, Y. H., Wu, T. H., Vogel, B., Milrad, M., & Johansson, E. (2014). A problem-based ubiquitous learning approach to improving the questioning abilities of elementary school students. *Journal of Educational Technology & Society*, *17*(4), 316-334.

Hung, W. (2006). The 3C3R model: A conceptual framework for designing problems in PBL. *Interdisciplinary Journal of Problem-based Learning*, *1*(1), 55-77.

Hung, W. (2009). The 9-step problem design process for problem-based learning: Application of the 3C3R model. *Educational Research Review*, *4*(2), 118-141.

Hung, W. (2011). Theory to reality: a few issues in implementing problem-based learning. *Educational Technology Research and Development*, *59*(4), 529-552.

Hung, W., Jonassen, D. H., & Liu, R. (2008). Problem-based learning. *Handbook of research on educational communications and technology*, *3*, 485-506.

Hurd, P. D. (2000). Science education for the 21st century. *School Science and Mathematics*, *100*(6), 282-288.

IBM Knowledge Center (n.d.). Factor Analysis. Retrieved from http://www.ibm.com/support/knowledgecenter/SSLVMB_21.0.0/com.ibm.spss.statistics.cs/factor_cars_intro.htm

Jerzembek, G., & Murphy, S. (2013). A narrative review of problem-based learning with school-aged children: implementation and outcomes. *Educational Review*, *65*(2), 206-218.

Jones, B. D., Epler, C. M., Mokri, P., Bryant, L. H., & Paretti, M. C. (2013). The effects of a collaborative problem-based learning experience on students' motivation in engineering capstone courses. *Interdisciplinary Journal of Problem-based Learning*, *7*(2), 34-71.

Jones, M. (2008). Developing clinically savvy nursing students: an evaluation of problem-based learning in an associate degree program. *Nursing Education Perspectives*, *29*(5), 278-283.

Kahn, J. H. (2006). Factor analysis in counseling psychology research, training, and practice: Principles, advances, and applications. *The Counseling Psychologist*, *34*(5), 684-718.

Kammer, R., Schreiner, L., Kim, Y. K., & Denial, A. (2015). The Validation of the Active Learning in Health Professions Scale. *Interdisciplinary Journal of Problem-Based Learning*, *9*(1), 10.

Kang, N. H., DeChenne, S. E., & Smith, G. (2012). Inquiry learning of high school students through a problem-based environmental health science curriculum. *School Science and Mathematics*, *112*(3), 147-158.

Kastner, J. W., May, W., & Hildman, L. (2001). Relationship between language skills and academic achievement in first grade. *Perceptual and Motor Skills*, *92*(2), 381-390.

Kaya, O. N. (2008). A student-centered approach: Assessing the changes in prospective science teachers' conceptual understanding by concept mapping in a general chemistry laboratory. *Research in Science Education*, *38*(1), 91-110.

Kelly, D., Xie, H., Nord, C.W., Jenkins, F., Chan, J.Y., and Kastberg, D. (2013). *Performance of U.S. 15-year-old students in mathematics, science, and reading literacy in an international context: First look at PISA 2012* (NCES 2014-024). U.S. Department of Education. Washington, DC: National Center for Education Statistics. Retrieved from http://nces.ed.gov/pubs2014/2014024rev.pdf

Khishfe, R. (2014). Explicit nature of science and argumentation instruction in the context of socioscientific issues: An effect on student learning and transfer. *International Journal of Science Education*, *36*(6), 974-1016.

Kim, K., Sharma, P., Land, S. M., & Furlong, K. P. (2013). Effects of active learning on enhancing student critical thinking in an undergraduate general science course. *Innovative Higher Education*, *38*(3), 223-235.

Kim, M., & Tan, H. T. (2013). A collaborative problem-solving process through environmental field studies. *International Journal of Science Education*, *35*(3), 357-387.

Kong, L. N., Qin, B., Zhou, Y. Q., Mou, S. Y., & Gao, H. M. (2014). The effectiveness of problem-based learning on development of nursing students' critical thinking: A systematic review and meta-analysis. *International Journal of Nursing Studies*, *51*(3), 458-469.

Kreijns, K., Van Acker, F., Vermeulen, M., & Van Buuren, H. (2013). What stimulates teachers to integrate ICT in their pedagogical practices? The use of digital learning materials in education. *Computers in Human Behavior*, *29*(1), 217-225.

Labov, J. B., Singer, S. R., George, M. D., Schweingruber, H. A., & Hilton, M. L. (2009). Effective practices in undergraduate STEM education part 1: examining the evidence. *CBE-Life Sciences Education*, *8*(3), 157-161.

Lam, S. F., Cheng, R. W. Y., & Choy, H. C. (2010). School support and teacher motivation to implement project-based learning. *Learning and Instruction*, *20*(6), 487-497.

Lara-Alecio, R., Tong, F., Irby, B. J., Guerrero, C., Huerta, M., & Fan, Y. (2012). The effect of an instructional intervention on middle school English learners' science and English reading achievement. *Journal of Research in Science Teaching*, *49*(8), 987-1011.

Liem, A. D., Lau, S., & Nie, Y. (2008). The role of self-efficacy, task value, and achievement goals in predicting learning strategies, task disengagement, peer relationship, and achievement outcome. *Contemporary Educational Psychology*, *33*(4), 486-512.

Linn, M. C., Clark, D., & Slotta, J. D. (2003). WISE design for knowledge integration. *Science Education*, *87*(4), 517-538.

Liu, M., Cho, Y., & Schallert, D. L. (2006). Middle school students' self-efficacy, attitudes, and achievement in a computer-enhanced problem-based learning environment. *Journal of Interactive Learning Research*, *17*(3), 225-242.

Liu, M., Williams, D., & Pedersen, S. (2002). Alien Rescue: A problem-based hypermedia learning environment for middle school science. *Journal of Educational Technology Systems*, *30*(3), 255-270.

Liu, M., Wivagg, J., Geurtz, R., Lee, S. T., & Chang, H. M. (2012). Examining how middle school science teachers implement a multimedia-enriched problem-based learning environment. *Interdisciplinary Journal of Problem-based Learning*, *6*(2), 46-84.

MacCallum, R. C., Widaman, K. F., Zhang, S., & Hong, S. (1999). Sample size in factor analysis. *Psychological Methods*, *4*(1), 84-99.

Magidson, J. F., Roberts, B. W., Collado-Rodriguez, A., & Lejuez, C. W. (2014). Theory-driven intervention for changing personality: Expectancy value theory, behavioral activation, and conscientiousness. *Developmental Psychology*, *50*(5), 1442-1458.

Marle, P. D., Decker, L., Taylor, V., Fitzpatrick, K., Khaliqi, D., Owens, J. E., & Henry, R. M. (2014). CSI–Chocolate Science Investigation and the Case of the Recipe Rip-Off: Using an Extended Problem-Based Scenario to Enhance High School Students' Science Engagement. *Journal of Chemical Education,91*(3), 345-350.

Maxwell, N. L., Mergendoller, J. R., & Bellisimo, Y. (2005). Problem-based learning and high school macroeconomics: A comparative study of instructional methods. *The Journal of Economic Education*, *36*(4), 315-331.

McEvoy, P. M., & Nathan, P. (2007). Perceived costs and benefits of behavioral change: reconsidering the value of ambivalence for psychotherapy outcomes. *Journal of Clinical Psychology*, *63*(12), 1217-1229.

McInnerney, J. M., & Roberts, T. S. (2004). Collaborative or cooperative learning. *Online collaborative learning: Theory and practice* (pp. 203-214). Retrieved from http://www.researchgate.net/profile/Earl_Woodruff/publication/27478772_Supporting_Online_Collaborative_Learning_in_Mathematics/links/00b7d53aaa861e4645000000.pdf#page=218

Meece, J. L., Wigfield, A., & Eccles, J. S. (1990). Predictors of math anxiety and its influence on young adolescents' course enrollment intentions and performance in mathematics. *Journal of educational psychology*, *82*(1), 60-70.

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

Meyer, E. J., Abrami, P. C., Wade, A., & Scherzer, R. (2011). Electronic portfolios in the classroom: Factors impacting teachers' integration of new technologies and new pedagogies. *Technology, Pedagogy and Education*, *20*(2), 191-207.

Michael, J. A., & Modell, H. I. (2003). *Active learning in secondary and college science classrooms: A working model for helping the learner to learn*. Mahwah, NJ: Lawrence Erlbaum Associates

Miflin, B. (2004). Adult learning, self-directed learning and problem-based learning: deconstructing the connections. *Teaching in Higher Education*, *9*(1), 43-53.

Minner, D. D., Levy, A. J., & Century, J. (2010). Inquiry-based science instruction—what is it and does it matter? Results from a research synthesis years 1984 to 2002. *Journal of Research in Science T eaching*, *47*(4), 474-496.

Muehlenkamp, J. J., Weiss, N., & Hansen, M. (2015). Problem-based learning for introductory psychology: Preliminary supporting evidence. *Scholarship of Teaching and Learning in Psychology*, *1*(2), 125-136.

Nagengast, B., Marsh, H. W., Scalas, L. F., Xu, M. K., Hau, K-T., & Trautwein, U. (2011). Who took the "x" out of expectancy-value theory? A psychological mystery, a substantive-methodological synergy, and a cross-national generalization. *Psychological Science, 22*(8), 1058-1066.

Nariman, N., & Chrispeels, J. (2016). PBL in the Era of Reform Standards: Challenges and Benefits Perceived by Teachers in One Elementary School. *Interdisciplinary Journal of Problem-Based Learning*, *10*(1), 5.

Nandi, P. L., Chan, J. N., Chan, C. P., Chan, P., & Chan, L. P. (2000). Undergraduate medical education: comparison of problem-based learning and conventional teaching. *Hong Kong Medical Journal*, *6*(3), 301-306.

National Research Council. (1996). *National science education standards*. Washington DC: National Academy Press. Retrieved from http://www.nap.edu/openbook.php?record_id=4962&page=R1

National Research Council. (2000). *How people learn: Brain, mind, experience, and school, expanded edition*. Committee on Developments in the Science of Learning & Committee on Learning Research and Educational Practice. Retrieved from http://www.nap.edu/openbook.php?isbn=0309070368

National Research Council. (2011a). *Promising practices in undergraduate science, technology, engineering, and mathematics Education: Summary of two workshops*. Planning Committee on Evidence on Selected Innovations in Undergraduate STEM Education and Board on Science Education, Division of Behavioral and Social Sciences and Education. Retrieved from http://www.doe.in.gov/sites/default/files/ccr/promising-practices-undergraduate-stem-education.pdf

National Research Council. (2011b). Successful K-12 STEM education: Identifying effective approaches in science, technology, engineering, and mathematics. Retrieved from http://www.nap.edu/catalog/13158/successful-k12-stem-education-identifying-effective-approaches-in-science-technology

National Research Council. (2012a). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas.* Committee on a Conceptual Framework for New K-12 Science Education Standards. Retrieved from http://www.nap.edu/openbook.php?record_id=13165

National Research Council. (2012b). *Education for life and work: Developing transferable knowledge and skills in the 21st century*. Committee on Defining Deeper Learning and 21st Century Skills. Retrieved from http://www.hewlett.org/uploads/documents/Education_for_Life_and_Work.pdf

Neufeld, V. R., & Barrows, H. S. (1974). The “McMaster Philosophy”: an approach to medical education. *Journal of Medical Education*, *49*(11), 1040-1050.

NGSS Lead States. (2013). *Next Generation Science Standards: For States, By States.* Washington, DC: The National Academies Press. Retrieved from http://www.nap.edu/download.php?record_id=18290#

Nicolaidou, I., Kyza, E. A., Terzian, F., Hadjichambis, A., & Kafouris, D. (2011). A framework for scaffolding students' assessment of the credibility of evidence. *Journal of Research in Science Teaching*, *48*(7), 711-744.

Niemiec, C. P., & Ryan, R. M. (2009). Autonomy, competence, and relatedness in the classroom Applying self-determination theory to educational practice. *Theory and Research in Education*, *7*(2), 133-144.

Nugent, G., Barker, B., Welch, G., Grandgenett, N., Wu, C., & Nelson, C. (2015). A Model of Factors Contributing to STEM Learning and Career Orientation. *International Journal of Science Education*, *37*(7), 1067-1088.

Nunnally, J. C., & Bernstein, I. H. (3rd Ed.). (1994). Psychometric theory. New York, NY: McGraw-Hill, Inc.

O'Connor, B. P. (2000). SPSS and SAS programs for determining the number of components using parallel analysis and Velicer's MAP test. *Behavior Research Methods, Instruments, & Computers*, *32*(3), 396-402.

Oja, K. J. (2011). Using problem-based learning in the clinical setting to improve nursing students' critical thinking: An evidence review. *Journal of Nursing Education*,*50*(3), 145-151.

Osborne, J. W., & Costello, A. B. (2005). Best practices in exploratory factor analysis: Four recommendations for getting the most from your analysis. *Practical Assessment, Research & Evaluation*, *10*(7), 1-9.

Owston, R. (2007). Contextual factors that sustain innovative pedagogical practice using technology: An international study. *Journal of Educational Change*, *8*(1), 61-77.

Panitz, T. (1999). Collaborative versus cooperative learning: A comparison of the two concepts which will help us understand the underlying nature of interactive learning. Retrieved from ERIC database (ED448443).

Partnership for 21st Century Skills. (2016). *Framework for 21st Century Learning*. Retrieved from http://www.p21.org/about-us/p21-framework

Pecore, J. L. (2013). Beyond beliefs: Teachers adapting problem-based learning to preexisting systems of practice. *Interdisciplinary Journal of Problem-based Learning*, *7*(2), 7-33.

Pecore, J. L., & Bohan, C. H. (2012). Problem-based learning: Teachers who flourish and flounder. *Curriculum and Teaching Dialogue*, *14*(1/2), 125-138.

Pedersen, S., Arslanyilmaz, A., & Williams, D. (2009). Teachers' assessment-related local adaptations of a problem-based learning module. *Educational Technology Research and Development*, *57*(2), 229-249.

Perez, T., Cromley, J. G., & Kaplan, A. (2014). The role of identity development, values, and costs in college STEM retention. *Journal of Educational Psychology*, *106*(1), 315-329.

Peters, D. L., & Daly, S. R. (2013). Returning to graduate school: Expectations of success, values of the degree, and managing the costs. *Journal of Engineering Education*, *102*(2), 244-268.

Pett, M. A., Lackey, N. R., & Sullivan, J. J. (Eds.). (2003). *Making sense of factor analysis.* Retrieved from http://methods.sagepub.com.prox.lib.ncsu.edu/book/making-sense-of-factor-analysis

Pintrich, P. R., Smith, D. A. F., Garcia, T., & McKeachie, W. J. (1991). A Manual for the use of the Motivated Strategies for Learnning Questionnaire (MSLQ), Report Number NCRIPTAL-91-B-004. Ann Arbor, MI: National Center for Research.

Plonczak, I., Brooks, J. G., Lodato, G., Wilson, R. E., & Caliendo, J. (2014). STEM studio. *Phi Delta Kappan*, 95(5), 52-56.

Poncheri, R. M., Lindberg, J. T., Thompson, L. F., & Surface, E. A. (2007). A comment on employee surveys: Negativity bias in open-ended responses. *Organizational Research Methods*, *11*(3), 614-630.

President's Council of Advisors on Science and Technology. (2012). *Engage to excel: Producing one million additional college graduates with degree in science, technology, engineering, and mathematics.* Retrieved from https://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-engage-to-excel-final_2-25-12.pdf

Ravitz, J., & Blazevski, J. (2014). Assessing the role of online technologies in project-based learning. *Interdisciplinary Journal of Problem-Based Learning*, *8*(1), 9.

Ribeiro, L. R. C. (2011). The pros and cons of problem-based learning from the teacher's standpoint. *Journal of University Teaching and Learning Practice*, *8*(1), 4.

Richardson, M., Abraham, C., & Bond, R. (2012). Psychological correlates of university students' academic performance: a systematic review and meta-analysis. *Psychological bulletin*, *138*(2), 353-387.

Roorda, D.L., Koomen, H.M. Y., Spilt, J.L., & Oort, F.J. (2011). The Influence of affective teacher-student relationships on students' school engagement and achievement: A Meta-analytic approach. *Review of Educational Research*, *81*(4), 493-529.

Rozenszayn, R., & Assaraf, O. B. Z. (2011). When collaborative learning meets nature: Collaborative learning as a meaningful learning tool in the ecology inquiry based project. *Research in Science Education*, *41*(1), 123-146.

Ryan, R. M., & Deci, E. L. (2000a). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology*, *25*(1), 54-67.

Ryan, R. M., & Deci, E. L. (2000b). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist*, *55*(1), 68-78.

Ryan, R. M., & Deci, E. L. (2002). Overview of self-determination theory: An organismic dialectical perspective. In E. L. Deci & R. M. Ryan (Eds.), *Handbook of self-determination research* (pp. 3-33). Rochester, NY: The University of Rochester Press.

Salkind, N. J. (Ed.). (2010). *Encyclopedia of research design* (Vol. 1). Thousnad Oaks, CA: Sage Publications, Inc.

Salinitri, F. D., Wilhelm, S. M., & Crabtree, B. L. (2015). Facilitating facilitators: Enhancing PBL through a structured facilitator development program.*Interdisciplinary Journal of Problem-Based Learning*, *9*(1), 73-82.

Sampson, V., Enderle, P., Grooms, J., & Witte, S. (2013). Writing to learn by learning to write during the school science laboratory: Helping middle and high school students develop argumentative writing skills as they learn core ideas. *Science Education*, *97*(5), 643-670.

Sandi-Urena, S., Cooper, M. M., & Stevens, R. H. (2011). Enhancement of metacognition use and awareness by means of a collaborative intervention. *International Journal of Science Education*, *33*(3), 323-340.

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

Savin-Baden, M. (2004). Understanding the impact of assessment on students in problem-based learning. *Innovations in Education and Teaching International*,*41*(2), 221-233.

sdt: Self-Determination Theory. (n.d.). An approach to human motivation and personality. Retrieved from http://www.selfdeterminationtheory.org/

Şendağ, S., & Odabaşı, H. F. (2009). Effects of an online problem based learning course on content knowledge acquisition and critical thinking skills. *Computers & Education*, *53*(1), 132-141.

Seung, E., Park, S., & Jung, J. (2014). Exploring preservice elementary teachers' understanding of the essential features of inquiry-based science teaching using evidence-based reflection. *Research in Science Education*,*44*(4), 507-529.

Sheingold, B. H., & Sheingold, S. H. (2013). Using a social capital framework to enhance measurement of the nursing work environment. *Journal of Nursing Management*, *21*(5), 790-801

Shemwell, J. T., Chase, C. C., & Schwartz, D. L. (2015). Seeking the general explanation: A test of inductive activities for learning and transfer. *Journal of Research in Science Teaching*, *52*(1), 58-83.

Simons, K. D., & Klein, J. D. (2007). The impact of scaffolding and student achievement levels in a problem-based learning environment. *Instructional Science*, *35*(1), 41-72.

Simpkins, S. D., Davis-Kean, P. E., & Eccles, J. S. (2006). Math and science motivation: A longitudinal examination of the links between choices and beliefs. *Developmental Psychology*, *42*(1), 70-83.

Skovlund, E., & Fenstad, G. U. (2001). Should we always choose a nonparametric test when comparing two apparently nonnormal distributions?.*Journal of clinical epidemiology*, *54*(1), 86-92.

Sørebø, Ø., Halvari, H., Gulli, V. F., & Kristiansen, R. (2009). The role of self-determination theory in explaining teachers' motivation to continue to use e-learning technology. *Computers & Education*, *53*(4), 1177-1187.

Sockalingam, N., Rotgans, J., & Schmidt, H. (2012). Assessing the quality of problems in problem-Based learning. *International Journal of Teaching and Learning in Higher Education*, *24*(1), 43-51.

Sockalingam, N., & Schmidt, H. G. (2011). Characteristics of problems for problem-based learning: The students' perspective. *Interdisciplinary Journal of Problem-based Learning*, *5*(1), 6-33.

Song, H. D., Grabowski, B. L., Koszalka, T. A., & Harkness, W. L. (2006). Patterns of instructional-design factors prompting reflective thinking in middle-school and college level problem-based learning environments. *Instructional Science*, *34*(1), 63-87.

Spilt, J. L., Koomen, H. M. Y., & Thijs, J. T. (2011). Teacher wellbeing: The importance of teacher-student relationships. *Educational Psychological Review*, *23*(4), 457-477.

Spronken-Smith, R., & Harland, T. (2009). Learning to teach with problem-based learning. *Active Learning in Higher Education*, *10*(2), 138-153.

Stanley, T., & Marsden, S. (2012). Problem-based learning: Does accounting education need it?. *Journal of Accounting Education*, *30*(3), 267-289.

Stepien, W., & Gallagher, S. (1993). Problem-based learning: As authentic as it gets. *Educational Leadership*, *50*, 25-28.

Stoneman, P., Sturgis, P., & Allum, N. (2012). Exploring public discourses about emerging technologies through statistical clustering of open-ended survey questions. *Public Understanding of Science*, *22*(7), 850-868.

Streiner, D. L. (2003). Starting at the beginning: an introduction to coefficient alpha and internal consistency. *Journal of personality assessment*, *80*(1), 99-103.

Strobel, J., & van Barneveld, A. (2009). When is PBL more effective? A meta-synthesis of meta-analyses comparing PBL to conventional classrooms. *Interdisciplinary Journal of Problem-based Learning*, *3*(1), 44-58.

Sungur, S., & Tekkaya, C. (2006). Effects of problem-based learning and traditional instruction on self-regulated learning. *The Journal of Educational Research*, 99(5), 307-320.

Tarhan, L., Ayar-Kayali, H., Urek, R. O., & Acar, B. (2008). Problem-based learning in 9th grade chemistry class: ‘Intermolecular forces’. *Research in Science Education*, *38*(3), 285-300.

Thompson, B., & Daniel, L. G. (1996). Factor analytic evidence for the construct validity of scores: A historical overview and some guidelines. *Educational and Psychological Measurement*, *56*(2), 197-208.

Tollefson, N. (2000). Classroom applications of cognitive theories of motivation. *Educational Psychology Review*, *12*(1), 63-83.

Trauth-Nare, A., & Buck, G. (2011). Assessment for learning. *The Science Teacher*, *78*(1), 34-39.

Trautwein, U., Marsh, H. W., Nagengast, B., Lüdtke, O., Nagy, G., & Jonkmann, K. (2012). Probing for the multiplicative term in modern expectancy–value theory: A latent interaction modeling study. *Journal of Educational Psychology*, *104*(3), 763-777.

Trost, S. M., & Oberlender, G. D. (2003). Predicting accuracy of early cost estimates using factor analysis and multivariate regression. *Journal of Construction Engineering and Management*, *129*(2), 198-204.

van Dinther, M., Dochy, F., & Segers, M. (2011). Factors affecting students' self-efficacy in higher education. *Educational Research Review*, *6*(2), 95-108.

van Eijck, M. (2010). Addressing the dynamics of science in curricular reform for scientific literacy: the case of genomics. *International Journal of Science Education*, *32*(18), 2429-2449.

Vardi, I., & Ciccarelli, M. (2008). Overcoming problems in problem-based learning: a trial of strategies in an undergraduate unit. *Innovations in Education and Teaching International*, *45*(4), 345-354.

Vasconcelos, C. (2012). Teaching environmental education through PBL: Evaluation of a teaching intervention program. *Research in Science Education*, *42*(2), 219-232.

Velicer, W. F., & Fava, J. L. (1998). Affects of variable and subject sampling on factor pattern recovery. *Psychological methods*, *3*(2), 231-251.

Vernon, D. T., & Blake, R. L. (1993). Does problem-based learning work? A meta-analysis of evaluative research. *Academic Medicine*, *68*(7), 550-63.

Walker, A., & Leary, H. (2009). A problem based learning meta analysis: Differences across problem types, implementation types, disciplines, and assessment levels. *Interdisciplinary Journal of Problem-based Learning*, *3*(1), 6-28.

Walton, H. J., & Matthews, M. B. (1989). Essentials of problem-based learning.*Medical Education*, *23*(6), 542-558.

Walton, J. (2014). Teachers as expert learners and fellow travelers. Issues in Teacher Education, 22(2), 67-92.

Wang, M. T. (2012). Educational and career interests in math: A longitudinal examination of the links between classroom environment, motivational beliefs, and interests. *Developmental Psychology*, *48*(6), 1643-1657.

Weiss, I. R., & Pasley, J. D. (2006). Scaling up instructional improvement through teacher professional development: Insights from the local systemic change initiative. *CPRE Policy Briefs*. Retrieved from http://repository.upenn.edu/cpre_policybriefs/32

Westhues, A., Barsen, C., Freymond, N., & Train, P. (2014). An outcome evaluation of a problem-based learning approach with MSW students. *Journal of Social Work Education*, *50*(3), 472-489.

Wigfield, A., & Cambria, J. (2010). Students' achievement values, goal orientations, and interest: Definitions, development, and relations to achievement outcomes. *Developmental Review*, *30*(1), 1-35.

Wigfield, A., & Eccles, J. S. (1992). The development of achievement task values: A theoretical analysis. *Developmental Review*, *12*(3), 265-310.

Wigfield, A., & Eccles, J. S. (2000). Expectancy–value theory of achievement motivation. *Contemporary Educational Psychology*, *25*(1), 68-81.

Williams, B., Brown, T., & Onsman, A. (2012). Exploratory factor analysis: A five-step guide for novices. *Australasian Journal of Paramedicine*, *8*(3), 1-13.

Wong, K. K. H., & Day, J. R. (2009). A comparative study of problem-based and lecture-based learning in junior secondary school science. *Research in Science Education*, *39*(5), 625-642.

Wood, W. B. (2009). Innovations in teaching undergraduate biology and why we need them. *Annual Review of Cell and Developmental*, *25*, 93-112.

Worthington, R. L., & Whittaker, T. A. (2006). Scale development research a content analysis and recommendations for best practices. *The Counseling Psychologist*, *34*(6), 806-838.

Wozney, L., Venkatesh, V., & Abrami, P. (2006). Implementing computer technologies: Teachers' perceptions and practices. *Journal of Technology and Teacher Education*, *14*(1), 173-207.

Yong, A. G., & Pearce, S. (2013). A beginner's guide to factor analysis: Focusing on exploratory factor analysis. *Tutorials in Quantitative Methods for Psychology*, *9*(2), 79-94.

Yoon, H., Woo, A. J., Treagust, D., & Chandrasegaran, A. L. (2014). The Efficacy of Problem-based Learning in an Analytical Laboratory Course for Pre-service Chemistry Teachers. *International Journal of Science Education*, *36*(1), 79-102.

Zhang, X., & Bartol, K. M. (2010). Linking empowering leadership and employee creativity: The influence of psychological empowerment, intrinsic motivation, and creative process engagement. *Academy of Management Journal*, *53*(1), 107-128.

Zimmerman, B. J. (1989). A social cognitive view of self-regulated academic learning. *Journal of Educational Psychology*, *81*(3), 329-339.

Zimmerman, B. J. (2000). Self-efficacy: An essential motive to learn. *Contemporary Educational Psychology*, *25*(1), 82-91.

Zimmerman, B. J., Bandura, A., & Martinez-Pons, M. (1992). Self-motivation for academic attainment: The role of self-efficacy beliefs and personal goal setting. *American Educational Research Journal*, *29*(3), 663-676.

Zimmerman, D. W. (1987). Comparative power of Student t test and Mann-Whitney U test for unequal sample sizes and variances. *The Journal of Experimental Education*, *55*(3), 171-174.

Zollman, A. (2012). Learning for STEM literacy: STEM literacy for learning. *School Science and Mathematics*, *112*(1), 12-19.

APPENDICES

Appendix A: Survey for Teachers' Intention of Implementing Problem-based Learning (Teachers' version)

This survey is for a research project being conducted by Huei-Chen Lao at North Carolina State University (NCSU). The purpose of this study is to examine the various factors that influence teachers' motivation to implement problem-based learning. You are invited to participate in this research project by taking this online survey and your responses will anonymous. Your participation is voluntary and you may withdraw at any time. At the end of the survey, you will have the option of entering a drawing for $30 gas gift cards (15 will be awarded) through a link that is **not** connected to the survey responses.

It will take approximately 10 minutes to finish this survey. Your responses will be confidential and we do not collect identifying information such as your name, email address or IP address. All data will be stored in a password protected electronic format. The results of this study will be used for research purposes and to inform the school district central office of the views of district teachers and administrators on problem-based learning.

This research has been reviewed according to NCSU IRB procedures for research involving human subjects. If you have any questions about this research study and the survey, please contact Huei-Chen Lao at hlao@ncsu.edu.

Electronic Consent:

By clicking the "AGREE" button, you agree that

*You have read and understand the above information.

*You voluntarily agree to take this survey with the understanding that you may choose to stop participating at any time.

*You are at least 18 years of age.

1. My gender is

   - Male
   - Female

2. My year of birth is __________________

3. I am:

   - Black or African American
   - White, non-Hispanic/non-Latino
   - Asian or Pacific Islander
   - Hispanic/Latino
   - Native American or Alaska Native
   - Other (please specify)________________________

4. I am

   - An administrator
   - A teacher

5. The number of years that I have been a school teacher is___________________

6. I **currently** teach at a

   - Middle school
   - High school
   - Other (please specify)_____________________________

7. The county in which I teach is____________________

8. I currently teach (check all that apply):

   - English/Language Arts

- Mathematics
- Science
- Social Studies
- Other (please specify)____________________________

For the purposes of this survey, **problem-based learning (PBL)** is defined as a type of pedagogy in which students direct their own learning under the guidance and facilitation of a teacher. With a PBL approach, students are first presented with a problem, followed by making inquiries into how to solve the problem, recognizing relevant facts from the initial problem scenario, generating hypotheses, and identifying the necessary information that they need to acquire in order to solve the problem. Through self-directed collaborative learning and guidance from the teacher/facilitator, students acquire new knowledge and apply it to develop viable solutions for the problem.

It is common that people use the terms "problem-based learning" and "project-based learning" interchangeably. For the purpose of this survey, consider that you have practiced PBL whether you call it problem-based learning or project-based learning.

9. I estimate that the percentage of teachers at my school who use PBL in their lessons is____________

10. The following statement best describes my training for PBL:
    - I have not received any training for PBL. [This response takes participant to question #12]
    - I have received informal training for PBL (colleague, self-taught). [This response takes participant to question #12]
    - I have received formal training for PBL.

- I have received both informal and formal training for PBL.

11. I have had the following amount of formal PBL training (e.g., professional development):

- 1 day or less
- 2-5 days
- 6-10 days
- More than 2 weeks

12. I have experience teaching with PBL.

- Yes [This response takes participant to question #16]
- No

13. I have never taught with PBL because (choose all that apply)

- I do **not** have the required professional training for PBL.
- I am **not** interested.
- Teaching with PBL is **not** important to me.
- I do **not** believe that I am able to successfully implement PBL.
- I do **not** have support from my school administrators.
- Other (please specify)______________________________________

14. Although I have not yet taught with PBL, I plan to use it this year.

- Strongly Disagree [This response takes participant to question #23]
- Disagree [This response takes participant to question #23]
- Somewhat Disagree [This response takes participant to question #23]
- Somewhat Agree
- Agree
- Strongly Agree

15. I plan to use PBL this year
    - Only as a trial. [This response takes participant to question #23]
    - Occasionally, for no more than one or two lesson units for a particular course. [This response takes participant to question #23]
    - On regular basis and will use PBL for up to a quarter of my teaching. [This response takes participant to question #23]
    - On regular basis and will use PBL for more than a quarter of my teaching. [This response takes participant to question #23]
16. The following statement best describes my **current** use of PBL:
    - Currently I do **not** teach with PBL at all.
    - I use PBL occasionally, for no more than one or two lesson units for a particular course.
    - I use PBL on a regular basis and on average about a quarter of my teaching is done by PBL.
    - I use PBL on a regular basis and on average about half of my teaching is done by PBL.
    - I use PBL for most of my teaching.
17. I plan to increase the level of PBL I use this year. (6-point Likert scale from strongly disagree to strongly agree)
18. I enjoyed using the PBL approach with my students. (6-point Likert scale from strongly disagree to strongly agree) ***(intrinsic value)***
19. I plan to continue using PBL in some capacity this year. (6-point Likert scale from strongly disagree to strongly agree)

20. The **advantages** of implementing PBL in my classroom are:

    ____

21. The **challenges** of implementing PBL in my classroom are:

    ____

22. I doubt that I will implement PBL this year as much as I have in the past. (6-point Likert scale from strongly disagree to strongly agree)
23. I feel supported by my school administration to implement PBL. (6-point Likert scale from strongly disagree to strongly agree) ***(school support)***

For the purposes of this survey, **problem-based learning (PBL)** is defined as a type of pedagogy in which students direct their own learning under the guidance and facilitation of a teacher. With a PBL approach, students are first presented with a problem, followed by making inquiries into how to solve the problem, recognizing relevant facts from the initial problem scenario, generating hypotheses, and identifying the necessary information that they need to acquire in order to solve the problem. Through self-directed collaborative learning and guidance from the teacher/facilitator, students acquire new knowledge and apply it to develop viable solutions for the problem.

It is common that people use the terms “problem-based learning” and “project-based learning” interchangeably. For the purpose of this survey, consider that you have practiced PBL whether you call it problem-based learning or project-based learning.

Teachers’ beliefs about PBL & its value to their students (6-point Likert Scale: strongly disagree, disagree, somewhat disagree, somewhat agree, agree, strongly agree)

24. PBL should use open-ended driving questions that allow students to develop more than one reasonable, complex answer. ***(teachers’ beliefs about PBL)***

25. PBL stimulates students' creativity. ***(PBL's value to students)***

26. PBL does **not** help students obtain a deeper understanding of the content knowledge than they do in a traditional classroom. ***(PBL's value to students)*** **(reverse-coded)**

27. In PBL students engage in issues relevant to their lives/communities. ***(PBL's value to students)***

28. I am concerned that PBL can lead to students missing out on learning important basic concepts. ***(psychological cost)*** **(reverse-coded)**

29. PBL enhances students' collaboration and communication skills. ***(PBL's value to students)***

30. With PBL, it is totally up to the teacher to give students feedback about the quality of their work-in-progress. ***(teachers' beliefs about PBL)***

31. I believe PBL is a pedagogy that is more appropriate for motivated students. ***(teachers' beliefs about PBL)***

32. Using PBL causes students to have negative attitudes toward learning. ***(PBL's value to students)*** **(reverse-coded)**

33. PBL promotes students' critical thinking. ***(PBL's value to students)***

34. Teaching with PBL would require more of my time than traditional lecture-based teaching. ***(effort cost)*** **(reverse-coded)**

35. In a PBL classroom, the teacher functions as a facilitator and therefore no content teaching is necessary. ***(teachers' beliefs about PBL)***

36. PBL gives too much responsibility to students. ***(teachers' beliefs about PBL)***

37. PBL is especially effective for students with low ability. ***(teachers' beliefs about PBL)***

38. Students with limited English language skills have trouble with PBL. ***(teachers' beliefs about PBL)***

Expectancy for success and self-determination (autonomy, competence, and relatedness) for practicing PBL (6-point Likert Scale: strongly disagree, disagree, somewhat disagree, somewhat agree, agree, strongly agree)

39. I will be able to implement PBL successfully. ***(expectancy for success)***
40. The instructional methods that I use are driven by state standards. ***(autonomy)*** **(reverse coded)**
41. I may not persist with PBL if my students struggle. ***(expectancy for success)*** **(reverse coded)**
42. I feel pressured by school administrators to implement PBL. ***(autonomy)***
43. I feel confident that I can successfully assess students' learning progress in a PBL setting. ***(competence)***
44. I am **not** sure that I can teach with PBL in ways that meet state and district standards. ***(competence)*** **(reverse coded)**
45. I decide whether I implement PBL or other teaching methods. ***(autonomy)***
46. People at work care about my experiences with PBL. ***(relatedness/support from peers)***
47. I do **not** feel competent to teach with a PBL approach. ***(competence)*** **(reverse-coded)**
48. My school administrators provide me choices and options in terms of implementing PBL or other teaching methods. ***(autonomy)***
49. There are **not** many people at work who are willing to help me with PBL. ***(relatedness/support from peers)*** **(reverse-coded)**

Value (6-point Likert Scale: strongly disagree, disagree, somewhat disagree, somewhat agree, agree, strongly agree)

50. I am **not** interested in implementing PBL. ***(intrinsic value)*** **(reverse-coded)**
51. Teaching well with PBL is important for my career. ***(attainment value)***
52. Teaching with PBL could be enjoyable. ***(intrinsic value)***
53. Teaching with PBL is **not** important for my professional growth. ***(attainment value)*** **(reverse-coded)**
54. PBL professional development will make me a better teacher. ***(utility value)***
55. The skills that I gain by implementing PBL may be useful beyond the classroom. ***(utility value)***

Cost (6-point Likert Scale: strongly disagree, disagree, somewhat disagree, somewhat agree, agree, strongly agree)

56. I worry that PBL might have a negative impact on how my students score on the end-of-course tests. ***(psychological cost)*** **(reverse-coded)**
57. Preparing to implement PBL would require too much of my time. ***(effort cost)***
58. I have easily accessible resources (e.g., technology, materials, or examples of PBL in my subject area) for implementing PBL. ***(effort cost)***
59. Implementing PBL will make classroom management more difficult. ***(effort cost)*** **(reverse-coded)**
60. It will be too stressful for me to cover the mandated curriculum if I implement PBL. ***(psychological cost)*** **(reverse-coded)**
61. I believe that the overall benefits from implementing PBL would outweigh the costs.

62. I am concerned that implementing PBL might have a negative impact on my teaching evaluation. ***(psychological cost)*** **(reverse-coded)**

63. I would like to receive PBL training in following areas (check all that apply):

    - Classroom management
    - Change from direct instruction to facilitating
    - Designing/structuring PBL lessons and units
    - Assessment (formative and/or summative)
    - Other (please specify)____
    - I do not want training on PBL

64. Is there anything else that you would like to say about PBL?

65. You have answered all the questions. Do you need to go back and make any changes before you click the forward button and submit your responses?

66. This is the end of the survey. Click the forward button and your responses will be submitted. Thank you for your time and effort in completing this survey. Would you like to be included in a prize drawing for $30 gift cards (15 will be awarded)?

    - Yes
    - No

Appendix B: Survey for Teachers' Intention of Implementing Problem-based Learning (Administrators' version)

This survey is for a research project being conducted by Huei-Chen Lao at North Carolina State University (NCSU). The purpose of this study is to examine the various factors that influence teachers' motivation to implement problem-based learning. You are invited to participate in this research project by taking this online survey and your responses will anonymous. Your participation is voluntary and you may withdraw at any time. At the end of the survey, you will have the option of entering a drawing for $30 gas gift cards (15 will be awarded) through a link that is **not** connected to the survey responses.

It will take approximately 10 minutes to finish this survey. Your responses will be confidential and we do not collect identifying information such as your name, email address or IP address. All data will be stored in a password protected electronic format. The results of this study will be used for research purposes and to inform the school district central office of the views of district teachers and administrators on problem-based learning.

This research has been reviewed according to NCSU IRB procedures for research involving human subjects. If you have any questions about this research study and the survey, please contact Huei-Chen Lao at hlao@ncsu.edu.

Electronic Consent:

By clicking the "AGREE" button, you agree that

*You have read and understand the above information.

*You voluntarily agree to take this survey with the understanding that you may choose to stop participating at any time.

*You are at least 18 years of age.

AGREE

1. My gender is
   - Male
   - Female
2. My year of birth is ___________________
3. I am:
   - Black or African American
   - White, non-Hispanic/non-Latino
   - Asian or Pacific Islander
   - Hispanic/Latino
   - Native American or Alaska Native
   - Other (please specify)__________________________
4. I am
   - An administrator
   - A teacher
5. The number of years that I have been a school administrator is____________________
6. I am **currently** a school administrator at a
   - Middle school
   - High school
   - Other (please specify)________________________________
7. The county in which I work as a school administrator is_____________________

For the purposes of this survey, **problem-based learning (PBL)** is defined as a type of pedagogy in which students direct their own learning under the guidance and facilitation of a teacher. With a PBL approach, students are first presented with a problem, followed by making inquiries into how to solve the problem, recognizing relevant facts from the initial problem scenario, generating hypotheses, and identifying the necessary information that they need to acquire in order to solve the problem. Through self-directed collaborative learning and guidance from the teacher/facilitator, students acquire new knowledge and apply it to develop viable solutions for the problem.

It is common that people use the terms “problem-based learning” and “project-based learning” interchangeably. For the purpose of this survey, consider that you have practiced PBL whether you call it problem-based learning or project-based learning.

8. The following statement best describes my training for PBL:

- I have not received any training for PBL. [This response takes participant to question #10]
- I have received informal training for PBL (colleague, self-taught). [This response takes participant to question #10]
- I have received formal training for PBL.
- I have received both informal and formal training for PBL.

9. I have had the following amount of formal PBL training (e.g., professional development):

- 1 day or less
- 2-5 days
- 6-10 days
- More than 2 weeks

10. I have experience teaching with PBL.

- Yes [This response takes participant to question # 12]
- No

11. I never taught with PBL because (choose all that apply)

    - I did **not** have the required professional training for PBL.
    - I was **not** interested.
    - Teaching with PBL was **not** important to me.
    - I did **not** believe that I was able to successfully implement PBL.
    - I did **not** have support from my school administrators.
    - Other (please specify)___________________________________

12. I estimate that the percentage of teachers at my school who use PBL in their lessons is

    ____

13. The **advantages** of implementing PBL in my school are:

    ____

14. The **challenges** of implementing PBL in my school are:

    ____

15. I feel that as an administrator I support teachers to implement PBL.

    - Strongly Disagree
    - Disagree
    - Somewhat Disagree
    - Somewhat Agree
    - Agree
    - Strongly Agree

Administrators' beliefs about PBL & its value to students (6-point Likert Scale: strongly disagree, disagree, somewhat disagree, somewhat agree, agree, strongly agree)

16. PBL should use open-ended driving questions that allow students to develop more than one reasonable, complex answer. ***(administrators' beliefs about PBL)***
17. PBL stimulates students' creativity. ***(PBL's value to students)***
18. PBL does **not** help students obtain a deeper understanding of the content knowledge than they do in a traditional classroom. ***(PBL's value to students)*** **(reverse-coded)**
19. In PBL, students engage in issues relevant to their lives/communities. ***(PBL's value to students)***
20. I am concerned that PBL can lead to students missing out on learning important basic concepts. ***(psychological cost)*** **(reverse-coded)**
21. PBL enhances students' collaboration and communication skills. ***(PBL's value to students)***
22. Teaching with PBL would require more of teachers' time than traditional lecture-based teaching. ***(effort cost)*** **(reverse-coded)**
23. With PBL, it is totally up to the teacher to give students feedback about the quality of their work-in-progress. ***(administrators' beliefs about PBL)***
24. I believe PBL is a pedagogy that is more appropriate for motivated students. ***(administrators' beliefs about PBL)***
25. Using PBL causes students to have negative attitudes toward learning. ***(PBL's value to students)*** **(reverse-coded)**
26. PBL promotes students' critical thinking. ***(PBL's value to students)***

27. In a PBL classroom, the teacher functions as a facilitator and therefore no content teaching is necessary. ***(administrators' beliefs about PBL)***
28. PBL gives too much responsibility to students. ***(administrators' beliefs about PBL)***
29. PBL is especially effective for students with low ability. ***(administrators' beliefs about PBL)***
30. Students with limited English language skills have trouble with PBL. ***(administrators' beliefs about PBL)***

Expectancy for success and self-determination (autonomy, competence, and relatedness) of teachers who practice PBL (6-point Likert Scale: strongly disagree, disagree, somewhat disagree, somewhat agree, agree, strongly agree)

31. The instructional methods that teachers use are driven by state standards. ***(autonomy)***
32. I feel confident that teachers can successfully assess students' learning progress in a PBL setting. ***(competence)***
33. I am not sure that teachers can teach with PBL in ways that meet state and district standards. ***(expectancy for success)*** **(reverse coded)**
34. People at work care about my experiences with PBL. ***(relatedness)***
35. I provide teachers choices and options in terms of implementing PBL or other teaching methods. ***(autonomy)***
36. There are **not** many people at work who are willing to help teachers with implementing PBL. ***(relatedness)*** **(reverse-coded)**

Cost (6-point Likert Scale: strongly disagree, disagree, somewhat disagree, somewhat agree, agree, strongly agree)

37. I worry that PBL might have a negative impact on how students score on the end-of-course tests. ***(psychological cost)*** **(reverse-coded)**

38. Preparing to implement PBL would require too much of teachers' time. ***(effort cost)***

39. Teachers have easily accessible resources (e.g., technology, materials, or examples of PBL in their subject areas) for implementing PBL. ***(effort cost)***

40. Implementing PBL will make classroom management more difficult. ***(effort cost)*** **(reverse-coded)**

41. It will be too stressful for teachers to cover the mandated curriculum if they implement PBL. ***(psychological cost)*** **(reverse-coded)**

42. I believe that the overall benefits from implementing PBL would outweigh the costs.

43. I am concerned that implementing PBL at my school might have a negative impact on my administrative evaluation. ***(psychological cost)*** **(reverse-coded)**

44. Teachers should make their own decisions whether they want to implement PBL or not. ***(autonomy)***

45. I would like to see teachers receive PBL training in following areas (check all that apply):

    - Classroom management
    - Change from direct instruction to facilitating
    - Designing/structuring PBL lessons and units
    - Assessment (formative and/or summative)
    - Others (please specify)___________________________
    - None of these

46. My school does **not** pressure teachers to implement PBL. ***(autonomy)***

47. Is there anything else that you would like to say about PBL?_______________________

48. You have answered all the questions. Do you need to go back and make any changes before you click the forward button and submit your responses?

49. This is the end of the survey. Click the forward button and your responses will be submitted. Thank you for your time and effort in completing this survey. Would you like to be included in a prize drawing for $30 gift cards (15 will be awarded)?

    - Yes
    - No

Appendix C: Prize Drawing

1. 15 winners will be chosen from a random draw of entries received. Each winner will win a $30 gas gift card and be notified by email. Please provide your name and email address for the prize drawing:

   First Name____

   Last Name____

   Email Address_____________________________________

2. Click the forward button and you are done. Thank you for taking the survey and good luck!