The Impact of Extended Professional Development in Project-Based Learning on Middle School Science Teachers

Margrett Caroline Upchurch-Ford

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THE IMPACT OF EXTENDED PROFESSIONAL DEVELOPMENT IN PROJECT-BASED LEARNING ON MIDDLE SCHOOL SCIENCE TEACHERS

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DEDICATION

I dedicate this dissertation to my loving and supportive family. To my husband, Tony, whose unwavering support, understanding, and patience have been the foundation of my success. He always knows when I need a little extra push or a little extra space and has been there to provide it without fail. He has been my rock and constant advocate, and I am forever grateful for his love and support. To my children, Edward and Ophelia, thank you for understanding when Mommie was busy and couldn’t always talk or play. The two of you have brought love and happiness into my life. You inspire me every day to do and be my best. I also want to thank my fabulous professors, especially those on my dissertation committee. Dr. Harbour, you have been my number-one cheerleader, believing in me even when my doubts were at their highest. I am forever grateful for your guidance and support. I also want to thank the outstanding middle school science teachers willing to participate in my study. Your participation in my sessions and your implementation of Project-Based Learning lessons were invaluable to the success of my research. Lastly, I want to thank my parents, who, while no longer with me, continue to protect and guide me. I hope I have made you proud.
ABSTRACT

This Mixed-Method Action Research study aimed to implement an extended Project-Based Learning professional development series with middle school science teachers. The professional development series took place during the teachers’ Communities of Practice, offering them high-quality support, active participation, and content-specific conversations.

The study collected data on (a) changes in teachers’ attitudes toward in-district professional development, (b) teachers’ perceptions of students’ 21st-century skills, and (c) changes in science teacher self-efficacy. Findings from this study add to the growing body of research indicating the need to offer teachers content-specific, supportive, and extended professional development opportunities. Additionally, the findings of this study indicate that teachers using Project-Based Learning in middle school science classrooms perceived an increase in their students’ use of 21st-century skills.

Keywords: 21st-Century Skills, Communities of Practice, Professional Development, Project-Based Learning, Social Constructivism, Teacher Self-Efficacy
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CHAPTER ONE: INTRODUCTION

National Context

As the world and job market change, so do the needs of our K–12 students. The education system needs to design lessons that will support 21st-century skill development. The need for skills such as collaboration, communication, creativity, and critical thinking is evident in today’s workforce and society. However, there needs to be more understanding of how to implement these 21st-century skills effectively in the classroom (Kim et al., 2019), as doing so benefits individual students, our communities, and the country. Studies have shown that Project-Based Learning (PBL) is an effective method for developing in students these skills, as well as other modern ones such as self-direction, global connection, and technology use (Little, 2013; Ravitz et al., 2012; Kuo et al., 2021). The National Research Council (NRC, 2009) also emphasized the need for science instruction to mirror scientists’ and engineers’ investigative practices to prepare students for future global challenges. Including 21st-century skills in K–12 education is imperative to equip students to succeed in today’s constantly changing society.

Research suggests that student-centered approaches such as PBL can promote 21st-century skills and student engagement effectively (Barkley et al., 2014). PBL is a method of teaching and learning that centers on students’ interactive inquiries into real-world problems; studies have shown it can benefit motivation, student learning, the acquisition of 21st-century skills, and relationships (Bell, 2010; Tamim & Grant, 2013). However, many teachers need help implementing PBL and often revert to traditional
teaching methods without proper professional development and support (Nariman & Chrispeels, 2016). Thus, a growing gap exists between professional development and implementing PBL in the classroom (Dole et al., 2016). To remedy this concern, teachers need better strategies for teaching students 21st-century skills through PBL to ensure students are equipped to succeed in today’s constantly changing society.

Many teachers need better long-term training and support to transfer knowledge from professional development sessions on PBL into actual classroom practice (Hung, 2011; Tamim & Grant, 2013; Nariman & Chrispeels, 2016). Effective professional development is essential for implementing PBL and should be sustained, hands-on, and applicable to teachers’ daily responsibilities. It should also involve group participation, opportunities for inquiry, reflection, collaboration, and connection to the standards the instructor teaches. Providing teachers with necessary support and resources through high-quality extended PBL professional development will equip them better to help students build the 21st-century skills they need.

**Local Context**

I entered the profession of education in 2001, bright-eyed and ready to teach the 21 first-graders assigned to my classroom. That first year opened my heart and my mind to what it takes to be a teacher: it is not all lectures and note-taking, but rather celebrations of failure and tears of joy when obstacles are overcome. Teaching requires creating engaging lesson plans that intrigue students and hold their attention, as well as bringing the content standards to life by applying them to what students see and do every day.
I implemented Project-Based Learning in my classroom before I knew what it was called. Over the years, I have taught first grade, fifth grade, and high school, and, in 2009, I moved into administration as first Assistant Principal and then Principal. Lessons I learned in the classroom made me a leader who expected teachers to be innovative and open-minded. While in my role as a school Principal, I modeled teaching with a flipped classroom, encouraged implementing differentiation, and deliberately created flexible schedules to support Project-Based Learning. In 2017, I received the opportunity to join the department of Curriculum and Instruction at Green Mountain School Districts’ District Office.

Over the past six years, I have worked closely with the nine elementary, three middle, and two high schools in Green Mountain School District as well as its instructional team to identify areas of academic weakness and design innovative ways to address these needs. Through this work, I helped identify that our students are entering the workforce lacking many of the skills outlined in the profile of the South Carolina Graduate as necessary to succeed in life beyond high school. Specifically, our students lack the 21st-century learning skills of: (a) communication, (b) collaboration, (c) creativity and innovation, and (d) engagement and self-direction (Little, 2013).

In response to these findings, I began the task of identifying programs we could infuse into our schools to support and improve the student skills our data showed were lacking. One such program was Project Lead the Way (PLTW). PLTW is a non-profit organization dedicated to developing K–12 STEM curricula and is one of the most widely used pre-college engineering, biomedical, and computer science programs in middle schools throughout the United States. A study by Mehalik et al. (2008) supported
using project-based programs, such as PLTW, for middle school students, citing improved science achievement, student engagement, and retention of science concepts as reasons to do so.

During the 2018–2019 school year, I successfully oversaw implementing PLTW courses at all three middle schools and our ninth-grade campus. During that year, we had over 960 students complete a PLTW course. For the following two years, I oversaw adding further PLTW courses, and this year we will impact roughly 3,000 students. However, adding PLTW as a standalone opportunity that only benefits some students is not the solution: we must support our total school population. Green Mountain School District needed a plan for preparing all teachers to use PBL, which led me to conducting action research that will guide and support the creation of an in-district professional development series aimed at rethinking middle school science lesson plan design to incorporate robust Project-Based Learning Units.

**Statement of the Problem**

As a curriculum and instruction team member at the district office, I identified the need for enhanced classroom use of PBL after my school district underwent AdvanceED accreditation during the 2017–2018 school year. The AdvancedED exit report included the following improvement recommendations: (a) to update and strengthen our mission and vision statements and (b) to conduct a systemic evaluation of the programs and initiatives we have ongoing within the district. The accreditors suggested using an outside research firm to determine the effectiveness of our current Communities of Practice (CoP) to maximize the benefits to our students. We engaged Hanover Research during the 2018–2019 school year to conduct a series of surveys, focus groups, and observations.
of our CoPs. While the overall findings supported the CoPs’ benefits, the teachers’ comments shed light on the lack of student preparation they witnessed in the classrooms. Teachers noted their students lacked appropriate communication skills, collaboration skills, engagement, self-direction, critical thinking, creativity, and problem-solving skills, and most demonstrated a lack of knowing how to learn independently. These findings were concerning and compelled me to research an evidence-based solution. I examined data from the Youth Risk Behavior Survey (YRBS), a study the Centers for Disease Control administered to all students in grades 9–12 during odd years starting in 1991. The data indicated that high school students self-report poor work ethic, disinterest in self-direction, a lack of overall organization skills, and little motivation/perseverance. A review of the 2019 state-administered Student Engagement Survey (SES) revealed that students in grades 3–12 reported limited opportunities in class for critical thinking and problem solving, a lack of interest in attendance, and a lack of interest in performing above the minimum requirements. Additionally, the 2019 state report card data revealed that only 76.3% of our students were college or career ready as they graduated from our high schools.

When analyzing the data points from the 2019 YRBS, 2019 SES, and 2019 state report card data in conjunction with the profile of the South Carolina graduate, I discovered that our students lacked four notable 21st-century student skills: (a) communication, (b) collaboration, (c) creativity and innovation, and (d) engagement and self-direction. Hodges (2018) indicated that “engaged students are 2.5 times more likely to say that they get excellent grades and do well in school, and they are 4.5 times more likely to be hopeful about the future than their actively disengaged peers” (n.p.). Between
2006–2018, “Gallup conducted more than 5 million surveys with students in grades five through 12” inquiring about school engagement (Hodges, 2018, n.p.). The findings are stark: only 47% of students self-reported being “engaged” with school, 29% reported as “not engaged,” and 24% as “actively disengaged” (Hodges, 2018). Furthermore, data illustrated that student engagement began to drop at the end of fifth grade and steadily declined until eleventh grade (Hodges, 2018). This timeline for the decline in student engagement, coupled with the state-mandated sixth-grade standardized science assessment, led to the study’s identification of middle school, grades six-eight, as the target grade span for robust support with maximum available quantitative data.

As I worked through our district’s data, I felt an overwhelming sense of responsibility. I decided we needed to find a better way to support our teachers in re-engaging the students and building 21st-century skills through the curriculum. I recognized the need to offer teachers a way to renew, change, or adapt their pedagogical practices if we are going to change our students’ engagement and academic outcomes.

This study’s problem of practice is to address the need of extended professional development that supports middle school science teachers when implementing PBL within classrooms. Notably, a clear distinction does exist between training and development. Richards and Farrell (2005) stated that traditional training encompasses brief activities or informational sessions that target short-term and immediate goals; in contrast, development refers to growth as a long-term goal leading to systemic change in teacher pedagogy. Therefore, I will explore (a) extended teacher professional development in PBL, (b) the relationship between PBL and teachers’ perceptions of students’ 21st-century skills, and (c) science teacher self-efficacy.
Purpose Statement

The purpose for this Mixed-Method Action Research (MMAR) study was to implement an extended PBL professional development series and (a) explore whether teachers’ attitudes toward in-district professional development changed, (b) explore teachers’ perceptions of students’ 21st-century skills, and (c) explore if extending PBL professional development impacted science teacher self-efficacy.

Research Questions

This action research study aims to explore how, in my role as a member of the district’s curriculum and instruction department, I can support all middle school science teachers in Green Mountain School District navigate the transition from traditional lessons to PBL Units through an extended professional development experience. Evidence from multiple studies has recommended focusing on content knowledge, active learning, active participation, extended duration, collaboration, and consistency to create effective professional development that influences teacher self-efficacy and increases student academic outcomes (Darling-Hammond et al., 2017; Desimone & Garet, 2015). In addition, research has noted quality professional development may be the answer to improving science instruction in K–12 education (Harrison et al., 2008; Hewson, 2007; Lin et al., 2013). Other researchers concluded that successful teacher professionalization leads to improved practice on a permanent level to achieve maximum student academic outcomes (Guskey, 2002; Penuel et al., 2007). Alemdar et al. (2018) concluded that providing authentic and hands-on middle school classes can benefit student engagement and academic achievement in science significantly. Other research indicated that PBL-designed lessons both engage students and inspire them to perform better in science and
math (Cantrell et al., 2006). Coupled with the evidence from prior research and my firsthand knowledge of Green Mountain School District, I explored the following research questions:

- **RQ1.** How do middle school science teachers’ attitudes toward in-district professional development change, if at all, after participating in an extended PBL-focused professional development series?
- **RQ2.** To what extent, if any, do middle school science teachers’ perceptions of students’ use of 21st-century skills in the classroom change when they implement PBL in their instruction?
- **RQ3.** How do middle school science teachers’ self-efficacy levels change, if at all, after participating in an extended PBL-focused professional development series?

**Researcher Subjectivities and Positionality**

Through this work, I acted “as an insider researcher as [I] collaborate(d) with other insiders as a way to do research that not only might have a greater impact on the setting but also has the potential to be more democratic” (Herr & Anderson, 2015, p. 45). Given my position at the district office, however, I was mindful of the advice Herr and Anderson (2015) gave about “power relations”: they refer to how power is distributed and exercised in a particular social context or relationship. The concept of power is central to their work, as they argue that power dynamics significantly shape social interactions and how individuals and groups relate to one another. According to Herr and Anderson (2015), power is not necessarily a fixed or static concept. Instead, it is a fluid and dynamic process that is shaped by a variety of factors, including social, cultural, and
historical context. They argue that power relations are not always visible or explicit; instead, they can be subtle and unconscious, shaping how people think, feel, and act. Herr and Anderson’s (2015) work highlights the importance of understanding and respecting the “power dynamics” that exist due to my position at the district office; I took this into account as I undertook my study.

List of Definitions

**Active Learning** – A learning environment where participants actively are engaged in unpacking and aligning new curriculum materials. This form of professional development environment allows the teachers to explore new materials or strategies through practice, investigation, problem-solving, and peer discussion (Heck et al., 2008).

**Communities of Practice** – Teachers working in collaborative settings where they are engaged in authentic discussion about core content, assessment, and student outcomes (Desimone et al., 2002; Penuel et al., 2006; Penuel et al., 2007).

**Pedagogy** – An individual teacher’s instructional delivery model that is closely tied to their beliefs on how learning happens and is generally derived from direct classroom experience (Guskey, 2002).

**Professional Development** – “Structured professional learning that results in changes in teacher practices and improvements in student learning outcomes” (Darling-Hammond et al., 2017, p. 1).

**Project-Based Learning** – An instructional technique that embraces the concept of presenting realistic and relevant problems to students to engage and challenge them (Evans et al., 2014; Kammer et al., 2015; Kim & Tan, 2013).
Project Lead the Way – Project Lead the Way (PLTW) is a rapidly expanding PBL program that K–12 schools are adopting across the United States (Hess et al., 2016).

Social Constructivism – A theory that proposes learning first takes place in a collaborative/social setting (“interpsychological”) before taking place on the individual/internal level (“intrapsychological”) (Vygotsky & Cole, 1978, p. 57).

Teacher Self-Efficacy – The teachers’ self-held belief in their abilities to successfully “promote students’ learning” (Hoy, 2000, n.p.).
CHAPTER TWO: LITERATURE REVIEW

The purpose for this MMAR study was to organize an extended PBL professional development series and (a) explore whether teachers’ attitudes toward in-district professional development changed, (b) explore teachers’ perceptions of students’ 21st-century skills, and (c) explore if extending PBL professional development impacted science teacher self-efficacy. With the purpose identified, I completed a detailed review of existing literature to formulate the specific research questions needed to resolve the problem. Alemdar et al. (2018) concluded that providing “interesting and engaging middle school engineering classes can significantly benefit student engagement and academic achievement in mathematics and science” (p. 375). Other studies supported the notion that organized and student-centered PBL modules engaged students and motivated them to perform better in science and math (Cantrell et al., 2006). The conclusions I drew from these research articles led to three research questions:

- **RQ1.** How do middle school science teachers’ attitudes toward in-district professional development change, if at all, after participating in an extended PBL-focused professional development series?

- **RQ2.** To what extent, if any, do middle school science teachers’ perceptions of students’ use of 21st-century skills in the classroom change when they implement PBL in their instruction?
• **RQ3.** How do middle school science teachers’ self-efficacy levels change, if at all, after participating in an extended PBL-focused professional development series?

This study provides evidentiary support for the district’s department of curriculum and instruction to initiate a districtwide professional development plan supporting the use of Project-Based Learning (PBL). Unlike traditional research projects, I specifically crafted the framework of this action research study to address the gaps documented within Green Mountain School District.

This MMAR study adds to the existing literature by addressing the need for more research on teachers' attitudes toward professional development. Farrow (2022) emphasizes the need for additional research on teacher attitudes and engagement during professional development. Meanwhile, Carrabba and Farmer (2018) suggest that allowing more time for professional development before implementing PBL could aid implementation. This MMAR study adds to the existing literature by expanding upon student 21st-century skill acquisition research. Current research acknowledges the importance of developing 21st-century skills for students (Kim et al., 2019; NRC, 2009; Ross et al., 2018), but research on the pedagogical approaches that cultivate these skills still needs to be conducted (Hixson et al., 2012; NRC, 2012). PBL is one approach to building student 21st-century skills, but more empirical evidence must be used to confirm its effectiveness (Capraro et al., 2016; Griffin et al., 2012). Additionally, this MMAR study adds to the existing literature addressing self-efficacy. While prior research focused on student self-efficacy, a notable gap existed surrounding teacher self-efficacy when implementing PBL (Hung, 2011; Tamim & Grant, 2013; Nariman & Chrispeels,
The literature I review in this chapter provided the evidence necessary for me to conduct an action research study to explore how I can support middle school science teachers in Green Mountain School District to navigate the transition from traditional lessons to PBL Units through effective communities of practice-based professional development experiences. The study used multiple methods to collect data, including (a) pre/post-teacher surveys, (b) classroom observations, (c) research notes from professional development sessions, and (d) teacher reflection journals. The study supports the idea that PBL can be a powerful approach for teachers to implement if they are seeking ways to boost student engagement and the 21st-century skills of (a) critical thinking, (b) problem solving, and (c) communication and collaboration. While the outcomes may be transferable to other school districts throughout the state or the country, they will drive the next steps taken within our district regarding PBL professional development.

Theoretical Framework

The principles of social constructivism, as Lev Vygotsky developed, suggest that learning is most effective in collaborative and social settings where teachers act as facilitators, encouraging students to direct their own learning. Research indicates that a social constructivist approach to professional development creates a supportive environment in which teachers can act as learners, share ideas, and research best practices (Hargreaves, 1994). Other studies, such as that of Akpan et al. (2020), have found that “knowledge develops as a result of social interaction and is not an individual possession but a shared experience” (p. 51). These ideas suggest that learners of all ages construct meaningful knowledge through participation in active learning opportunities.
In using social constructivism as this study’s foundational framework, each element of the research incorporated (a) active learning, (b) learning in a social context, (c) motivation and engagement, and (d) learning in context. The social constructivism framework posits that teachers’ experiences and interactions with students, colleagues, and the broader community are what shape their understanding of science. This framework suggests that successful teacher learning should occur in an active, social process (Stewart, 2014; Gilrane et al., 2008). Professional development should be designed to support teachers in actively constructing their understanding of PBL through collaboration and inquiry.

The study focused on middle school science teachers participating in an extended PBL professional development series. Research has suggested that people designing PBL professional development programs must customize them to teachers’ specific learning needs across an extended period, providing ongoing support (Brion, 2020). Additionally, teachers should be allowed time to collaborate and share resources and ideas with their peers (Tamim & Grant, 2013). Teachers’ most effective professional development typically occurs through active and engaged participation in CoPs (Gilrane et al., 2008).

Social Constructivism

Social constructivism describes learning as a social process that occurs within a physical and social context (Brophy, 2002; Bruner, 1996; Lave & Wenger, 1991; Vygotsky & Cole, 1978). Vygotsky theorized that learning is most effective within a collaborative and social setting in which teachers act as facilitators, allowing students to share ideas and actively participate in their learning (Vygotsky & Cole, 1978). Vygotsky emphasized the importance of socialization and collaboration among learners (Hodson &
Hodson, 1998; Jaramillo, 1996). Thus, the social constructivist approach to professional development aims to create a supportive environment where teachers can act as learners, share ideas, and research best practices (Hargreaves, 1994; Vygotsky & Cole, 1978). In this environment, learners exchange ideas and develop new understanding through social discourse with peers within their community (Brophy, 2002).

Combining these ideas suggests that learners construct meaningful knowledge through participation in active learning opportunities. Thus, in selecting social constructivism as the foundational framework for this study, I determined each professional development component would incorporate (a) active learning, where learners construct their knowledge, (b) learning in a social context, where learners are encouraged to problem-solve and reflect on their experiences through social interaction and dialogue, (c) motivation and engagement, and (d) learning in context through participating in authentic activities.

**Importance of Professional Development Design**

This section will present a comprehensive overview of the importance of designing effective professional development programs, analyzing current research on the best practice for creating impactful professional development. Additionally, I will discuss the crucial role of teachers as learners and the concept of communities of practice.

**Effective Professional Development**

Professional development provides teachers with the opportunity to learn and grow within their profession (Darling-Hammond et al., 2017; Gardner et al., 2019). Students taught by teachers who participate in meaningful and ongoing PD achieve higher academic levels than students whose teachers do not (Wojnowski & Pea, 2013).
Studies also indicate that appropriate professional development can increase teachers’ sense of self-efficacy (Overbaugh & Lu, 2008; Mouza & Barrett-Greenly, 2015). As a result, experts in the field established evidence-based practices for staff development and developed guidelines for high-quality professional development (Auerbach & Andrews, 2018; Choy et al., 2006; Maeng & Bell, 2015). The professional development factors most strongly associated with high teacher self-efficacy and change in teachers’ instructional pedagogy (a) focus on content knowledge and active learning teaching methods, (b) model effective practices that align with the teachers’ current and future beliefs, and (c) have ongoing support from a subject matter expert (Auerbach & Andrews, 2018; Maeng & Bell, 2015; Martin et al., 2010; Darling-Hammond et al., 2017; Borko et al., 2010).

**Teachers as Learners**

One cannot overstate the importance of teacher preparedness for engaging Project-Based Learning (Hajan, 2019; Brion, 2020). Therefore, it is essential to discuss how adults learn within a professional development setting. Within the frameworks of Social Constructivism, Communities of Practice, and Project-Based Learning, professional development that incorporates active participation, social experiences, and constructive peer interaction also should encourage learning, retention, and implementation. Further, Dweck’s Growth Mindset theory can apply here, as mindset and teacher self-efficacy interact. Dweck’s (2016) growth mindset theory asserts that when learners believe they can improve their abilities through dedication and hard work, they are willing to put in extra effort, leading to higher achievement.
When working with teachers as learners, facilitators must recognize that new pedagogical thinking could lead to uncertainty. “Uncertainty produces both excitement and anxiety” (Shulman, 2005, p. 57), which is why mindset plays an important role in teacher professional development. The mindset a teacher brings to a professional development session can determine its outcome, and when a teacher lacks a growth mindset, they may not receive all of the session’s benefits.

In addition to a growth mindset, teachers need strong content knowledge and be a member of a supportive team. Teacher learners need to build professional relationships with their CoPs and actively engage one another in their shared learning experience (Wenger, 2011).

**Communities of Practice**

The theory of Communities of Practice suggests that learning occurs through shared activities in a community of practitioners—in this case, teachers (Lave & Wenger, 1991; Wenger, 2011). CoP theory outlines the importance of shared practices, collective meaning-making, and teacher self-efficacy. CoPs play a crucial role in teacher professional development, identity, and belief in their ability to impart meaningful knowledge to their students. Knowing that PBL will require significant, thoughtful scaffolding to support teachers’ professional development and students’ development of problem-solving and collaboration skills (Savery, 2015), CoPs appear to be a natural way to facilitate trainings in PBL.

Multiple studies have concluded that productive and active CoPs aid in the successful implementation of new teaching practices. Findings from these studies noted that teachers who work in CoPs were engaged in authentic discussion about core content,
assessment, and student outcomes (Desimone et al., 2002; Penuel et al., 2006; Penuel et al., 2007). Within a CoP, our interactions with peers, academic standards, and the school environment create knowledge (Harasim, 2017). Gardiner (2010) concluded that teachers working in collaborative groups, such as CoPs, achieve more than those who work alone. Likewise, teachers who receive ongoing and direct peer support report higher student academic performance (Walsh & Elmslie, 2005) and higher student engagement levels (Shaughnessy, 2004).

Other noteworthy studies highlighted the need for school leadership to be actively supportive and involved in the CoP process. Principal support is an essential predictor of the effectiveness of professional development (Heck et al., 2008; Johnson, 2007). Penuel et al. (2007) and Garet et al. (2001) found that providing protected time for teachers to plan collaboratively was essential and that these CoPs should be subject matter specific. Several studies supported the need for CoPs to be content-specific so teachers can draw upon their content-specific knowledge to map out strategies that align with the techniques modeled during professional development and their science standards (Carlsen, 1993; Cronin-Jones, 1991). Notably, CoPs also are associated with changes in learners’ behavior and mindsets (Mergel, 1998). Translated to the school setting, this would lead to a change in teaching pedagogy and classroom instructional practices.

**Importance of 21st-Century Skills**

This section will examine the significance of student acquisition of 21st-century skills. It will commence with an in-depth presentation of research on the definition and application of 21st-century skills within the K–12 education system. Additionally, I will
analyze and discuss thoroughly the role of Project-Based Learning in supporting the development of these skills in the classroom.

**21st-Century Skills**

Developing 21st-century skills is critical for students to succeed in today’s rapidly changing and interconnected world. These skills—including problem-solving, critical thinking, collaboration, communication, digital literacy, creativity, and adaptability—are necessary for students to be able to participate effectively in their communities, pursue their personal and professional goals, and contribute to a better world (Kim et al., 2019).

One method for developing these skills is through Project-Based Learning. A study by Sahin (2015) found that students in STEM classes that used PBL exhibited increased self-direction, collaboration, and communication skills. Furthermore, research has suggested consistently that PBL improves 21st-century skills such as critical thinking, collaboration, communication, creativity, self-direction, global connection, and use of classroom technology (Little, 2013; Ravitz et al., 2012; Wan Husin et al., 2016). Science instruction that mirrors the investigative practices of PBL prepares students for the 21st-century challenges they will face in the future (NRC, 2009; Ross et al., 2018).

PBL also promotes effective communication and collaboration skills, as students become competent communicators who can listen to and understand others’ views effectively, share their ideas, negotiate, and present the results of their work or learning (Bender, 2012; Buck Institute for Education, 2015). Findings from these studies highlight the importance of implementing PBL in middle school science education and the potential for PBL to enhance student acquisition of 21st-century skills.
Project-Based Learning

PBL is a student-centered approach where the teacher acts as a facilitator, cultivating an environment in which students negotiate and collaborate with their peers to develop solutions to authentic issues (Chan & Blikstein, 2018; Kavanagh & Rainey, 2017). A high-quality Project-Based Learning curriculum design includes the following key elements: (a) a real-world problem for students to address, (b) the complete inquiry process, and (c) student-driven instruction (Easter et al., 2019; Flavell, 1979; Kammer et al., 2015; Kim & Tan, 2013; NRC, 2009). Studies also have documented that exposure to PBL can increase student achievement in mathematics across demographic backgrounds with indifference to prior student performance levels (Han et al., 2014). Han et al. (2014) noted that historically lower-performing students showed notably higher achievement scores in mathematics than their peers when they engaged in PBL. Additionally, Chan and Blikstein (2018) investigated PBL implementation, identifying three key student behavior indicators that directly align with 21st-century skills: (a) collaboration with teammates, (b) independent sustained inquiry, and (c) communication.

While social constructivism’s theoretical principles outline how a person learns, the teaching standards of Project-Based Learning provide the framework for structuring the information. Prior studies noted that teachers participating in content-specific professional development, which capitalized on their prior knowledge in interactive and hands-on delivery models, were more likely to report changes to classroom practices (Desimone et al., 2002; Penuel et al., 2007). Johnson (2006) contributed a noteworthy observation on teacher resistance, concluding that teachers’ prior content knowledge and
underlying beliefs about teaching both impact new knowledge shared during professional
development.

To implement PBL successfully, teachers need to collaborate, and this should take
place among two or more teachers focused on the same academic learning standards
(Carpenter et al., 2007). These collaborative meetings should take the form of
Communities of Practice consisting of teacher dialogue on content expertise and PD
training on PBL instruction and reflective conversation (Chang & Lee, 2010). Working
within CoPs will allow teachers to share knowledge, ideas, strategies, successes, and
failures in a supportive and safe environment (Wentworth & Davis, 2002).

**Importance of Teacher Self-Efficacy**

This section will present a comprehensive examination of the critical importance
of teacher self-efficacy. It will commence with a detailed definition and discussion of the
concept of teacher self-efficacy, including its fundamental components and key features.
An analysis of the impacts that can be seen in the classroom when teachers exhibit high
levels of self-efficacy will follow.

**Teacher Self-Efficacy**

Bandura (2012) explained that self-efficacy is an individual’s belief in their
capability to accomplish a specific task or achieve a goal. Teacher self-efficacy derives
from four primary sources: (a) mastery experiences, when teachers have first-hand
success with a teaching strategy; (b) vicarious experience, when teachers might observe a
peer using an effective strategy with success and feel empowered to use the strategy; (c)
social persuasion, when a school deliberately highlights effective teaching strategies and
the teacher feels confident to try these strategies as well; and (d) emotional and
physiological states, when teachers’ well-being influences their levels of self-efficacy (Bandura, 2012). For this study, I define teacher self-efficacy as a teacher’s perception of their ability to make pedagogical change in the classroom instruction using PBL instructional strategies, even when student engagement may be low (Tschannen-Moran & Hoy, 2007). Studies have linked increased teacher self-efficacy to teachers exploring new teaching methods, taking risks, and trying new instructional techniques (Allinder, 1994; Guskey, 1988; Stein & Wang, 1988).

Further research has suggested that teachers who exhibit high teacher self-efficacy tend to be organized, be open to innovative ideas, be slower to exhibit signs of stress, and have a greater capacity for dealing with disciplinary disruptions (Allinder, 1994; Jerald, 2007; Jerusalem & Mittag, 1995; Witt-Rose, 2003; Tschannen-Moran & McMaster, 2009). Prior research also has implied that positive teacher self-efficacy may increase a teacher’s willingness to try in their classroom setting new skills and techniques they have learned during professional development (Eden & Kinnar, 1991). Several studies support the idea that a teacher’s belief in their capability to further student academic growth and increase student engagement directly contributes to student academic outcomes (Allinder, 1994; Capraro et al., 2016; Witt-Rose, 2003). “Teachers’ efficacy beliefs are critical to improving student learning” (Takahashi, 2011, p. 212); in other words, if a teacher believes they can affect student learning directly, they are more likely to try different pedagogical strategies, like Project-Based Learning.

Conversely, teachers who exhibit low self-efficacy directly impact students negatively, leading to lower student engagement and academic performance, which in turn lowers teacher self-efficacy more (Bandura, 1997; Capraro et al., 2016; Hoy &
Davis, 2006). Schools can foster teacher self-efficacy through intentionally cultivating a climate of support and allotting time for peer collaboration, as found in Communities of Practice.

Classroom Impact

Studies indicate that teachers who participate in effective professional development are better equipped to provide high-quality instruction. Furthermore, teachers who engage frequently in ongoing professional development activities tend to create more robust lesson plans and observe a greater student academic achievement (Martin et al., 2010). Teachers who participate in Communities of Practice, attend effective professional development, and exhibit high self-efficacy and are less susceptible to professional burnout. They report higher job satisfaction and document higher student engagement and academic achievement levels (Ross et al., 2001; Tschannen-Moran & Hoy, 2007). Teachers who develop well-designed lesson plans tend to have more confidence and a stronger sense of self-efficacy when entering the classroom. Research suggests that teachers who possess a high level of self-efficacy are more likely to be persistent in assisting struggling students, resulting in better academic outcomes for these students (Podell & Soodak, 1993), and are less likely to be critical of students who make mistakes.
CHAPTER THREE: METHODOLOGY

This action research study aims to assess the effects of extended PBL professional development on (a) teachers’ attitudes toward in-district professional development, (b) teachers’ perceptions of students’ 21st-century skills, and (c) if extended PBL professional development impacts science teacher self-efficacy. Evidence recommended focusing on content knowledge, active learning, active participation, extended duration, collaboration, and consistency to create effective professional development that influences teacher self-efficacy and increases student academic outcomes (Darling-Hammond et al., 2017; Desimone & Garet, 2015). Other researchers concluded that successful teacher professional development improved practice permanently to achieve maximum student academic outcomes (Guskey, 2002; Penuel et al., 2007). In addition, research indicated that effective professional development may be the answer to improving science instruction in K–12 education (Harrison et al., 2008; Hewson, 2007; Lin et al., 2013). Alemdar et al. (2018) concluded that providing stimulating and interactive classes in middle school can improve student engagement and academic performance in science significantly. Moreover, research supported that PBL units engage students and motivate them to perform better in science and mathematics (Cantrell et al., 2006; Guo et al., 2020; Lavonen et al., 2017). Drawing from both the evidence from prior research and my firsthand knowledge of Green Mountain School District, I explored the following research questions:
• **RQ1.** How do middle school science teachers’ attitudes toward in-district professional development change, if at all, after participating in an extended PBL-focused professional development series?

• **RQ2.** To what extent, if any, do middle school science teachers’ perceptions of students’ use of 21st-century skills in the classroom change when they implement PBL in their instruction?

• **RQ3.** How do middle school science teachers’ self-efficacy levels change, if at all, after participating in an extended PBL-focused professional development series?

**Research Design**

This study followed the Mixed-Method Action Research (MMAR) methodology, combining quantitative and qualitative data collection and analysis methods (Ivankova and Wingo, 2018). Researchers use this approach to study a specific social or educational problem while also taking action to address the problem. According to Ivankova and Wingo (2018), MMAR is a repeated process that involves several phases: planning, acting, observing, and reflecting. In the planning phase, the researcher identifies the problem or phenomenon that will be studied and develops a research design that includes both quantitative and qualitative methods. In the acting phase, the researcher performs an intervention or change in the studied setting. The observing phase involves collecting, analyzing, and interpreting the data. Finally, in the reflecting phase, the researcher integrates the findings from the observation and analysis and makes recommendations to the research stakeholders.
Ivankova and Wingo (2018) noted that the use of mixed methods allows for a more comprehensive understanding of the problem being studied, enabling the collection of both quantitative data, such as statistical data from surveys, and qualitative data, such as teacher journals, research notes, and classroom observations. This approach can provide a rich and nuanced understanding of the problem and a complete picture of the relationship between the problem and the intervention.

Additionally, Ivankova and Wingo (2018) highlighted the benefit of the research’s action-oriented approach, which implies that the researcher is not just collecting data but also actively trying to improve the situation by implementing solutions. This not only will enhance the researcher’s understanding of the issue, but it also allows for the opportunity to test solutions during the study.

This MMAR study employs both quantitative and qualitative research methods to examine various forms of data and create a comprehensive, multi-dimensional understanding of the problem under investigation. Specifically, this study followed the convergent parallel mixed methods approach. The convergent parallel design involves collecting and analyzing qualitative and quantitative data separately and then combining the results in a convergent manner to produce a more in-depth picture of the findings in alignment with the research questions (Creswell, 2014). According to Creswell and Plano Clark (2011), mixed methods research is appropriate in the following situations:

1. When a single method and its associated data are not sufficient to address a problem;
2. When initial findings from one method require further clarification;
3. When data from a small sample need to be generalized to a larger population;
4. When the study design needs to be strengthened; and,

5. When there is a complex research issue that requires examination.

This MMAR study provided an opportunity to implement an extended PBL professional development series and (a) explore whether teachers’ attitudes toward in-district professional development changed, (b) explore teachers’ perceptions of students’ 21st-century skills, and (c) explore if extended PBL professional development impacts science teacher self-efficacy. I collected classroom observational data using the National Institute for Excellence in Teaching (NIET), Look-for Tool: Science tool (NIET, n. d.). The NIET Look-For Tool is a walk-through observation form strategically designed to help teachers and administrators identify effective teaching practices in the classroom. The NIET Science Look-For Tool focuses explicitly on effective teaching practices in science education.

The Look-For Tool is based on NIET’s Teacher and Student Advancement system, which is a comprehensive system for improving teacher effectiveness and student achievement. The tool uses a set of specific “look fors” or indicators of effective teaching in science, such as scientific inquiry, hands-on activities, and data analysis (NIET, n. d.). The NIET Look-For Tool was designed for short observations that appraise classroom instruction and identify areas for improvement.

**Research Setting**

Green Mountain School District provides public education for students in grades K–12 in the Southeastern United States. The district serves approximately 11,800 students spread across approximately 137 square miles of suburban and rural area. Green Mountain School District is currently the second fastest-growing school district in the
state with 15 schools, three of which are middle schools serving grades 6–8. Table 3.1 lists student demographic information about these three schools.

Table 3.1 Green Mountain School District Middle School Student Demographics 22–23

<table>
<thead>
<tr>
<th></th>
<th>Total Population</th>
<th>Female</th>
<th>Male</th>
<th>Asian</th>
<th>Black</th>
<th>Hispanic</th>
<th>Mixed</th>
<th>White</th>
</tr>
</thead>
<tbody>
<tr>
<td>District</td>
<td>10,817</td>
<td>49%</td>
<td>51%</td>
<td>4%</td>
<td>15%</td>
<td>6%</td>
<td>2%</td>
<td>71%</td>
</tr>
<tr>
<td>Middle School A</td>
<td>1,185</td>
<td>51%</td>
<td>49%</td>
<td>3%</td>
<td>19%</td>
<td>8%</td>
<td>8%</td>
<td>61%</td>
</tr>
<tr>
<td>Middle School B</td>
<td>863</td>
<td>49%</td>
<td>51%</td>
<td>5%</td>
<td>14%</td>
<td>10%</td>
<td>7%</td>
<td>63%</td>
</tr>
<tr>
<td>Middle School C</td>
<td>582</td>
<td>51%</td>
<td>49%</td>
<td>1%</td>
<td>6%</td>
<td>5%</td>
<td>4%</td>
<td>84%</td>
</tr>
</tbody>
</table>

This MMAR study examined the effects of extended professional development focused on PBL and teachers’ attitudes toward district PD, the frequency of incorporating 21st-century skills into lesson plans, and changes in teacher self-efficacy among middle school science teachers. The study spanned 15 weeks of the school year.

During the seven-part professional development series, I introduced PBL tools and strategies targeted at rethinking middle school science lesson plan design, selecting PBL components that specifically focus on (a) authentic assignments, (b) student voice and choice, (c) reflection, (d) critique and revision, (e) public products, (f) challenging problems or questions, and (g) sustained student inquiry (Buck Institute of Education, 2015). Following the professional development framework by Garet et al. (2001) and Penuel et al. (2007), I designed an extended professional development series for middle school science teachers to explore integrating state standards into a comprehensive PBL unit plan.
Participants

Green Mountain School District provides public education for students in grades K–12 in the Southeastern United States. The district serves approximately 11,800 students, 2,630 in grades 6–8 (middle school); the district employs 20 middle school science teachers who were each invited to participate in the study (Appendix A). Seven middle school science teachers volunteered to participate in this nonprobability convenience sample (Creswell & Plano Clark, 2011). Creswell and Plano Clark (2011) describe a nonprobability convenience sample as a type of sampling method where researchers select participants based on their availability or interest in participating rather than using a random selection process. This sampling method is often used when a researcher wants to study a specific population that is hard to access or identify, or, in my case, having limited access to a sample outside of Green Mountain School District. Creswell (2007) did point out that nonprobability sampling has limitations, which include the potential for bias, lack of representativeness, and difficulties with generalization to a larger population.

In my role at the district office, I support several initiatives, including providing targeted professional development activities for our district’s teachers and staff. As a PBL-endorsed teacher, I was asked by the Assistant Superintendent for Curriculum and Instruction to lead a professional development session with the district’s science teachers in August 2022. During this 1-hour PBL professional development session, I invited interested teachers to participate in my expanded PBL professional development series (Appendix A). Interested teachers were given two weeks to respond via a Google Form to express their interest in joining this study. Of the twenty middle school science teachers
in the district, seven signed up to participate in the extended PBL professional development series and MMAR study. Table 3.2 lists the demographics of these seven teachers and their assigned pseudonyms.

Table 3.2 Participants

<table>
<thead>
<tr>
<th>Pseudonym</th>
<th>Race/Gender</th>
<th>Experience</th>
<th>Degree</th>
<th>Grade Taught</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albertson</td>
<td>White/male</td>
<td>6 years</td>
<td>Bachelors</td>
<td>8th</td>
</tr>
<tr>
<td>Wall</td>
<td>White/female</td>
<td>22 years</td>
<td>Masters</td>
<td>8th</td>
</tr>
<tr>
<td>Davis</td>
<td>White/male</td>
<td>19 years</td>
<td>Bachelors</td>
<td>7th</td>
</tr>
<tr>
<td>Greene</td>
<td>Black/female</td>
<td>8 years</td>
<td>Bachelors</td>
<td>6th</td>
</tr>
<tr>
<td>Williams</td>
<td>White/female</td>
<td>15 years</td>
<td>Masters</td>
<td>6th</td>
</tr>
<tr>
<td>Culvert</td>
<td>White/female</td>
<td>27 years</td>
<td>Bachelors</td>
<td>7th</td>
</tr>
<tr>
<td>Childs</td>
<td>White/female</td>
<td>11 years</td>
<td>Masters</td>
<td>6th</td>
</tr>
</tbody>
</table>

**Data Collection Methods**

For this study, I used a mixed-method approach to provide both rich quantitative and qualitative evidence for analysis (Creswell, 2007). Data include: (a) pre/post-teacher surveys, (b) classroom observations, (c) researcher notes from professional development sessions, and (d) teacher reflection journals. Table 3.3 illustrates the alignment among the four data collection sources and the research questions.
Table 3.3 Research Questions and Data Collection Source Alignment

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Data Collection Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ1: How do middle school science teachers’ attitudes toward in-district professional development change, if at all, after participating in an extended PBL-focused professional development series?</td>
<td>Pre/post-survey</td>
</tr>
<tr>
<td></td>
<td>Teacher reflection journals</td>
</tr>
<tr>
<td></td>
<td>Researcher notes</td>
</tr>
<tr>
<td>RQ2: To what extent, if any, do middle school science teachers’ perceptions of students’ use of 21st-century skills in the classroom change when they implement PBL in their instruction?</td>
<td>Pre/post-survey</td>
</tr>
<tr>
<td></td>
<td>Teacher reflection journals</td>
</tr>
<tr>
<td></td>
<td>Classroom observation</td>
</tr>
<tr>
<td></td>
<td>Researcher notes</td>
</tr>
<tr>
<td>RQ3: How do middle school science teachers’ self-efficacy levels change, if at all, after participating in an extended PBL-focused professional development series?</td>
<td>Pre/post-survey</td>
</tr>
<tr>
<td></td>
<td>Teacher reflection journals</td>
</tr>
<tr>
<td></td>
<td>Researcher notes</td>
</tr>
</tbody>
</table>

**Pre/Post-Survey Administration**

I administered surveys to the seven Green Mountain School District middle school science teachers who volunteered to participate in this study. They completed the teacher pre-surveys one week before the first professional development session and the post-surveys after they concluded teaching the PBL unit they designed for this extended PBL professional development. They accessed surveys through Google Forms via Google Classrooms. The survey did not track email addresses and thus provided anonymous responses. The pre/post-survey consisted of three sections: (a) teachers’ attitude toward in-district professional development, (b) The Science Teaching Efficacy Belief Instrument (STEBI) to gather data on the teachers’ beliefs, and (c) the 21st-Century Teaching and Learning Survey (WVDE-CIS-28). Teachers took the same survey
at the beginning and end of the study. Survey data automatically populated to a secure Microsoft Excel spreadsheet housed on the Green Mountain School District servers.

The Science Teaching Efficacy Belief Instrument

I used the Science Teaching Efficacy Belief Instrument (STEBI) to assess teacher self-efficacy changes. The STEBI is a commonly used survey tool that measures science teachers’ beliefs about their ability to facilitate students’ science learning. Riggs and Enochs (1990) developed the STEBI, and it is widely used in teacher efficacy and science teaching research. The STEBI is a self-report survey instrument designed to measure science teachers' beliefs about their ability to teach science effectively. Specifically, the STEBI assesses two dimensions of science teaching self-efficacy: Personal Science Teaching Efficacy (PSTE) and Science Teaching Outcome Expectancy (STOE).

PSTE refers to the belief that one has the skills and abilities necessary to teach science effectively. While STOE refers to the belief that teaching science will result in positive student outcomes, such as increased academic achievement and engagement. Its validity has been supported through factor analysis studies that have identified the underlying dimensions of science teacher efficacy. Higher scores on the STEBI are related to positive teacher behaviors and student outcomes. Numerous studies demonstrating high internal consistency reliability coefficients have established the STEBI’s reliability (Ramdani et al., 2019).

21st-Century Teaching and Learning Survey

I used the 21st-Century Teaching and Learning Survey (WVDE-CIS-28) (Hixson et al., 2012) to assess teachers’ perceptions of students’ use of 21st-century skills in the classroom. This instrument was informed by the International Innovative Teaching and
Learning study (Shear et al., 2010), the Deeper Learning framework from The William and Flora Hewlett Foundation (2010), and Partnership for 21st Century Skills (p21.org). The reliability and validity of the original survey were established (α = .90).

**Classroom Observations**

I observed each middle school science teacher twice for 10–20 minutes each time. During observations, I completed the NIET Look-for Tool: Science (NIET, n.d.). The NIET tool was designed to observe science instructional strategies. It enabled me to take detailed notes to include specific comments from students, comments from the teacher, details of student-student interactions, types of work on display, student engagement, and teacher engagement. I noted the classroom activities and student responses on the NIET observation form during these observations. For each teacher, I conducted one observation before the implementation of the PBL unit and one during the PBL unit.

**Researcher Notes**

Each of the seven middle school science teachers participated in a seven-part professional development series. I intentionally designed the extended PBL professional development sessions to cover the Buck Institute’s PBLWorks Gold Standards (Buck Institute of Education, 2015). I held the professional development sessions in the same format as the district-initiated Communities of Practice (CoPs), and we met bi-weekly across 15 weeks in the fall of 2022. During the professional development sessions, I took detailed notes of the conversations among myself and the teachers. I advised the teachers that others in the group would hear what they said and that I could use the comments they made during the sessions to support my research.
Teacher Reflection Journal

At the conclusion of each extended PBL professional development session, I provided the seven teachers with a Google Form link to the session’s journal prompt (Appendix B). I asked teachers to respond to each prompt in no more than 200 words.

Professional Development Series

I structured the professional development sessions to incorporate what PBLWorks outlines as the seven essential project design elements for the Gold Standard for teaching PBL: (a) authentic assignments, (b) student voice and choice, (c) reflection, (d) critique and revision, (e) public products, (f) challenging problems or questions, and (g) sustained student inquiry (Buck Institute of Education, 2015). During each session, I provided opportunities for the participants to interact with materials, share ideas, and plan for implementation (Appendix B).

Data Analysis

The research design for this study is a mixed-methods approach, encompassing both quantitative and qualitative data collection and analysis. This research method has gained popularity in recent years as it allows for a more complete analysis of complex social issues from multiple perspectives (Ivankova & Wingo, 2018).

Table 3.4 Alignment of Research Questions, Data Collection, and Data Analysis

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Data Collection Sources</th>
<th>Data Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ1: How do middle school science teachers’ attitudes toward in-district professional development change, if at all, after participating in an extended PBL-focused professional development series?</td>
<td>Quantitative: • Pre/post-survey Qualitative: • Teacher reflection journals • Researcher notes</td>
<td>Quantitative: • Paired t-test Qualitative: • Deductive coding • Inductive coding</td>
</tr>
</tbody>
</table>
RQ2: To what extent, if any, do middle school science teachers’ perceptions of students’ use of 21st-century skills in the classroom change when they implement PBL in their instruction?

<table>
<thead>
<tr>
<th>Quantitative:</th>
<th>Qualitative:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre/post-survey</td>
<td>Teacher reflection journals</td>
</tr>
<tr>
<td><strong>Paired t-test</strong></td>
<td>Researcher notes</td>
</tr>
<tr>
<td><strong>Deductive coding</strong></td>
<td>Classroom observations</td>
</tr>
</tbody>
</table>

RQ3: How do middle school science teachers’ self-efficacy levels change, if at all, after participating in an extended PBL-focused professional development series?

<table>
<thead>
<tr>
<th>Quantitative:</th>
<th>Qualitative:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre/post-survey</td>
<td>Teacher reflection journals</td>
</tr>
<tr>
<td><strong>Paired t-test</strong></td>
<td>Researcher notes</td>
</tr>
<tr>
<td><strong>Deductive coding</strong></td>
<td><strong>Inductive coding</strong></td>
</tr>
</tbody>
</table>

This study used a mixed-methods approach to gather different data types and create a holistic understanding of the research problem. I collected and analyzed the data in a way that allowed for triangulation and improved reliability of the findings (Creswell, 2014). Table 3.4 presents the alignment of research questions, data collection, and data analysis.

**Quantitative Analysis**

For this study, I used a paired t-test to collect quantitative data. A paired t-test is a statistical test that determines if there is a significant difference in the means of two groups. For this MMAR, I used a paired t-test to compare the mean scores from the pre- and post-teacher surveys. The paired t-test helped to determine whether the difference in the mean scores before and after the extended PBL professional development was significant enough to conclude that the new strategy was effective.

I used anonymous surveys as the method of data collection to ensure easy and contact-free access for the respondents and to promote honest feedback. I administered the surveys using the platform Google Forms, which does not track the respondents’ email addresses, thus ensuring the anonymity of the data. The survey automatically
collected and stored responses in a secure Microsoft Excel spreadsheet on the Green Mountain School District servers.

**Inferential Statistical Analysis**

I collected quantitative data by analyzing the pre- and post-teacher surveys. The survey contained a series of Likert-type questions grouped into six Likert scales: (a) science teaching efficacy beliefs, (b) critical thinking skills, (c) collaborations skills, (d) communication skills, (e) creativity and innovation skills, and (f) self-direction skills. I analyzed results from the pre/post-surveys using a Microsoft Excel spreadsheet and the statistical functions for mean, median, mode and paired t-test. I used the inferential statistical analysis to identify differences between the pre/post-survey to see if any notable changes occurred in (a) teachers’ attitudes toward in-district professional development, (b) teachers’ perceptions of students’ 21st-century skills, and (c) science teacher self-efficacy.

**Qualitative Analysis**

The qualitative data came from my research notes taken during and after the professional development sessions, classroom observations, and teacher reflection journals. I analyzed the qualitative data using deductive and inductive coding approaches. I identified deductive codes, which were aligned with my research questions and data collection tools, before the professional development series. Deductive coding allowed me to sort the data into categories according to data type (Miles et al., 2018). In doing so, I maintained reliability within my study. I used the deductive strategy to help organize and focus my data alignment with my research questions but recognized that it might only encompass part of the picture. To balance any bias I may have as the researcher, I
also used the inductive strategy to understand what organically emerged within the data without forcing it into the direction I wanted it to go. The inductive codes are based on the frequency of all words and phrases used during the professional development series, classroom observations, and teacher reflections (Corbin & Strauss, 2008). By blending both deductive and inductive analysis, my research was well organized and rigorous, adding reliability to this study.

**Deductive Coding**

I used qualitative deductive, or *a priori*, data analysis to analyze the data I gathered during the classroom observations, teacher reflection journals, and researcher notes I took during the extended PBL professional development series and PBL implementation. I based the predetermined priori codes on the research questions I had created for this MMAR study.

To facilitate creating a priori codes for RQ1, I reviewed the (a) pre-survey questions on past professional development (Appendix C), (b) teacher reflection journal prompts (Appendix B), and (c) extended PBL professional development session details (Appendix B). I identified each component’s key concepts and themes and developed a category or subscale and codes aligning to each data collection tool. I intentionally worded categories, subscales, and codes to be specific enough to capture the data accurately but remain general enough to apply to multiple instances of the concept. Table 3.5 lists the a priori codes for RQ1.
Table 3.5 A Priori Codes for RQ1

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Category/Subscale</th>
<th>A Priori Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ1: How do middle school science teachers’ attitudes toward in-district professional development change, if at all, after participating in an extended PBL-focused professional development series?</td>
<td>Curriculum and Instruction</td>
<td>Curriculum alignment, Instructional strategies, Differentiation, Assessment and evaluation, Impact on student learning, Relevance to their teaching</td>
</tr>
<tr>
<td></td>
<td>Classroom Management</td>
<td>Classroom management, Student motivation, Engagement, Time management</td>
</tr>
<tr>
<td></td>
<td>Professional Development</td>
<td>Coaching or mentoring, Collaborative learning, Self-reflection, Professional growth and development, Perceived effectiveness</td>
</tr>
<tr>
<td></td>
<td>Teacher Mindset and Support</td>
<td>Self-efficacy, Confidence, Interest and enthusiasm, Self-reflection, Motivation, Support and resources, Professional identity, Collaboration</td>
</tr>
</tbody>
</table>

To facilitate creating a priori codes for RQ2, I reviewed the (a) NIET Look-for Tool: Science walk-through observation form (Appendix D), (b) teacher reflection
journal prompts (Appendix B), (c) extended PBL PD session details (Appendix B), and (d) 21st-Century Teaching and Learning Survey (Appendix C). I identified each component’s key concepts and themes and developed a category or subscale and codes aligning to each data collection tool. I intentionally worded categories, subscales, and codes to be specific enough to capture the data accurately but remain general enough to apply to multiple instances of the concept. Table 3.6 lists the a priori codes for RQ2.

Table 3.6 A Priori Codes for RQ2

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Category/Subscale</th>
<th>A Priori Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ2: To what extent, if any, do middle school science teachers’ perceptions of students’ use of 21st-century skills in the classroom change when they implement PBL in their instruction?</td>
<td>Cognitive Skills</td>
<td>Critical thinking</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Problem-solving</td>
</tr>
<tr>
<td></td>
<td>Social and Interpersonal Skills</td>
<td>Communication</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Collaboration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Leadership</td>
</tr>
<tr>
<td></td>
<td>Creativity and Innovation</td>
<td>Creativity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Innovation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Entrepreneurship</td>
</tr>
<tr>
<td></td>
<td>Self-Directed Learning</td>
<td>Self-directed learning</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Leadership</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Entrepreneurship</td>
</tr>
</tbody>
</table>

To facilitate creating a priori codes for RQ3, I reviewed the (a) Teachers’ Sense of Efficacy Scale (Appendix C), (b) teacher reflection journal prompts (Appendix B), and (c) extended PBL professional development session details (Appendix B). I identified each component’s key concepts and themes and developed a category or subscale and codes aligning to each data collection tool. I intentionally worded categories, subscales, and codes to be specific enough to capture the data accurately but remain general enough to apply to multiple instances of the concept. Table 3.7 lists the a priori codes for RQ3.
Table 3.7 A Priori Codes for RQ3

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Category/Subscale</th>
<th>A Priori Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ3: How do middle school science teachers’ self-efficacy levels change, if at all, after participating in an extended PBL-focused professional development series?</td>
<td>Curriculum and Instruction</td>
<td>Subject matter knowledge, Pedagogical strategies, Curriculum alignment, Inquiry-based instruction, Scientific literacy</td>
</tr>
<tr>
<td></td>
<td>Classroom Management and Student Engagement</td>
<td>Classroom management, Student engagement, Problem solving</td>
</tr>
<tr>
<td></td>
<td>Assessment</td>
<td>Assessment, Technology integration</td>
</tr>
<tr>
<td></td>
<td>Professional Development and Collaboration</td>
<td>Collaboration, Professional growth and development, Reflection, Professional identity</td>
</tr>
</tbody>
</table>

**Inductive Coding**

Inductive analysis is an organic strategy where themes emerge throughout the data collection. For this, I coded my researcher notes, classroom observations, and teacher reflections using NVivo coding (Saldaña & Omasta, 2016). Incorporating NVivo coding allowed me to develop codes in the participants’ own words. Inductive coding requires multiple rounds of coding to refine and isolate the focus of the collected data. I initially reviewed the research notes, classroom observations, and teacher reflections, which are essential tools of action research (Mertler, 2017). Then I open-coded the data to develop codes based on what the data presented. In subsequent coding rounds, I identified emerging themes in the data. From the themes, I could identify critical
qualitative data that accurately reflects how the participants responded to the PBL PD through direct quotations and observational data.

**Informed Consent**

A signed Memorandum of Agreement between the researcher, the University of South Carolina, and Green Mountain School District granted permission to conduct pre- and post-teacher surveys, perform classroom observations, and conduct an extended PBL professional development series for teachers.

**Data Protection**

I took every precaution to maintain that I analyzed the data collected in a purposeful manner designed to assuage any bias or potential manipulation. I will store all data I collected, as I am on staff with Green Mountain School District, at the district offices for three years. Once three years have passed, I will destroy the data. Additionally, I have assigned all data a pseudonym. Table 3.8 exemplifies this coding.

**Table 3.8 Example of Codes for Qualitative Data**

<table>
<thead>
<tr>
<th>Code Number</th>
<th>Example</th>
<th>Data Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PreS#mmdd</td>
<td>PrsS#1010</td>
<td>Pre-Survey on October 10</td>
</tr>
<tr>
<td>TJ#mmdd(#tn)</td>
<td>TJ#1017(5)</td>
<td>Teacher Journal on October 17 by teacher #5</td>
</tr>
<tr>
<td>OB#mmdd(#tn)</td>
<td>OB#1020(7)</td>
<td>Observation on October 20 of teacher #7</td>
</tr>
<tr>
<td>PostSmmdd</td>
<td>PostS#1212</td>
<td>Post-Survey on December 12</td>
</tr>
</tbody>
</table>

**Procedures and Timeline**

I divided the research into four phases, as Table 3.6 outlines, including the expectations and time frame for each stage. I then explain each phase in-depth.
Table 3.9 Timeline

<table>
<thead>
<tr>
<th>Phase</th>
<th>Expectation</th>
<th>Time Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 1: Participant Identification/Recruitment</td>
<td>1-hour district PBL Letter of invitation Google Form intent to participate Pre-survey</td>
<td>2 weeks</td>
</tr>
<tr>
<td>Phase 2: Extended PBL PD</td>
<td>Seven-part PBL PD Classroom observations Teacher reflection journals Creation of PBL unit Implementation of PBL unit Reflection on PBL Unit</td>
<td>15 weeks</td>
</tr>
<tr>
<td>Phase 3: Data Collection</td>
<td>Classroom observations Teacher reflection journals Researcher notes Post-survey</td>
<td>15 weeks</td>
</tr>
<tr>
<td>Phase 4: Data Analysis</td>
<td>Inferential statistical analysis of pre/post-survey with SPSS tool Deductive and inductive analysis of researcher notes, classroom observations, and teacher reflection journals</td>
<td>6 weeks</td>
</tr>
</tbody>
</table>

**Phase 1: Participant Identification/Recruitment**

I recruited teachers for this study at the start of the school year during a district-led professional development session to help introduce new science textbook materials. These new materials have PBL interwoven into their design. After this session, I presented my research proposal and provided each attendee with a letter to participate (Appendix A). Teachers who agreed to be part of the study began meeting as a CoP in the fall of 2022. These sessions took place during their regularly scheduled weekly CoP time,
a 50-minute block. All study activities occurred during traditional school hours and within Green Mountain School District.

**Phase 2: Extended PBL PD**

Each participating middle school science teacher took part in a seven-part professional development series. I structured the PD sessions to support teachers in creating a PBL unit, implementing that unit, and reviewing it. We held these sessions in the same format as the district-approved CoPs and met bi-weekly for 15 weeks.

Session One focused on increasing awareness that the learning process is more important than the content in terms of both student retention and increasing 21st-century skills and career integration. The session included a pre-survey, an icebreaker activity, an introduction to the professional development series, and activities that explored the importance of PBL. Session Two focused on constructing learning experiences by considering the link between authenticity, expected outcomes, and increasing 21st-century skills and career integration. Session Three focused on the importance of student voice and choice in building an authentic lesson, using backward mapping as a planning tool for PBL, and exploring inquiry strategies to support students’ ability to comprehend inquiry at all levels. Session Four focused on exploring inquiry strategies to support students’ ability to comprehend inquiry at all levels, increasing 21st-century skills and career integration, and exploring the variety of online resources. The session included a pre-session activity, a reflection journal, an article review, a critique and revision activity, and an exit ticket. Session Five focused on increasing students’ ability to communicate their understanding of materials and ideas and engage in probing conversations, increasing awareness that content has less impact on student retention than process, and
exploring inquiry strategies to support students’ ability to comprehend inquiry at all levels. The session included a pre-session activity, an article review, a reflection journal, a public product activity, and an exit ticket. Session Six focused on constructing learning experiences by considering the link between authenticity and the expected outcome and completing the PBL lesson plan. Session Seven focused on delivering inquiry-based instruction to elevate rigor, critical thinking, and student engagement, increasing students’ ability to communicate successfully their understanding of materials and ideas, constructing learning experiences by considering the link between authenticity and the expected outcome, and increasing 21st-century skills. It included an asynchronous activity, a reflection journal, and a prompt for thoughts on extended professional development. The full PBL professional development lesson plan is in Appendix B.

Phase 3: Data Collection

Teachers were engaged actively in the PBL professional development sessions during the data collection phase. This 15-week timespan allowed for bi-weekly PBL professional development sessions to run concurrently with structured data collection. During the first two weeks of data collection, I conducted one classroom observation for each participating teacher. I did not announce these observations, and I completed them prior to teachers shifting their lesson plans to reflect PBL strategies introduced during the extended PBL professional development. After each of the seven PBL professional development sessions, I asked teachers to write a 200-word reflection with prompts I provided. The journal entries were administered via a secure link in our shared Google Classroom. The link did not collect email addresses and therefore kept responses anonymous. Over the 15 weeks, participating teachers submitted a total of 43 unique
journal reflection entries. Once participating teachers created their PBL units, they shared their implementation timelines so I could plan a second unannounced classroom observation. During this second classroom observation, the participating teacher followed the PBL lesson plan they created during our PBL professional development sessions. Upon completing the unit, each teacher received a secure link to the post-survey.

**Phase 4: Data Analysis**

This MMAR study examined the effectiveness of extended professional development on PBL for teachers. The study collected both quantitative and qualitative data to gain a complete grasp of the impact of extended PBL professional development. I administered a pre- and post-teaching survey through an anonymous Google Forms link for the quantitative data. The survey consisted of three data collection tools: questions about teacher opinions on PBL and professional development, an abridged version of the Measuring 21st-Century Teaching and Learning Survey, and the Science Teacher Efficacy Belief Instrument. I applied a paired t-test to analyze the data and establish if there was a statistically significant variation between the pre- and post-survey results. Due to the small sample size (seven participants), I also examined the data for skewness by comparing the mean, mode, and median. A small sample size can be a limitation for a paired t-test as it decreases the test’s statistical power. With a sample size of fewer than 30, there is less information to estimate the population mean difference and the variability around it, leading to wider confidence intervals and less precise results.

I collected the qualitative data through researcher notes, teacher journal entries, and classroom observations. During the seven extended professional development sessions, I took researcher notes and asked teachers to keep reflection journals on five
separate occasions. I conducted classroom observations twice for each of the seven teachers. I analyzed the data using a deductive and inductive approach. My deductive analysis used predetermined codes to create a detailed inventory of the qualitative information. My inductive analysis involved transcribing the data and identifying patterns and themes using the coding software NVivo.

Reflecting with the Participants and Next Steps

The findings from this study support using extended professional development as an effective professional development strategy when implementing PBL. Research also supports the relationships among PBL, student/teacher engagement, and increased 21st-century skills (Cook & Weaver, 2015; Han et al., 2015). Additionally, this literature provided the evidence necessary for me to conduct an action research study to explore how I can support middle school science teachers in Green Mountain School District to navigate the transition from traditional lessons to PBL Units through effective communities of practice-based professional development experiences. The study capitalized on various sources of data, including (a) pre/post-teacher surveys, (b) classroom observations, (c) research notes from professional development sessions, and (d) teacher reflection journals. The study supported the idea that PBL can be a powerful approach for teachers to implement if they are seeking ways to boost engagement and the 21st-century skills of (a) critical thinking, (b) creativity, (c) problem solving, (d) communication, (e) collaboration, and (f) self-direction. While the outcomes may be transferable to other school districts throughout the state or country, they will drive the next steps taken within our district regarding PBL professional development.
CHAPTER FOUR: ANALYSIS AND FINDINGS

This MMAR aims to gauge the impact of extended professional development in PBL on middle school science teachers. This research has three prongs: (a) evaluating teacher attitudes about professional development, (b) exploring the incorporation of 21st-century skills, and (c) measuring teacher self-efficacy. Three questions guide the MMAR:

- **RQ1.** How do middle school science teachers’ attitudes toward in-district professional development change, if at all, after participating in an extended PBL-focused professional development series?
- **RQ2.** To what extent, if any, do middle school science teachers’ perceptions of students’ use of 21st-century skills in the classroom change when they implement PBL in their instruction?
- **RQ3.** How do middle school science teachers’ self-efficacy levels change, if at all, after participating in an extended PBL-focused professional development series?

This chapter presents the study’s findings, including quantitative and qualitative data. The chapter’s first section presents quantitative results from three sources: (a) research notes I took during the extended PBL professional development sessions, (b) teacher reflection journals teachers completed at specific times during the extended PBL professional development series, and (c) classroom observations I conducted on each participating teacher before and after the extended PBL professional development. The
chapter’s second section provides qualitative results from the same three sources. Finally, the third section identifies and provides evidence for four themes from the data analysis.

**Quantitative Analysis and Findings**

I collected the quantitative data for this MMAR study via a pre/post-survey, which I administered through an anonymous Google Forms link. The survey consisted of three data collection tools: (a) four researcher-created questions inquiring about teacher opinions on PBL and professional development (see Table 4.1); (b) an abridged version of Measuring 21st-Century Teaching and Learning Survey, which Hixson et al. (2012) developed for the West Virginia Department of Education (see Table 4.2); and (c) the Science Teacher Efficacy Belief Instrument, which Riggs and Enochs (1990) developed and published in *Science Education* (see Table 4.3).

I used a paired t-test to examine the quantitative data to decide if a statistically significant variation was present between the pre/post-teacher survey tool. A paired t-test is a parametric statistical analysis tool researchers can employ to measure data points with equal intervals among two groups, such as in a pre/post-survey scenario (Johnson & Christensen, 2014). For a paired t-test, responses should be distributed normally on a bell-shaped curve (Johnson & Christensen, 2014). Due to the small sample size of my MMAR (fewer than 30 teachers), there was a chance that the scores would not be distributed onto a normal curve. To gain an in-depth perspective, I compared the mean, mode, and median to check for skewness. The following section outlines the quantitative data analysis and findings.
Teacher Opinions on PBL and Professional Development Results

Descriptive Statistics

I have reported the teacher opinions on PBL and professional development pre/post-survey results in Table 4.1, which includes the pre/post-survey questions, the mean, standard deviation, and paired t-test results. The scale for this survey ranged from 1 = not really to 5 = to a very great extent.

Pre-Survey and Post-Survey Comparison

I compared responses from the survey questions using a paired t-test to determine if they contained statistical significance or fell within the normal range of difference. I used a $p$ value of less than .05 as the benchmark for statistical significance.

Overall, the results showed that after attending the extended PBL professional development series, participating teachers felt more comfortable implementing PBL in their classrooms than they did before attending. The pre-survey response was ($M = 2.60$), whereas the post-survey response was ($M = 4.8$) with a statistically significant variance of ($p = 0.0295$). The results also indicated a statistically significant difference in how teachers felt about their past professional development experiences ($M = 2.20$) and their extended PBL professional development experience, which was beneficial “to a very great extent” to all respondents ($M = 5.0$). This response shift was statistically significant with a paired t-test score of ($p = 0.0086$). Another area with statistically significant variance in the pre/post-survey results related to the professional development’s impact on student success and academic growth. The pre-survey results were mid-range ($M = 3.0$), while the post-survey results were beneficial “to a very great extent” to all respondents ($M = 5.0$), resulting in a statistically significant difference ($p = 0.0111$).
Table 4.1 Descriptive Statistics for Teacher Opinions on PBL and Professional Development

<table>
<thead>
<tr>
<th></th>
<th>Pre-Survey</th>
<th>Post-Survey</th>
<th>Mean Pre</th>
<th>SD</th>
<th>Mean Post</th>
<th>SD</th>
<th>Paired t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>How comfortable do you feel about implementing PBL in your classroom?</td>
<td>How comfortable do you feel about implementing PBL in your classroom after our extended PBL professional development series?</td>
<td>2.60</td>
<td>1.14</td>
<td>4.80</td>
<td>0.40</td>
<td>0.0295</td>
<td></td>
</tr>
<tr>
<td>Have previous professional development opportunities been beneficial to you as a middle school science teacher?</td>
<td>Has this extended PBL professional development opportunity been beneficial to you as a middle school science teacher?</td>
<td>2.20</td>
<td>1.30</td>
<td>5.00</td>
<td>0.00</td>
<td>0.0086</td>
<td></td>
</tr>
<tr>
<td>Has information from professional development in the past led to changes in your teaching practice?</td>
<td>Do you feel the extended PBL professional development will lead to changes in your teaching practice?</td>
<td>3.20</td>
<td>1.10</td>
<td>4.40</td>
<td>0.49</td>
<td>0.1087</td>
<td></td>
</tr>
<tr>
<td>Has information from past professional development impacted the success and the academic growth of your students?</td>
<td>Do the feel this extended PBL professional development impacted the success and the academic growth of your students?</td>
<td>3.00</td>
<td>1.00</td>
<td>5.00</td>
<td>0.00</td>
<td>0.0111</td>
<td></td>
</tr>
</tbody>
</table>

While many items indicated significant difference, there were some items that were not significant. The question about whether professional development would lead to changes in teaching practices did not have statistical significance ($p = 0.187$). While the
means did increase from 3.20 (pre-survey) to 4.40 (post-survey), the variance was not statistically significant.

**Measuring 21st-Century Teaching and Learning Survey**

**Descriptive Statistics**

I asked each participating teacher to note the frequency with which they have students perform activities that reflect specific 21st-century skills within their classroom environment. The scale was as follows: 1 = almost never; 2 = a few times per semester; 3 = a few times per month; 4 = a few times per week; 5 = almost daily. I administered this survey both prior to the extended PBL professional development and upon its conclusion. Table 4.2 reports the pre/post-survey results and includes the pre/post-survey questions, the mean, standard deviation, and paired t-test results.

**Pre-survey and Post-survey Comparison**

When comparing the overall mean score for the survey, as a whole, it is notable that the pre-survey mean across skill sets was (M = 2.68). I interpret this to report that the participating teachers, on average, asked students to use 21st-century skills “a few times per month” or less. In contrast, the mean across skills sets was (M = 4.63) on the post-survey, interpreted that during the PBL, teachers were asking students “almost daily” to use 21st-century skills in the classroom. When I analyzed the overall results from the pre/post-survey, a paired t-test result of (p = 0.0000018) indicated statistical significance between the pre- and post-responses. In other words, this result indicates that the observed difference was unlikely to result from chance alone, adding reliability to extended PBL professional development.
Table 4.2 Measuring 21st-Century Teaching and Learning Survey

<p>| “In your teaching of middle school science, how often have you asked the students to do the following:” | Mean Pre-Survey | SD | Mean Post-Survey | SD | Paired t-test |
|---|---|---|---|---|---|---|
| Communication Skills | | | | | | |
| Structure data for use in written products or oral presentations (e.g., creating charts, tables, or graphs)? | 2.43 | 1.62 | 4.17 | 1.00 | 0.0248 |
| Convey their ideas using media other than a written paper (e.g., posters, video, blog, etc.)? | 3.29 | 1.25 | 4.50 | 0.76 | 0.0618 |
| Prepare and deliver an oral presentation to the teacher or others? | 2.43 | 1.40 | 3.83 | 1.40 | 0.0152 |
| Answer questions in front of an audience? | 3.29 | 1.50 | 4.50 | 1.21 | 0.1112 |
| Decide how they will present their work or demonstrate their learning? | 2.43 | 1.27 | 4.33 | 0.76 | 0.0037 |
| Collaboration Skills | | | | | | |
| Work in pairs or small groups to complete a task together? | 3.57 | 0.79 | 5.00 | 0.00 | 0.0030 |
| Work with other students to set goals and create a plan for their team? | 2.71 | 0.95 | 5.00 | 0.00 | 0.0007 |
| Create joint products using contributions from each student? | 2.57 | 1.13 | 4.83 | 0.38 | 0.0016 |
| Present their group work to the class, teacher or others? | 2.43 | 1.27 | 5.00 | 0.00 | 0.0017 |
| Work as a team to incorporate feedback on group tasks or products? | 2.43 | 1.81 | 4.50 | 0.53 | 0.0113 |
| Give feedback to peers or assess other students work? | 2.57 | 1.40 | 5.00 | 0.00 | 0.0037 |</p>
<table>
<thead>
<tr>
<th></th>
<th>Mean Pre-survey</th>
<th>SD</th>
<th>Mean Post-Survey</th>
<th>SD</th>
<th>Paired t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Creativity &amp; Innovation Skills</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use idea creation techniques such as brainstorming or concept mapping?</td>
<td>2.57</td>
<td>1.27</td>
<td>4.33</td>
<td>0.76</td>
<td>0.0105</td>
</tr>
<tr>
<td>Generate their own ideas about how to confront a problem or question?</td>
<td>2.57</td>
<td>1.13</td>
<td>4.50</td>
<td>0.79</td>
<td>0.0038</td>
</tr>
<tr>
<td>Test out different ideas and work to improve them?</td>
<td>2.86</td>
<td>1.21</td>
<td>4.67</td>
<td>0.76</td>
<td>0.0068</td>
</tr>
<tr>
<td>Invent a solution to a complex, open-ended question or problem?</td>
<td>2.71</td>
<td>1.25</td>
<td>4.83</td>
<td>0.38</td>
<td>0.0034</td>
</tr>
<tr>
<td>Create an original product or performance to express their ideas?</td>
<td>2.43</td>
<td>1.13</td>
<td>5.00</td>
<td>0.00</td>
<td>0.0010</td>
</tr>
<tr>
<td><strong>Self-Direction Skills</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Take initiative when confronted with a difficult problem or questions?</td>
<td>2.71</td>
<td>1.38</td>
<td>4.50</td>
<td>0.79</td>
<td>0.0107</td>
</tr>
<tr>
<td>Choose their own topics of learning or questions to pursue?</td>
<td>2.14</td>
<td>1.46</td>
<td>4.50</td>
<td>0.79</td>
<td>0.0107</td>
</tr>
<tr>
<td>Plan the steps they will take to accomplish a complex task?</td>
<td>2.57</td>
<td>1.40</td>
<td>4.83</td>
<td>0.38</td>
<td>0.0047</td>
</tr>
<tr>
<td>Choose for themselves what examples to study or resources to use?</td>
<td>2.14</td>
<td>1.68</td>
<td>4.50</td>
<td>0.053</td>
<td>0.0047</td>
</tr>
<tr>
<td>Monitor their own progress toward completion of a complex task and modify their work accordingly?</td>
<td>3.14</td>
<td>1.57</td>
<td>5.00</td>
<td>0.00</td>
<td>0.0205</td>
</tr>
<tr>
<td>Use specific criteria to assess the quality of their work before it is completed?</td>
<td>2.71</td>
<td>1.38</td>
<td>4.67</td>
<td>0.49</td>
<td>0.0096</td>
</tr>
<tr>
<td>Use peer, teacher or expert feedback to revise their work?</td>
<td>3.00</td>
<td>1.29</td>
<td>4.50</td>
<td>0.79</td>
<td>0.0248</td>
</tr>
</tbody>
</table>
The pre/post-survey consisted of 23 questions asking participating teachers about the frequency with which they ask their students to practice specific 21st-century skills. The results show that all seven of the participating teachers reported observing an increase in how often their students used 21st-century skills in their classroom. Furthermore, the majority of the pre/post-survey paired t-test indicated statistical significance with $p$ values of less than .05. Only two questions did not meet the threshold of $p < .05$ threshold; both were in the subcategory of communication skills. These two outliers were: (1) “Convey ideas using media other than paper,” which had a pre-survey mean of ($M = 3.29$), a post-survey mean of ($M = 4.50$), and a ($p = 0.0618$); and (2) “Answer questions in front of an audience,” which had a pre-survey mean of ($M = 3.29$), a post-survey mean of ($M = 4.50$), and a ($p = 0.1112$).

Some of the statistically significant results appeared in the collaboration skills subcategory. Teachers perceived that, with PBL, their students worked together to set goals and create a plan for their team more frequently. Pre-survey responses for this survey item were ($M = 2.71$), indicating “a few times per month,” whereas post-survey responses were ($M = 5.00$), or “almost daily,” with a ($p = 0.0007$). Two other positive outliers appeared in the collaboration subcategory: (a) “Create joint products using contributions from each student,” with a pre-survey mean of ($M = 2.57$), a post-survey mean of ($M = 4.83$), and a ($p = 0.0016$); and (b) “Present group work to others,” with a pre-survey mean of ($M = 2.43$), a post-survey mean of ($M = 5.00$). and a ($p = 0.0017$).

One final significant data point emerged from the creativity and innovation skills subcategory. During the pre-survey, teachers reported asking students on average ($M= 2.43$), “a few times per month” or less, to create an original product or performance to
express their ideas. The post-survey results indicated that teachers were asking students to create original products (M = 5.00) “almost daily.” This statistically significant increase (p = 0.0010) indicates that the test results are unlikely to have occurred by chance and that the difference between the pre/post-survey is likely to correlate to the extended PBL professional development.

**Science Teacher Efficacy Belief Instrument**

*Descriptive Statistics*

I asked each participating teacher to rank their level of agreement with a series of 25 questions on a science teaching efficacy belief instrument. The scale was as follows: 1 = strongly agree; 2 = agree; 3 = uncertain; 4 = disagree; 5 = strongly disagree. I administered this tool prior to the extended PBL professional development and upon the conclusion of the series. Table 4.3 reports the pre/post-survey results, consisting of the pre/post-survey questions, the mean, standard deviation, and paired t-test results.

Table 4.3 Science Teacher Efficacy Belief Instrument

<table>
<thead>
<tr>
<th>“Indicate the degree to which you agree or disagree with each statement below.”</th>
<th>Mean Pre-Survey</th>
<th>SD</th>
<th>Mean Post-Survey</th>
<th>SD</th>
<th>Paired t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>When a student does better than usual in science, it is often because the teacher exerted a little extra effort.</td>
<td>2.00</td>
<td>1.00</td>
<td>2.43</td>
<td>0.53</td>
<td>0.4072</td>
</tr>
<tr>
<td>I am continually finding better ways to teach science.</td>
<td>1.43</td>
<td>0.53</td>
<td>1.00</td>
<td>0.00</td>
<td>0.0781</td>
</tr>
<tr>
<td>Even when I try very hard, I don’t teach middle school science as well as I do other subjects/grade levels.</td>
<td>4.14</td>
<td>0.69</td>
<td>4.43</td>
<td>0.53</td>
<td>0.3559</td>
</tr>
<tr>
<td>“Indicate the degree to which you agree or disagree with each statement below.”</td>
<td>Mean Pre-Survey</td>
<td>SD</td>
<td>Mean Post-Survey</td>
<td>SD</td>
<td>Paired t-test</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>When the science grades of students improve, it is most often due to their teacher having found a more effective teaching approach.</td>
<td>2.14</td>
<td>0.53</td>
<td>1.29</td>
<td>0.49</td>
<td>0.0453</td>
</tr>
<tr>
<td>I know the steps necessary to teach science concepts effectively.</td>
<td>2.00</td>
<td>0.82</td>
<td>1.86</td>
<td>0.38</td>
<td>0.7358</td>
</tr>
<tr>
<td>I am not very effective in monitoring science experiments.</td>
<td>3.86</td>
<td>1.35</td>
<td>4.86</td>
<td>3.78</td>
<td>0.0382</td>
</tr>
<tr>
<td>If students are underachieving in science, it is most likely due to ineffective science teaching.</td>
<td>3.57</td>
<td>1.51</td>
<td>3.43</td>
<td>0.53</td>
<td>0.7882</td>
</tr>
<tr>
<td>I generally teach science ineffectively.</td>
<td>4.43</td>
<td>0.53</td>
<td>4.57</td>
<td>0.53</td>
<td>0.6036</td>
</tr>
<tr>
<td>The inadequacy of a student’s science background can be overcome by good teaching.</td>
<td>1.57</td>
<td>0.79</td>
<td>1.00</td>
<td>0.00</td>
<td>0.1030</td>
</tr>
<tr>
<td>The low science achievement of some students cannot generally be blamed on their teachers.</td>
<td>3.29</td>
<td>0.95</td>
<td>2.57</td>
<td>0.23</td>
<td>0.1403</td>
</tr>
<tr>
<td>When a low achieving child progresses in science, it is usually due to extra attention given by the teacher.</td>
<td>1.86</td>
<td>0.69</td>
<td>2.43</td>
<td>0.53</td>
<td>0.1723</td>
</tr>
<tr>
<td>I understand science concepts well enough to be effective in teaching middle school science.</td>
<td>1.57</td>
<td>0.53</td>
<td>1.86</td>
<td>0.38</td>
<td>0.3559</td>
</tr>
<tr>
<td>Increased effort in science teaching produces little change in some students’ science achievement.</td>
<td>4.00</td>
<td>0.82</td>
<td>2.43</td>
<td>0.53</td>
<td>0.0105</td>
</tr>
<tr>
<td>The teacher is generally responsible for the achievement of students in science.</td>
<td>1.86</td>
<td>0.38</td>
<td>2.43</td>
<td>0.53</td>
<td>0.0006</td>
</tr>
<tr>
<td>“Indicate the degree to which you agree or disagree with each statement below.”</td>
<td>Mean Presurvey</td>
<td>SD</td>
<td>Mean Postsurvey</td>
<td>SD</td>
<td>Paired t-test</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Students’ achievement in science is directly related to their teacher’s effectiveness in science teaching.</td>
<td>1.86</td>
<td>0.38</td>
<td>1.71</td>
<td>0.49</td>
<td>0.6036</td>
</tr>
<tr>
<td>If parents comment that their child is showing more interest in science at school, it is probably due to the performance of the child's teacher.</td>
<td>2.00</td>
<td>0.82</td>
<td>1.57</td>
<td>0.53</td>
<td>0.2894</td>
</tr>
<tr>
<td>I find it difficult to explain to students why science experiments work.</td>
<td>4.29</td>
<td>0.49</td>
<td>4.14</td>
<td>0.38</td>
<td>0.3559</td>
</tr>
<tr>
<td>I am typically able to answer students’ science questions.</td>
<td>1.43</td>
<td>0.53</td>
<td>1.14</td>
<td>0.38</td>
<td>0.1723</td>
</tr>
<tr>
<td>I wonder if I have the necessary skills to teach science.</td>
<td>4.43</td>
<td>0.79</td>
<td>3.71</td>
<td>1.25</td>
<td>0.2199</td>
</tr>
<tr>
<td>Effectiveness in science teaching has little influence on the achievement of students with low motivation.</td>
<td>2.43</td>
<td>1.27</td>
<td>5.00</td>
<td>0.00</td>
<td>0.0017</td>
</tr>
<tr>
<td>Given a choice, I would not invite the principal to evaluate my science teaching.</td>
<td>4.57</td>
<td>0.53</td>
<td>4.57</td>
<td>0.53</td>
<td>Null</td>
</tr>
<tr>
<td>When a student has difficulty understanding a science concept, I am usually at a loss as to how to help the student understand it better.</td>
<td>4.57</td>
<td>0.53</td>
<td>4.29</td>
<td>0.49</td>
<td>0.1723</td>
</tr>
<tr>
<td>When teaching science, I usually welcome student questions.</td>
<td>1.57</td>
<td>0.53</td>
<td>1.14</td>
<td>0.38</td>
<td>0.0781</td>
</tr>
<tr>
<td>I don’t know what to do to turn students on to science.</td>
<td>4.29</td>
<td>0.49</td>
<td>4.43</td>
<td>0.53</td>
<td>0.6891</td>
</tr>
<tr>
<td>Even teachers with good science teaching abilities cannot help some kids learn science.</td>
<td>3.29</td>
<td>1.50</td>
<td>3.86</td>
<td>1.07</td>
<td>0.3208</td>
</tr>
</tbody>
</table>
**Pre-Survey and Post-Survey Comparison**

Following the STEBI protocol established by its authors, the STEBI was scored by assigning points to each item as follows: 5 = Strongly Agree, 4 = Agree, 3 = Uncertain, 2 = Disagree, and 1 = Strongly Disagree. The scores were then recoded according to the reverse scoring rules, which reversed the scores so that 5 = Strongly Disagree and 1 = Strongly Agree for items presented in reverse or negative form. Sub-scores for the PSTE and STOE were generated using this method. The highest possible sub-score for PSTE is 65. The participants in this study scored 56.58 on the pre-survey and 57.90 on the post-survey. The highest possible sub-score for STOE is 60. The participants in this study scored 44.15 on the pre-survey and 46.29 on the post-survey. The sub-scores translated into a pre-survey overall mean for the PSTE was (M = 4.35), the post-survey mean was (M = 4.45), and the paired t-test for statistical significance was (p = 0.2835), greater than the stated threshold of a p value of less than .05 for reliability. The STOE pre-survey had an overall mean of (M = 3.68), the post-survey mean was (M = 3.86), and a paired t-test value of (p = 0.5568), also greater than the stated threshold. These findings indicated that no prevailing changes occurred during the MMAR study impacting PSTE or STOE. In fact, of the 25 survey items, only five items yielded statistically significant results:

1. “When the science grades of students improve, it is most often because their teacher has found a more effective teaching approach” had a pre-survey mean of (M = 2.14), a post-survey mean of (M = 1.29), and a (p = 0.0453).
2. “I am not very effective in monitoring science experiments” had a pre-survey mean of (M = 3.86), a post-survey mean of (M = 4.86), and a (p = 0.0382).
3. “Increased effort in science teaching produces little change in some students’ science achievement” had a pre-survey mean of (M = 4.00), a post-survey mean of (M = 2.43), and a (p = 0.0105).

4. “Effectiveness in science teaching has little influence on the achievement of students with low motivation” had a pre-survey mean of (M = 2.43), a post-survey mean of (M = 5.00), and a (p = 0.0017).

5. “The teacher is generally responsible for the achievement of students in science” had a pre-survey mean of (M = 1.86), a post-survey mean of (M = 2.43), and a (p = 0.0006).

Among the five items, four indicated positive changes in science teacher outcome expectancy and one indicated a positive change in science teacher self-efficacy:

1. The teachers indicated by a pre-survey mean of (M = 2.14) that they “agree” utilizing more effective teaching approaches influenced student grades in science, while their post-survey mean response (M = 1.29) indicated they “strongly agree.” This finding suggested the teachers may have learned new and more effective teaching strategies during the extended PBL professional development and used them during their PBL implementation.

2. The pre-survey indicated teachers “disagreed” by a mean of (M = 3.86) with the statement that they are “not effective in monitoring science experiments within their classroom.” The post-survey indicated they gained confidence in effectively monitoring classroom science experiments as the mean increased to (M = 4.86) “strongly disagree.”
3. Teachers indicated they “disagree” (M = 2.43) with the idea that “effective teaching has little influence on the academic achievement of unmotivated students,” meaning they believed this idea from the start. However, notably in the post-survey, teacher self-efficacy rose as the mean changed to (M = 5.00), or “strongly disagree.” All seven of the teachers firmly believed the statement.

4. The pre-survey indicated teachers were “uncertain” by a mean of (M = 2.43) that teachers are “generally responsible for the student’s science achievements.” The post-survey indicated this belief changed: they “agreed” (M = 1.86) teachers are generally responsible for students’ achievement.

The fifth notable data result reflects an adverse finding from the Science Teacher Efficacy Belief Instrument. The statement asked if increased effort in science teaching produces little change in some students’ science achievement. The teachers responded with a mean of (M = 4.00), or “disagree,” indicating they felt increased teacher effort produces little or no change for “some” students. Importantly, this question measures “effort,” not “effectiveness,” as seen in the third outlier above. Participating teachers indicated in the post-survey response that they “agreed” with a mean of (M = 2.43) that exerting more effort in science teaching produces little change in “some” students. This is a lower outcome expectancy indicating that teacher beliefs have shifted. The post-survey response indicated that teachers now feel that it is not what they, as the teacher, do in the classroom that impacts learning. Instead, what the students do in the classroom impacts student learning.
Qualitative Analysis and Findings

I collected the qualitative data for this MMAR study via researcher notes, teacher journal entries, and classroom observations. I took researcher notes during the seven extended professional development sessions, requested teacher reflection journals on five separate occasions, yielding 35 journal entries, and conducted classroom observations twice for each of the seven teachers, providing 14 observation data sources for analysis. Table 4.4 summarizes the data sets collected throughout the MMAR study. Overall, there were 16 deductive codes and 71 inductive codes, totaling 87 unique codes.

Table 4.4 Summary of Qualitative Data Sources

<table>
<thead>
<tr>
<th>Qualitative data source</th>
<th>Number of Sources</th>
<th>Type of coding</th>
<th>Number of codes applied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Researcher notes</td>
<td>7</td>
<td>Deductive</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Inductive</td>
</tr>
<tr>
<td>Teacher Reflection</td>
<td>35</td>
<td>Deductive</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Inductive</td>
</tr>
<tr>
<td>Classroom Observation</td>
<td>14</td>
<td>Deductive</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Inductive</td>
</tr>
<tr>
<td>Totals</td>
<td>56</td>
<td></td>
<td>87</td>
</tr>
</tbody>
</table>

Deductive Analysis

Before conducting the extended PBL professional development, I designed a list of 35 unique deductive codes to analyze the qualitative data. I derived deductive codes from the data collection tools I used in my MMAR study and aligned them with my research questions. Chapter 3 includes additional details on my method for creating the
deductive codes. I established the codes based on these dimensions: eight teacher attitudes toward in-district professional development, eight 21st-century skills codes, and seven teacher self-efficacy codes. I omitted 12 codes I did not employ during the deductive process, leading to the assignment of 23 predetermined codes (see Figure 4.1). These predetermined codes guided my transcription of the qualitative data creating a detailed inventory of the qualitative information (Saldaña & Omasta, 2016).

<table>
<thead>
<tr>
<th>Curriculum alignment (8)</th>
<th>Critical thinking (16)</th>
<th>Impact on student learning (27)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inquiry-based instruction (11)</td>
<td>Problem-solving (21)</td>
<td>Engagement (19)</td>
</tr>
<tr>
<td>Classroom management (14)</td>
<td>Communication (29)</td>
<td>Time management (29)</td>
</tr>
<tr>
<td>Assessment (18)</td>
<td>Leadership (8)</td>
<td>Coaching or mentoring (3)</td>
</tr>
<tr>
<td>Reflection (7)</td>
<td>Creativity (6)</td>
<td>Collaborative learning (9)</td>
</tr>
<tr>
<td>Differentiation (5)</td>
<td>Innovation (2)</td>
<td>Confidence (12)</td>
</tr>
<tr>
<td>Authenticity (22)</td>
<td>Self-directed learning (11)</td>
<td>Support and resources (18)</td>
</tr>
<tr>
<td>Motivation (15)</td>
<td>Leadership (3)</td>
<td></td>
</tr>
</tbody>
</table>

Figure 4.1 Predetermined Deductive Codes

**Inductive Analysis**

Upon concluding the extended PBL professional development, I began an inductive analysis of all sources of collected qualitative data. To accomplish this, I transcribed all research notes, teacher journal entries, and classroom observations into a singular Microsoft Word document. I separated each thought or phrase and attributed the speaker when known or the teacher journal entry code I assigned. I did not craft any codes preceding this initial round of coding (Gläser-Zikuda, 2020; Saldaña & Omasta, 2016), meaning that I applied multiple codes to the same line or sentence, helping to convey the text’s deeper meaning.
Upon completion of the preliminary round of open coding, I uploaded the Microsoft Word document into NVivo. NVivo is a qualitative data analysis software that supports researchers with coding, organizing, and analyzing qualitative data. The software allowed me to note different coding types, such as value coding, NVivo coding, process coding, and value coding (Saldaña & Omasta, 2016). I then conducted subsequent coding cycles, searching for lines or phrases that I had missed.

I used the NVivo coding (Charmaz, 2014; Manning & Kunkel, 2014; Saldaña & Omasta, 2016), and the program used the teachers’ own words and phrases as codes. This yielded codes such as choice, chaos, and tiring. According to Saldaña and Omasta (2016), the program assigned codes for actions taken by the students, such as ownership, challenging, and motivating, based on their self-described actions. It also assigned codes for attitudes, beliefs, and values toward a topic, idea, or themselves based on the participants’ perspective. This generated codes such as proud, excited, and enjoyable.

After analyzing the data, I executed various stages of coding to refine the codes. This included transferring and printing the codes from NVivo software, editing them on paper and whiteboard, and identifying codes that could be renamed or merged with existing codes. I then recorded these changes on the software and repeated the process multiple times to achieve the most precise codes. Initially, the program generated 140 codes, but after several rounds of coding, I ended with 71 codes (Figure 4.2).
| adaptability | active classroom | applicable to real life |
| assesssments | authenticity | better retention |
| building classroom culture | challenging | chaos |
| choice | classroom culture | classroom environment |
| clear assessment | collaboration | confident |
| create | creative thinking | designs |
| desire to learn | different conclusions | different outcomes |
| driving question | engaged | enjoyable |
| entry event | environment | excited |
| failure is positive | feedback is important | innovative |
| interested | interesting | mastery |
| meaningful | motivation | trial and error |
| ownership | presentation | problem-centered |
| project-centered | proud | public product |
| real-world problems | reflection | relevance |
| relevant | role of feedback | rubrics |
| scaffolding | self-direction | self-reflection |
| solving problems | standards based instruction | student centered |
| student choice | student voice | student led |
| student ownership | student perseverance | understanding |
| teacher student relationships | support during implementation | takes a lot of planning |
| takes risk | support | teamwork |
| time management | took longer than expected | multiple solutions to a single problem |
| students working independently | working outside of school time |

Figure 4.2 Determined Inductive Codes

**From Codes to Categories**

After numerous rounds of coding via NVivo, in addition to paper and manual coding on a white board, I conducted a first round of categorizing assigning 21st-century
skills as the category headings into which to filter the codes. This manner of categorizing is an analytic strategy (Saldaña & Omasta, 2016) to help focus emerging categories toward answering the research questions I proposed in my MMAR study. Round 1 featured categories such as critical thinking, collaboration, and social skills (Figure 4.3).

**Round 1**

<table>
<thead>
<tr>
<th>Critical Thinking</th>
<th>Creativity</th>
<th>Collaboration</th>
<th>Communication</th>
<th>Leadership</th>
<th>Initiative</th>
<th>Social Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>challenging</td>
<td>different</td>
<td>engaged</td>
<td>failure is</td>
<td>confident</td>
<td>desire to</td>
<td>active</td>
</tr>
<tr>
<td>motivation</td>
<td>conclusions</td>
<td>solving</td>
<td>positive</td>
<td>student led</td>
<td>learn</td>
<td>classroom</td>
</tr>
<tr>
<td>trial and error</td>
<td>enjoyable</td>
<td>problems</td>
<td>feedback is</td>
<td>students</td>
<td>interested</td>
<td>building</td>
</tr>
<tr>
<td></td>
<td>excited</td>
<td>takes a lot</td>
<td>important</td>
<td>working</td>
<td>meaningful</td>
<td>classroom</td>
</tr>
<tr>
<td></td>
<td>innovative</td>
<td>of planning</td>
<td>presentation</td>
<td>independently</td>
<td>proud</td>
<td>culture</td>
</tr>
<tr>
<td></td>
<td>student</td>
<td>teamwork</td>
<td></td>
<td></td>
<td>self-</td>
<td>takes risk</td>
</tr>
<tr>
<td>choice</td>
<td>choice</td>
<td>understanding</td>
<td></td>
<td></td>
<td>direction</td>
<td>adaptability</td>
</tr>
<tr>
<td></td>
<td>student</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>voice</td>
<td>voice</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 4.3 Categories Identified during Round 1

Next, I conducted two additional rounds of categorization. In the second round, I used the seven essential project-design elements from PBLWorks as the category headings to filter the codes. Round 2 featured categories such as public product, student voice and choice, and sustained inquiry (Figure 4.4). Then, for the third round, I used the seven project-based teaching practices from PBLWorks as the code headings to filter the codes. Round 3 featured categories such as build culture, design, plan, and engage and coach (Figure 4.5).
Round 2

<table>
<thead>
<tr>
<th>Challenging Problem</th>
<th>Sustained Inquiry</th>
<th>Authenticity</th>
<th>Student Choice &amp; Voice</th>
<th>Reflection</th>
<th>Critique &amp; Revision</th>
<th>Public Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>creative thinking</td>
<td>authenticity</td>
<td>desire to learn</td>
<td>collaboration</td>
<td>challenging failure is positive self-reflection</td>
<td>adaptability feedback is important rubrics solving problems</td>
<td>assessments clear assessment confident different conclusions mastery presentation</td>
</tr>
<tr>
<td>driving question</td>
<td>engaged</td>
<td>meaningful ownership</td>
<td>excited motivation student centered student ownership</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>enjoyable</td>
<td>self-direction</td>
<td>proud</td>
<td>student centered student ownership</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>entry event</td>
<td>student choice</td>
<td>relevant</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>innovative</td>
<td>student voice</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>student led</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 4.4 Categories Identified during Round 2

Round 3

<table>
<thead>
<tr>
<th>Design &amp; Plan</th>
<th>Align to Standards</th>
<th>Build Culture</th>
<th>Manage Activities</th>
<th>Scaffold Learning</th>
<th>Assess Learning</th>
<th>Engage &amp; Coach</th>
</tr>
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<tr>
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<td>entry event</td>
<td>active classroom</td>
<td>challenging student choice</td>
<td>creative thinking engaged innovative student ownership</td>
<td>assessments clear assessment</td>
<td>collaboration time</td>
</tr>
<tr>
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<td>interesting</td>
<td>authenticity</td>
<td>student centered student ownership</td>
<td>feedback is important</td>
<td>different conclusions</td>
<td>enjoyable failure is positive</td>
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<tr>
<td>classroom</td>
<td>relevant</td>
<td>chaos</td>
<td>voice time management</td>
<td>ownership</td>
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<td>ownership proud</td>
</tr>
<tr>
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<td></td>
<td>excited</td>
<td></td>
<td></td>
<td>different conclusions</td>
<td>self-reflection</td>
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<tr>
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<td>meaningful</td>
<td></td>
<td></td>
<td>feedback is important</td>
<td>ownership support during implementation</td>
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<td>motivation</td>
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<td>teamwork</td>
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<td>relationships</td>
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Figure 4.5 Categories Identified during Round 3

From Categories to Themes

Qualitative data analysis needs to identify themes the data supports. Themes allow the researcher accurately to retell findings relevant to the MMAR study (Yi, 2018). For this stage in the data analysis, I printed out several copies of the refined categories and
codes from rounds 2, 3, and 4. I then color-coded word associations, word frequency, or any other pattern I ascertained across two or more rounds of coding (Figure 4.6).

<table>
<thead>
<tr>
<th>Critical thinking</th>
<th>Creativity</th>
<th>Collaboration</th>
<th>Communication</th>
<th>Leadership</th>
<th>Initiative</th>
<th>Social Skills</th>
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<td>failure is positive</td>
<td>confident</td>
<td>desire to learn</td>
<td>active classroom</td>
</tr>
<tr>
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<td>enjoyable</td>
<td>solving problems</td>
<td>feedback is important</td>
<td>student led</td>
<td>interested</td>
<td>building classroom culture</td>
</tr>
<tr>
<td>trial and error</td>
<td>excited</td>
<td>takes a lot of planning</td>
<td>presentation</td>
<td>students working independently</td>
<td>meaningful</td>
<td>takes risk</td>
</tr>
<tr>
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<td>teamwork</td>
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</tr>
<tr>
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<td>understanding</td>
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<td>self-direction</td>
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<td></td>
<td>student perseverance</td>
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<td></td>
<td>working outside of school time</td>
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<tr>
<th>Challenging problem</th>
<th>Sustained inquiry</th>
<th>Authenticity</th>
<th>Student Choice &amp; Voice</th>
<th>Reflection</th>
<th>Critique &amp; Revision</th>
<th>Public Product</th>
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<tr>
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<td>engaged</td>
<td>meaningful</td>
<td>excited</td>
<td>failure is positive</td>
<td>feedback is important</td>
<td>clear assessment</td>
</tr>
<tr>
<td>enjoyable</td>
<td>self-direction</td>
<td>ownership</td>
<td>motivation</td>
<td>self-reflection</td>
<td>rubrics</td>
<td>confident</td>
</tr>
<tr>
<td>entry event</td>
<td>student choice</td>
<td>proud</td>
<td>student centered</td>
<td>solving problems</td>
<td>different conclusions</td>
<td></td>
</tr>
<tr>
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<td>student voice</td>
<td>relevant</td>
<td>student ownership</td>
<td></td>
<td>mastery</td>
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<td></td>
<td>student led</td>
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<th>Build Culture</th>
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<th>Scaffold Learning</th>
<th>Assess learning</th>
<th>Engage &amp; coach</th>
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<td>assessments</td>
<td>collaboration</td>
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<td>authentic</td>
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<td>clear assessment</td>
<td>enjoyable</td>
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<td>different conclusions</td>
<td>failure is positive</td>
</tr>
<tr>
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<td>standards based instruction</td>
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<td>time management</td>
<td>student ownership</td>
<td>feedback is important</td>
<td>ownership</td>
</tr>
<tr>
<td>question</td>
<td>student centered</td>
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<td>mastery</td>
<td>proud</td>
<td></td>
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<tr>
<td>takes a lot of planning</td>
<td>motivation</td>
<td>rubrics</td>
<td>support during implementation</td>
<td>teamwork</td>
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<tr>
<td>student centered</td>
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Figure 4.6 Color-Coding for Themes
The color-coded analysis refined the categories and codes, allowing me to formulate themes representative of the qualitative data I collected and address the research questions my MMAR study posed. After carefully analyzing the data, I identified four themes. Theme 1 focuses on how authenticity fosters student initiative. Theme 2 focuses on how extended PBL professional development empowers teachers. Theme 3 focuses on how student voice and choice encourage the development of 21st-century skills. And theme 4 focuses on clear assessments and final project outcomes. Table 4.5 offers a more detailed overview of each theme, its assertion, and the supporting categories.

Table 4.5 Themes, Assertions, and Categories

<table>
<thead>
<tr>
<th>Theme</th>
<th>Assertion</th>
<th>Categories</th>
</tr>
</thead>
</table>
| 1: Students took more initiative in their learning when projects were authentic. | Classroom observations, teacher reflection journals, and research notes outlined a marked increase in student-driven behaviors when students viewed the projects as having real-world application and being of interest to them. | Desire to learn  
Interested  
Meaningful  
Ownership  
Relevant |
| 2: Teachers were empowered to design and implement a PBL when they received extended support beyond the professional development time. | Teacher reflection journals and research notes outlined the level of support teachers needed to feel prepared and confident in their PBL, along with their positive affirmations about having an extended PD to support them. | Building classroom culture  
Standards based instruction  
Time management  
Collaboration  
Support during implementation |
<table>
<thead>
<tr>
<th>Theme</th>
<th>Assertion</th>
<th>Categories</th>
</tr>
</thead>
</table>
| **3: Students exhibited increased use of 21st-century skills when given choice and voice.** | Classroom observations, teacher reflection journals, and research notes captured the changes in student behavior pre/post-PBL implementation. | Collaboration  
Engaged  
Excited  
Motivation  
Student choice/voice  
Student ownership |
| **4: Clear assessments led to higher quality public products.** | Classroom observations, teacher reflection journals, and research notes captured the level of mastery each student attained and its correlation to the public product rubric. | Clear assessments  
Confident  
Different conclusions  
Mastery  
Presentation  
Feedback is important  
Rubrics |

**Presentation of Findings**

In this section, I will discuss the four themes that emerged from the qualitative and quantitative data review. I present each theme with supporting details from researcher notes, teacher journals, and classroom observations.

**Theme One: Students Took More Initiative in Their Learning When Projects Were Authentic**

**Desire to Learn/Interested**

Participants shared that their students exhibited an increased desire to learn when they employed PBL. During the extended PBL professional development series, before implementing a PBL, teachers shared their impressions of students’ desire to learn was that students were apathetic. Student apathy became a prevailing concern during our first
two extended PBL sessions. Teachers shared that apathy has been a long-standing middle school issue exacerbated in our post-COVID-19 era. Mr. Davis stated, “most of my students don’t care about their grades, even those playing sports.” Other teachers felt it was not solely apathy but also a profound disinterest in the subject that caused students to disengage. Ms. Wall shared that her students often complain the class is “boring” or make comments such as “when will I ever need to know the parts of a plant cell.”

The teachers shared that once they began instructing using PBL, a shift in their students’ desire to learn and/or an increase in student interest occurred. Teacher journal reflection entries noted that starting with the entry event, students became more “talkative” and “attentive” and began expressing “genuine” interest. Students began taking initiative: (a) seeking ways to do more research, (b) bringing in items from home, (c) suggesting ideas, and (d) “productively” collaborating with their peers. During a classroom observation, Ms. Childs shared that her students were “working harder for me during the PBL than they ever have.” She felt this increased desire to learn and take an initiative occurred because the project presented a real-world, open-ended, authentic problem for them to research and try to solve. She said, “students have a natural desire to create, and problem solve, and this project taps into that.”

**Meaningful/Relevant**

Participants felt that their students took more initiative because the PBL was meaningful and/or relevant to them. During our first three extended PBL professional development sessions, teachers openly expressed their concerns about creating a “truly authentic experience” for their students. I acknowledged their concerns that authentic PBL can be challenging and require them to be innovative. I assured the participants that
their students would take the initiative if they could create projects relevant to the students’ lives.

During the extended PBL professional development series, I encouraged the teachers to craft a substantial introductory activity to be their “hook” for gaining student interest. To do this, I worked with each teacher individually to ensure the entry activity would be meaningful and/or relevant for their students. One teacher shared with me after their PBL implementation that it “was a lot of work, but it was probably the most authentic lesson I have taught in my career.”

The teachers shared that once they began the PBL lesson, a shift in their students’ desire to learn and interest occurred. Teacher journal reflection entries noted instances of students finding meaning and relevance in the project:

TJ#1110(3): One of my students has a younger brother in the 4th-grade class we are partnering with for our PBL. He is so excited that he gets to make the phases of the moon project his brother will “have” to do in class!

TJ#1110(4): One of my quiet kids [who] never says anything, said, “finally, I get to do something I can use for a job”… he wants to design a web page for his project and thinks that’s what he’ll do after high school.

TJ#1112(6): Kids really like the idea of finding ways to make the school more “environmentally friendly” they told me this project is the first time we have done something “important.”
The students associated the PBL lesson outcomes with providing a public product that would be meaningful and relevant to their family, future jobs, or self. Teachers noted that when the students viewed the public product as meaningful or relevant, the entire project became more authentic and genuine, increasing their engagement and pushing them to take the initiative to produce the best public products they could.

**Ownership**

Participants shared that their students exhibited increased ownership in the learning process when they employed PBL. During our third and fourth extended PBL professional development sessions, teachers openly expressed their concerns about students being able to research and work independently. In these two sessions, we discussed; (a) sustained inquiry, (b) student choice and voice, (c) management of activities, and (d) scaffolding. Many teachers shared students “can’t handle working in groups,” that the students “do not manage their time wisely,” and that past attempts at scaffolding led to many incomplete assignments.

After the PBL implementation, teachers reported their students’ new perspectives on learning. Ms. Childs shared that “when they [the students] were in charge of their learning, they got to choose the focus of their project and what the outcome was going to be. They were much more interested because they were in the driver’s seat.” Ms. Culvert said, “When kids take ownership, the outcomes are limitless.” Ms. Greene shared, “I have kids coming to my class during their other class, asking ‘can I work on my project….Ms/Mr (other teachers name) said I could.”’ In every participating teacher’s class, I observed students taking ownership of their work during the PBL implementation.
**Quantitative Data Alignment**

The quantitative data is consistent with the findings of the qualitative data: the teachers perceived their students as taking more initiative in their learning when projects were authentic. The Measuring 21st-Century Teaching and Learning Survey post-survey results reported in Table 4.6 highlight the data with relevance to Theme 1. The scale was as follows: 1 = almost never; 2 = a few times per semester; 3 = a few times per month; 4 = a few times per week; 5 = almost daily. The table includes the pre/post-survey questions, mean, standard deviation, and paired t-test results.

The study’s quantitative data collected through the Measuring 21st-Century Teaching and Learning Survey indicates that teachers perceived their students as demonstrating 21st-century skills with higher frequency when projects were authentic. These skills include the ability to:

- Decide how they will present their work or demonstrate their learning.
- Generate their ideas about how to confront a problem or question.
- Take the initiative when confronted with a complex problem or questions.
- Choose their topics of learning or questions to pursue.
- Plan the steps they will take to accomplish a complex task.
- Choose for themselves what examples to study or resources to use.
- Monitor their progress toward completion of a complex task and modify their work accordingly.
Table 4.6 Measuring 21st-Century Teaching and Learning Survey – Theme 1 Data

<table>
<thead>
<tr>
<th></th>
<th>Mean Pre-Survey</th>
<th>SD</th>
<th>Mean Post-Survey</th>
<th>SD</th>
<th>Paired t-test</th>
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<td><strong>Communication Skills</strong></td>
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<tr>
<td>Decide how they will present</td>
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<td>1.27</td>
<td>4.33</td>
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<td>their work or demonstrate</td>
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<tr>
<td>their learning?</td>
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<tr>
<td><strong>Creativity &amp; Innovation Skills</strong></td>
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<tr>
<td>Generate their own ideas about</td>
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<td>1.13</td>
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<td>0.0038</td>
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<td>how to confront a problem or</td>
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<td></td>
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<tr>
<td>question?</td>
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<tr>
<td><strong>Self-Direction Skills</strong></td>
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<tr>
<td>Take initiative when</td>
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<td>1.38</td>
<td>4.50</td>
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<td>Choose their own topics of</td>
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<td>pursue?</td>
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<td>Choose for themselves what</td>
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<td>to use?</td>
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<td>Monitor their own progress</td>
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<td>accordingly?</td>
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<td>Use specific criteria to assess</td>
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<td>before it is completed?</td>
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<tr>
<td>Use peer, teacher or expert</td>
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<td>1.29</td>
<td>4.50</td>
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<td>0.0248</td>
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<td>feedback to revise their work?</td>
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The post-survey data suggests that students are more likely to take ownership of their learning and develop essential 21st-century skills such as critical thinking, problem-solving, and self-direction when they are allowed to work on authentic projects. The post-
survey results indicate that teachers observed an improvement in students’ ability to take initiative and make decisions about their learning, indicating that the authenticity of the projects has a positive impact on student engagement and the development of 21st-century skills.

**Theme Two: Teachers Were Empowered to Design and Implement a PBL Lesson**

**When They Received Extended Support Beyond the Professional Development Time**

**Building Classroom Culture**

Participants shared that receiving extended support through the PBL professional development and implementation allowed them to build a classroom culture that reinforced their PBL activities. Prior to the extended PBL professional development series, some participating teachers were concerned about changing their classroom culture to better suit PBL implementation. Ms. Culvert asked, “How do I explain to administrators what I am doing? Because if they walk in and it looks like chaos and it kind of is chaos, they are not going to understand.” To this, I responded, “If an administrator stops by, have them ask a student to share what they are working on and why, and if the students can explain what they are doing and the standards they are working on, your administrator should have no issue.”

During our fourth and fifth extended PBL professional development sessions, I described effective PBL creating the right classroom culture, in addition to designing a good project. I shared evidence for how and why classroom culture fosters an environment conducive to collaboration and creativity by creating a community of trust, as well as how classroom culture was essential to encouraging inquiry, risk-taking, persistence, and self-directed learning.
During classroom observations, I documented the shift in classroom culture. During the pre-PBL observation, I observed many traditional strategies: (a) projected PowerPoint, (b) student interactive notebooks, (c) teacher lecturing, (d) little classroom discussion, and (e) all students seated. However, when I observed during the PBL unit, I noted: (a) students working actively in groups, (b) students looking up information on Chromebooks, (c) students graphing results, (d) students engaging in trial and error problem-solving, and (e) teachers acting as facilitators. During one PBL observation, an assistant principal (AP) also dropped in for a formal observation. The AP stayed in the room far longer than I expected and began talking with the students. One group took his interest, and he began questioning what they were doing. When the student quickly explained the project and the expected outcomes, he brainstormed with them. The AP departed after the students had a successful run with their project, and they all exchanged high fives. After the observation, I spoke to the AP about his impression of the class.

OB#1127(9): At first, I was like, whoa, ok, what’s going on in here…but then when I started listening to the kids, I could tell they were fully engaged and had a clear objective. I spent a lot of time with this group of guys, I’m not saying they get into trouble, but all of them together had me curious. I watched them and could tell they were struggling a little, so I gave them some advice. Man, they were so excited when their project worked. It was real impressive.

OB#1122(1): It was an exhausting process, I’m just exhausted, and the room is a wreck…it was great, but I’m so glad it is over, and they [the students] are taking all of it [the projects] home.
Standards-Based Instruction

Participants shared that extended support beyond the PBL professional development and implementation ensured standards-based instruction. During the initial extended PBL professional development session, several teachers shared their concern that creating and implementing a PBL lesson would take time away from teaching state standards. Mr. Davis shared that with an “already very busy schedule, short planning periods, and increased [meeting obligations], finding time to make a new lesson will be hard.” The three 6th-grade teachers were concerned particularly about having enough time to cover all of their standards, as the state tests science annually in grade 6. Ms. Williams said, “well, I’m just glad we are still teaching the old standards this year. If it was next year, this wouldn’t be possible,” referring to her participation in the extended PBL professional development. I interpret this statement as referring to the time constraints she would feel with having a new state standard that would be tested and needing the time to plan a PBL.

During our fifth and sixth extended PBL professional development sessions, teachers began to craft the PBL lessons they would implement. In these sessions, I repeatedly said, “start with your standards in mind.” I told them that the primary goal of PBL is authenticity, which includes being authentic about standards. Participating teachers found their planning process became more intentional and complex as they layered multiple standards into the PBL, in contrast to the more singularly focused lesson plans they used in the past. Specifically, teachers found that they and their students were thinking deeper and across a broader range of standards using PBL. Ms. Childs shared, “I think using PBL made the students more engaged and more likely to retain the
information,” indicating she felt PBL increased student mastery and retention of the standards covered during the project.

**Time Management/Collaboration**

Participants shared that time management and collaboration are essential to successfully implementing PBL. During the extended PBL professional development series, the topics of time management and time constraints came up in seven out of seven (100%) sessions. Before and after implementation, teachers felt that PBL requires “lots of planning” and is a “huge and exhausting process.” Ms. Childs pointed out that trying to find time and comprehensively plan for the PBL process is “not easy”: “you’re never going to have everything ready. You just have to start and be flexible.” Another teacher who had missed a session and was behind on her timeline emailed me the following:

Sorry I haven’t responded to you. My home life and school life have been CRAZY BUSY! I had a personal day Friday, and I’m attending the Teacher Clarity sessions at the DO today and tomorrow. My original timing for the project is completely off now. I will attempt to figure out the new timing. (Wall)

Teacher journal entries shared Ms. Wall’s overwhelmed sentiments:

TJ#0921(2): How to get them engaged without it taking me hours and hours of planning!!

TJ#0921(6): Having the time to prep, plan and deliver differentiated lessons consistently!

Other teachers felt the planning time was less of an issue than the classroom implementation time: “one of the hard parts with PBL is that many of the students’ projects look very different and take different lengths of time to accomplish” (Mr. Davis).
Out of the seven participating teachers, only three (43%) were able to complete their PBL within the timeline they initially set. Ms. Williams shared, “I planned for ten days. It took 12 for most students (I had some COVID-19 absences). Next time I will plan for at least 15 days, and not during Halloween.”

**Support during Implementation**

Participants felt receiving extended support beyond the PBL professional development and implementation was a positive experience they learned from. Below are comments from teachers shared via email or face-to-face after implementation.

Childs: Thanks again for all of your guidance and support throughout this PBL process. I truly believe we took a project that we already did, and we refined it to make it more authentic for our students.

Williams: Our wheels are already turning as to what we can do for our next PBL.

Wall: I would never have made it through this PBL without your support. You were always available whenever I was having a meltdown. I would have just quit if I hadn’t had your help. PS My students can’t stop talking about when we will do another PBL!!

**Quantitative Data Alignment**

The quantitative data is consistent with the qualitative data, in that teachers reported feeling empowered to design and implement a PBL lesson when they received extended support. The Descriptive Statistics for Teacher Opinions on PBL and Professional Development survey results in Table 4.7 highlight indicators relevant to
Theme 2. The scale is as follows: 1 = not really; 5 = to a very great extent. The table includes pre/post-survey questions, mean, standard deviation, and paired t-test results.

Table 4.7 Descriptive Statistics for Teacher Opinions on PBL and Professional Development – Theme 2 Data

<table>
<thead>
<tr>
<th>Pre-Survey Question</th>
<th>Post-Survey Question</th>
<th>Mean Pre-Survey</th>
<th>SD</th>
<th>Mean Post-Survey</th>
<th>SD</th>
<th>Paired t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>How comfortable do you feel about implementing PBL in your classroom?</td>
<td>How comfortable do you feel about implementing PBL in your classroom after our extended PBL professional development series?</td>
<td>2.60</td>
<td>1.14</td>
<td>4.80</td>
<td>0.40</td>
<td>0.0295</td>
</tr>
<tr>
<td>Have previous professional development opportunities been beneficial to you as a middle school science teacher?</td>
<td>How comfortable do you feel about implementing PBL in your classroom after our extended PBL professional development series?</td>
<td>2.20</td>
<td>1.30</td>
<td>5.00</td>
<td>0.00</td>
<td>0.0086</td>
</tr>
<tr>
<td>Has information from professional development in the past led to changes in your teaching practice?</td>
<td>Do you feel the extended PBL professional development will lead to changes in your teaching practice?</td>
<td>3.20</td>
<td>1.10</td>
<td>4.40</td>
<td>0.49</td>
<td>0.1087</td>
</tr>
</tbody>
</table>

The quantitative data I collected from the Teacher Opinions on PBL and Professional Development survey shows that teachers felt empowered to design and implement PBL lessons when they received ongoing support through the extended PBL professional development series. The survey results indicate teachers felt more comfortable implementing PBL in their classrooms after the series.
All seven participating teachers noted the extended PBL professional development was more “beneficial to them as middle school science teachers” than past in-district professional development opportunities had been. They felt the series helped them better understand the PBL method and how to apply it in their classrooms and with their standards.

Moreover, teachers indicated that, “to a great extent,” they felt the extended PBL professional development would lead to changes in their teaching practice. They felt the ongoing support they received during the professional development series would help them improve their teaching methods and better support student learning. The post-survey results demonstrate that extended professional development and support beyond the professional development time are crucial for teachers to feel equipped and empowered to implement PBL in their classrooms.

**Theme Three: Students Exhibited Increased Use of 21st-Century Skills When Given Choice and Voice**

**Collaboration**

Participants felt their students exhibited increased collaboration skills during the PBL when they had choice and voice. During our initial extended PBL professional development session, teachers expressed concern that, for students, the entire concept of talking to their peers for collaboration “seems foreign to them.”

PBL encourages students to think more critically and creatively to complete tasks. Being able to work with peers helped the students display (1) problem-solving skills, (2) creative solutions to problems, (3) collaborative work toward completing a project, and
(4) effective communication with each other. Teacher journal reflection entries noted instances of students finding meaning and relevance in the project:

TJ#1111(5): My students had to learn to listen to each other, respect each other’s opinions, and work together to make a public product that worked.

TJ#1110(1) Students really had to listen to each other and work together to reach their goal.

TJ#1110(2): I just kept encouraging my students to explore their own solutions with their partners

TJ#1113(7): Providing student choice made it easier for my student to start talking to one another. While there was some arguing they mostly were just excited to be in charge of creating their own public product. Like not having to all do the same project made it a competition to see who could do the best.

Teachers felt that when the students were given a choice and voice on how and what to research, they (a) increased collaborations, (b) learned conflict negotiation, (c) showed compassion when things failed, and (d) celebrated when things worked. For the students to research in a group to solve an authentic problem, they had to practice and develop collaboration.

**Engaged**

Participants felt their student engagement increased during the PBL when they were given choice and voice. During the initial extended PBL professional development session, teachers expressed their belief that many of their students lacked engagement.
Ms. Greene shared that “students are not engaged, they don’t know how to take notes, they don’t know how to study, they are always playing games or distracted by their Chromebook.” Other points of concern included student use of “cell phones,” the observation that students “will not talk” and “will not work in groups,” and Mr. Albertson added that his “students don’t know how to take notes or know how to study.”

During PBL implementation, the teachers observed shifts in their students’ behaviors, sharing students were “becoming active participants in their own learning” and fully engaged with the PBL inquiry process. Teachers felt having choice and voice in a project empowered the students. Teachers also shared how creating a “real” problem for students to engage with actively encouraged them to think more critically and creatively in order to complete tasks. The PBL approach encourages students to creatively solve problems while exploring their interests. Ms. Culvert added that during her PBL implementation, one student told her, “I’m like a scientist now; I’m making my knowledge.”

TJ#0910(7): My students struggle with engagement, and this will give them an opportunity to think outside the box and use their imagination which should reengage them.

Motivation

Participants felt their students exhibited increased motivation during the PBL when they were given choice and voice. Teachers shared many stories about the shift they noticed in student motivation while implementing the PBL. Ms. Wall noted her students were “way more excited” when they came into class and usually “ran late to
their next class” as they rushed to clean up after the bell. During a classroom observation, students told me:

OB#1127(9): I liked having my own ideas on what to learn, normally it’s just what [the teacher] wants to do.

OB#1127(14): When I have choice, I want to do it.

OB#1127(8): We do the same projects in science every year, so yeah this is fun I get to pick how my [project] works.

Student Choice and Voice

Participants felt their students exhibited increased 21st-century skills during the PBL when they were given choice and voice. During the third session of the extended PBL professional development series, teachers shared their past experiences with assignments that supported student choice and voice. The dominant strategy six out of seven (86%) participating teachers used was “choice boards.” Choice boards are an instructional tool that allow students to choose their way of studying a particular concept (Coppens, 2021). They ask students to complete activities or answer uniform questions with several options for accomplishing a task. Choice boards are completely teacher-generated. The teachers agreed allowing student choice did increase engagement but also noted the students quickly “bored,” and it was hard to sustain. I shared that “classrooms that encourage independent critical thinking by providing choice and voice also build student creativity and inquiry skills, and student engagement.”

Teachers reported giving students a say in their learning process increased their use of 21st-century skills. The teachers noted increased social interaction as students collaborated to (a) brainstorm, (b) provide feedback, and (c) problem-solve. Teachers
also reported their students appeared to be highly motivated when completing a project of their choosing. It challenged them to be critical thinkers open to failure, changes, and creativity. One teacher even reported that student creativity surpassed their own:

Williams: My students came up with interactive and insightful activities that interested both them and their peers, they were far more inventive than I am.

**Student Ownership**

Participants felt their students exhibited increased ownership during the PBL when presented with choice and voice. During the fifth session of the extended PBL professional development series, I showed a short video from PBLWorks documenting a Tiny House PBL. After watching the video, teachers stated they easily could see the students’ pride and ownership. The teachers shared they would like to create an environment that would elicit the same level of ownership in their students as they had seen in the video. Teachers shared past projects “wound up in the trash can,” had “been done the morning/class before theirs,” or were “made by the parents,” but that students rarely were “proud” of them.

During the PBL implementation, teachers felt their students were motivated and took greater ownership when the project addressed an issue or topic that was authentic to the student. During the PBL, teachers reported the following:

Greene: Multiple students were bringing in supplies form home, this never happens.

Childs: I had one student, have his grandpa build a complete shelving unit, out of hardwood, for his project, or to help others.
Wall: I have this one student who never does anything, no homework, or
classwork, wears headphones EVERYDAY, completely
disinterested in my class. Suddenly trying to make a [project] and
is volunteering to bring in stuff for the group and even other
groups!

Quantitative Data Alignment

The quantitative data is consistent with the qualitative data, in that, when teachers
implemented PBL in the classroom, they perceived students exhibiting increased use of
21st-century skills when they had choice and voice. The Measuring 21st-Century
Teaching and Learning survey results in Table 4.8 highlight the indicators relevant to
Theme 3. The scale was as follows: 1 = almost never; 2 = a few times per semester; 3 = a
few times per month; 4 = a few times per week; 5 = almost daily. The table includes
pre/post-survey questions, mean, standard deviation, and paired t-test results.

Table 4.8 Measuring 21st-Century Teaching and Learning Survey – Theme 3 Data

<table>
<thead>
<tr>
<th>“In your teaching of middle school science, how often have you asked the students to do the following?”</th>
<th>Mean Pre-Survey</th>
<th>SD</th>
<th>Mean Post-Survey</th>
<th>SD</th>
<th>Paired t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication Skills</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structure data for use in written products or oral presentations (e.g., creating charts, tables, or graphs)?</td>
<td>2.43</td>
<td>1.62</td>
<td>4.17</td>
<td>1.00</td>
<td>0.0248</td>
</tr>
<tr>
<td>Answer questions in front of an audience?</td>
<td>3.29</td>
<td>1.50</td>
<td>4.50</td>
<td>1.21</td>
<td>0.1112</td>
</tr>
<tr>
<td>Decide how they will present their work or demonstrate their learning?</td>
<td>2.43</td>
<td>1.27</td>
<td>4.33</td>
<td>0.76</td>
<td>0.0037</td>
</tr>
</tbody>
</table>
### Collaboration Skills

<table>
<thead>
<tr>
<th>Activity</th>
<th>Mean Pre-Survey</th>
<th>SD</th>
<th>Mean Post-Survey</th>
<th>SD</th>
<th>Paired t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work in pairs or small groups to complete a task together?</td>
<td>3.57</td>
<td>0.79</td>
<td>5.00</td>
<td>0.00</td>
<td>0.0030</td>
</tr>
<tr>
<td>Work with other students to set goals and create a plan for their team?</td>
<td>2.71</td>
<td>0.95</td>
<td>5.00</td>
<td>0.00</td>
<td>0.0007</td>
</tr>
<tr>
<td>Create joint products using contributions from each student?</td>
<td>2.57</td>
<td>1.13</td>
<td>4.83</td>
<td>0.38</td>
<td>0.0016</td>
</tr>
<tr>
<td>Present their group work to the class, teacher or others?</td>
<td>2.43</td>
<td>1.27</td>
<td>5.00</td>
<td>0.00</td>
<td>0.0017</td>
</tr>
<tr>
<td>Give Feedback to peers or assess other students work?</td>
<td>2.57</td>
<td>1.40</td>
<td>5.00</td>
<td>0.00</td>
<td>0.0037</td>
</tr>
</tbody>
</table>

### Creativity & Innovation Skills

<table>
<thead>
<tr>
<th>Activity</th>
<th>Mean Pre-Survey</th>
<th>SD</th>
<th>Mean Post-Survey</th>
<th>SD</th>
<th>Paired t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generate their own ideas about how to confront a problem or question?</td>
<td>2.57</td>
<td>1.13</td>
<td>4.50</td>
<td>0.79</td>
<td>0.0038</td>
</tr>
<tr>
<td>Test out different ideas and work to improve them?</td>
<td>2.86</td>
<td>1.21</td>
<td>4.67</td>
<td>0.76</td>
<td>0.0068</td>
</tr>
<tr>
<td>Invent a solution to a complex, open-ended question or problem?</td>
<td>2.71</td>
<td>1.25</td>
<td>4.83</td>
<td>0.38</td>
<td>0.0034</td>
</tr>
<tr>
<td>Create an original product or performance to express their ideas?</td>
<td>2.43</td>
<td>1.13</td>
<td>5.00</td>
<td>0.00</td>
<td>0.0010</td>
</tr>
</tbody>
</table>

<p>| “In your teaching of middle school science, how often have you asked the students to do the following?” |</p>
<table>
<thead>
<tr>
<th>Mean Pre-Survey</th>
<th>SD</th>
<th>Mean Post-Survey</th>
<th>SD</th>
<th>Paired t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>“In your teaching of middle school science, how often have you asked the students to do the following?”</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Self-Direction Skills

<table>
<thead>
<tr>
<th>Activity</th>
<th>Mean Pre-Survey</th>
<th>SD</th>
<th>Mean Post-Survey</th>
<th>SD</th>
<th>Paired t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Take initiative when confronted with a difficult problem or questions?</td>
<td>2.71</td>
<td>1.38</td>
<td>4.50</td>
<td>0.79</td>
<td>0.0107</td>
</tr>
<tr>
<td>Plan the steps they will take to accomplish a complex task?</td>
<td>2.57</td>
<td>1.40</td>
<td>4.83</td>
<td>0.38</td>
<td>0.0047</td>
</tr>
<tr>
<td>Choose for themselves what examples to study or resources to use?</td>
<td>2.14</td>
<td>1.68</td>
<td>4.50</td>
<td>0.053</td>
<td>0.0047</td>
</tr>
</tbody>
</table>
The post-survey data indicates teachers perceived their students exhibiting increased use of 21st-century skills when given choice and voice in their learning. The quantitative data shows students demonstrated higher frequency in the following skills:

- Structure data for use in written products or oral presentations;
- Work in pairs or small groups to complete a task together;
- Create joint products using contributions from each student;
- Present their group work to the class, teacher, or others;
- Create an original product or performance to express their ideas; and
- Plan the steps they will take to accomplish a complex task.

These skills are tied closely to the ability to work collaboratively, communicate effectively, and think critically, all of which are important for building 21st-century skills. The teachers’ perception that their students were more engaged in learning when given choice and voice reinforces this connection. They reported students worked in pairs or small groups, created joint products, and presented their work to others at a greater frequency when allowed to make choices and have a say in their learning.

**Theme Four: Clear Assessments Lead to Higher Quality Public Products**

*Clear Assessments, Rubrics, and Presentations*

Participants noted their students produced higher-quality work when guided by clear assessments and rubrics. We discussed formative and summative assessments during our fifth extended PBL professional development session. Teachers shared they all had used rubrics in some form, but most included basic elements such as (a) name, (b) three bullet points, and (c) no spelling errors. I asked if these rubrics guided students to create high-quality finished products, and 100% of the teachers answered “no.” When a
clear rubric guides and supports how students, as a group, try to answer a primary challenge, they will produce higher-quality projects. Finally, rubrics require teachers to assess projects in a meaningful way that accurately reflects the student’s understanding of the material.

Participants shared their students produced higher quality work when they could draw different conclusions creatively.

OB#1125(2): Here is our rubric, we just followed the “at standard” column and it told us what to do to get an A.

Davis: Switching to a PBLWorks rubric has eliminated the ambiguity. In the past I would have students ask me to change a point because they didn’t agree with what I “gave” them. With this rubric I have had no arguments, it’s very clear cut.

Confident

Participants shared their students were more confident during the PBL implementation and the public product presentations. Teachers shared before PBL, students would “refuse” to stand in front of the class to give a presentation. Moreover, students “hated” when they had to answer questions aloud in class. In sharp contrast, students vied to go first when presenting their public product.

Culvert: I had two boys so excited to go first that one of them knocked over his chair standing up so quickly.

Childs: I have this one very sweet student who is on the spectrum and will not talk with any of her classmates. She always works alone and is never engaged in peer activities. She is very shy and always keeps
her head down. During our entry event I told the class that it was important to pick groups wisely and that we need to make sure “no one was left out.” I think they got the hint because nearly every group asked her to join them. She is also a fantastic drawer so many groups wanted her artist talent. Once in a group who needed and wanted her, she opened right up. She even started smiling and laughing in class. Her drawings were front and center for her group and even now after the PBL she is sitting with and talking with her group.

**Feedback Is Important**

Participants shared their students desired higher-quality feedback and this feedback influenced higher-quality work. During the fourth and fifth extended PBL professional development sessions, we discussed critique and revision, as well as engaging and coaching, and how these are forms of feedback. Ongoing formative assessment practices in PBL let students know where they are in relation to the standards and if they are on track to complete the project. Ms. Greene shared that “in the past, I haven’t been prompt in providing feedback,” explaining that, at times, she has not returned work to students for weeks.

**Wall:** I was surprised my students wanted detailed feedback, even more surprised when they used it.

**Davis:** Because PBL is a lengthy process I needed for my students to know where they are in the process and not get lost down a rabbit hole, lose time and never complete the project.
Quantitative Data Alignment

The quantitative data is consistent with the qualitative data, in that clear assessments led to higher quality public products. The Measuring 21st-Century Teaching and Learning survey results in Table 4.9 highlight the indicators relevant to Theme 4. The scale was as follows: 1 = almost never; 2 = a few times per semester; 3 = a few times per month; 4 = a few times per week; 5 = almost daily. The table includes pre/post-survey questions, mean, standard deviation, and paired t-test results.

Table 4.9 Measuring 21st-Century Teaching and Learning Survey – Theme 4 Data

<table>
<thead>
<tr>
<th>“In your teaching of middle school science, how often have you asked the students to do the following?”</th>
<th>Mean Pre-Survey</th>
<th>SD</th>
<th>Mean Post-Survey</th>
<th>SD</th>
<th>Paired t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collaboration Skills</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Work as a team to incorporate feedback on group tasks or products?</td>
<td>2.43</td>
<td>1.81</td>
<td>4.50</td>
<td>0.53</td>
<td>0.0113</td>
</tr>
<tr>
<td>Give Feedback to peers or assess other students work?</td>
<td>2.57</td>
<td>1.40</td>
<td>5.00</td>
<td>0.00</td>
<td>0.0037</td>
</tr>
<tr>
<td>Self-Direction Skills</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monitor their own progress toward completion of a complex task and modify their work accordingly?</td>
<td>3.14</td>
<td>1.57</td>
<td>5.00</td>
<td>0.00</td>
<td>0.0205</td>
</tr>
<tr>
<td>Use specific criteria to assess the quality of their work before it is completed?</td>
<td>2.71</td>
<td>1.38</td>
<td>4.67</td>
<td>0.49</td>
<td>0.0096</td>
</tr>
<tr>
<td>Use peer, teacher or expert feedback to revise their work?</td>
<td>3.00</td>
<td>1.29</td>
<td>4.50</td>
<td>0.79</td>
<td>0.0248</td>
</tr>
</tbody>
</table>
The quantitative survey data indicates clear assessment leads to higher-quality public products. The Measuring 21st-Century Teaching and Learning Survey data show students demonstrated higher frequency in the following skills:

- Working as a team to incorporate feedback on group tasks or products;
- Giving feedback to peers or assessing other students’ work;
- Monitoring their progress toward completion of a complex task and modifying their work accordingly;
- Using specific criteria to assess the quality of their work before it is completed; and
- Using peer, teacher, or expert feedback to revise their work.

These skills are essential for successful PBL as they ensure students can collaborate, give and receive constructive feedback, self-evaluate their work, and make necessary revisions to improve their final product’s quality. The data suggest providing clear assessments, with specific criteria and opportunities for feedback, is crucial for improving the quality of the students’ public products. Giving students feedback from peers, teachers, or experts to revise their work before they complete a project leads to a higher quality final product.

The Descriptive Statistics for Teacher Opinions on PBL and Professional Development survey results in Table 4.10 highlight the indicators relevant to Theme 4. The scale was as follows: 1 = not really; 5 = to a very great extent. The table includes pre/post-survey questions, mean, standard deviation, and paired t-test results.
Table 4.10 Descriptive Statistics for Teacher Opinions on PBL and Professional Development – Theme 4 Data

<table>
<thead>
<tr>
<th>Pre-Survey Question</th>
<th>Post-Survey Question</th>
<th>Mean Pre-Survey</th>
<th>SD</th>
<th>Mean Post-Survey</th>
<th>SD</th>
<th>Paired t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Has information from past professional development impacted the success and the academic growth of your students?</td>
<td>Do the feel this extended PBL professional development impacted the success and the academic growth of your students?</td>
<td>3.00</td>
<td>1.00</td>
<td>5.00</td>
<td>0.00</td>
<td>0.0111</td>
</tr>
</tbody>
</table>

The Teacher Opinions on PBL and Professional Development survey data suggests the extended PBL professional development directly impacted the “success and academic growth of the students.” The data supports the idea that when teachers provide students with clear and specific assessment criteria, the quality of their work will improve.
CHAPTER FIVE: DISCUSSION, IMPLICATIONS, AND LIMITATIONS

This chapter contextualizes my research findings with existing literature on teacher professional development, the impact of PBL on students’ 21st-century skills, and science teachers’ self-efficacy. The purpose for this MMAR study was to implement an extended PBL professional development series and (a) explore whether teachers’ attitudes toward in-district professional development changed, (b) explore teachers’ perceptions of students 21st-century skills, and (c) explore if extended PBL professional development impacts science teacher self-efficacy. I gathered and examined both quantitative and qualitative data. I describe here the (a) discussion, (b) implications, and (c) limitations of this study.

Discussion

These findings’ significance becomes apparent in context with broader research on teacher professional development, the effects of PBL on 21st-century skills in students, and science teacher self-efficacy. To address the research questions, I reviewed the collected data and compared it to prior literature. The study aimed to investigate the effects of extended PBL professional development on (a) middle school science teachers’ attitude toward in-district professional development, (b) teacher perception of 21st-century skills in students, and (c) self-efficacy in middle school science teachers.
RQ1: How do middle school science teachers’ attitudes toward in-district professional development change, if at all, after participating in an extended PBL-focused professional development series?

Research suggests effective teacher professional development should be sustained, involve hands-on applications of the content, apply to teachers’ daily academic responsibilities, and involve group participation and collaboration (Darling-Hammond et al., 2017; Darling-Hammond & McLaughlin, 2011; Shernoff et al., 2017). However, most teachers attend ineffective professional development sessions (Darling-Hammond et al., 2009). These sessions are typically short, lack hands-on application, are not directly applicable to teachers’ daily academic responsibilities, and involve minimal group participation or collaboration (Darling-Hammond & McLaughlin, 2011). Thus, in this MMAR study, I felt it was important to explore changes that occurred in middle school science teachers’ attitudes toward in-district professional development after they participated in an extended PBL-focused professional development.

My use of PBL was intentional, as research supports a shift toward PD that aligns with the characteristics of PBL, such as providing opportunities for inquiry and reflection, collaboration, connections to real-world work, and participant-driven learning (Attebury, 2017; Shernoff et al., 2017). In recent years, PBL has become an increasingly popular teaching method in middle school science classrooms (Condliffe, 2017). However, for many teachers, PBL can be challenging to implement without proper professional development (Salinitri et al., 2015; Walton, 2014). Research also suggests many professional development sessions fail to support the transfer of knowledge into actual classroom practice (Hung, 2011; Tamim & Grant, 2013; Nariman & Chrispeels,
2016) and do not incorporate best strategies for supporting teachers or provide the long-term training required for PBL to succeed in the classroom (Brion, 2020).

For this MMAR study, I chose to collect quantitative data on teacher attitudes toward in-district professional development, which I measured using the Teacher Opinions on PBL and Professional Development survey. Results showed teachers who attended the extended PBL professional development felt more comfortable implementing PBL in their classrooms after the series than before attending. The pre-survey response was (M = 2.60), whereas the post-survey response was (M = 4.8) with a variance of (p = 0.0295). Furthermore, the results indicated teachers felt their past professional development experiences offered less benefit to their content area (M = 2.20) than the extended PBL professional development, which was beneficial “to a very great extent” to all respondents (M = 5.0). This increase was statistically significant (p = 0.0086). Additionally, the question on professional development’s impact on student success and academic growth demonstrated statistically significant variance in the pre/post-survey results. The pre-survey results were mid-range (M = 3.0), while the post-survey results were beneficial “to a very great extent” beneficial to all respondents (M = 5.0). A paired t-test score of (p = 0.0111) validated this response shift. However, the question about whether professional development would lead to changes in their teaching practices needed more statistical significance (p = 0.187). While the mean shifted from (M = 3.20) to (M = 4.40), the variance was too insignificant to determine if the extended PBL professional development would lead to long-term changes in teacher practice.

The qualitative data I collected during this study deepens the discussion on how teachers’ attitudes toward in-district professional development changed after participating
in the extended PBL professional development session. Teachers in this MMAR study reported feeling empowered to design and implement a PBL when they received extended support beyond the professional development time. Teacher reflection journals and research notes outlined the increased level of support teachers needed to feel prepared and confident in their PBL, along with their positive affirmations about having extended professional development to support them. Early in the study, it became clear that the allotted bi-weekly 50-minute CoP time would not allow for the level of support teachers needed to feel confident in planning their PBL lessons. Fortunately, I could accommodate meeting with teachers outside of the extended PBL professional development meeting times. My flexibility allowed me to meet with teachers in pairs or individually during their planning periods. To offer the maximum support, I made myself available in person, by phone, email, or zoom. I met with five out of the seven teachers on 16 separate occasions.

**Importance of Building PBL Culture**

The PBL professional development series, conducted in the same format as the district-initiated CoP’s, was critical in facilitating collaboration among participating teachers and establishing a PBL culture. Drawing upon the social constructivist framework (Vygotsky & Cole, 1978), each session was deliberately designed with the following components: (a) a stimulating and captivating pre-activity, (b) an authentic activity for small group or partner work that directly correlated with each participant's specific lesson, (c) multiple scaffolding strategies to sustain an interactive learning environment, and (d) a designated time for both group and personal reflection (Akpan et al., 2020; Brophy, 2002; Stewart, 2014). The study’s design also aligns with Dole et al.
suggestions that PBL requires support and guidance in designing, implementing, and assessing student projects. To be successful facilitators of PBL, teachers must receive adequate (a) professional development, (b) mentoring, and (c) collaboration with other educators who are implementing PBL in the classroom (Darling-Hammond et al., 2017).

Brand and Moore (2011) highlighted the importance of collaboration among teachers, facilitators, and administrators in all aspects of teaching and learning. Darling-Hammond et al. (2017) recommended that PD include opportunities for teachers to work together, collaborate in meaningful discussions and problem-solving, and develop a collective vision of quality instruction. Guskey (2017) also emphasized the importance of a collective vision that allows teachers to discuss and reflect on their practice in a supportive environment.

Smith (2001) notes that when stakeholders show investment in and support for teachers, it motivates them to participate in a shared learning experience. During the MMAR study, participants reported the additional support they received alongside the extended PBL professional development allowed them to build a classroom culture reinforcing PBL activities. However, some participating teachers raised concerns, with one teacher asking, “How do I explain to administrators what I am doing? Because if they walk in and it looks like chaos and it kind of is chaos, they are not going to understand.”

Stakeholder support is vital to the success of PBL professional development. When teachers have the support of administrators, school boards, district personnel, and other stakeholders, they are more likely to take risks, try new teaching strategies, and reflect on their practice (Garet et al., 2001). When stakeholders show they are invested in and care about supporting teachers, it motivates teachers to join in a shared learning
experience (Smith, 2001). During one PBL observation, this concept played out in real time when an assistant principal (AP) dropped in for a formal observation. The AP stayed in the room far longer than I expected and began talking with the students. One group took his interest, and he began questioning what they were doing. When the student quickly explained the project and the expected outcomes, he brainstormed with them.

After the observation, I spoke to the AP about his impression of the class, and he admitted that, at first, he was confused and “concerned” about what he saw. I took that opportunity to share with him what PBL was and why the teacher was implementing it, and his concern changed to admiration. Once I shared what we were doing, he made the connection and instantly was relieved and impressed with what he saw in the classroom.

According to research by Heck et al. (2008) and Johnson (2007), principal support and leadership are critical factors in successfully implementing PBL in middle school science classrooms. They found that when principals were involved actively in planning and implementing PBL, teachers were more likely to feel supported and had greater success in implementing PBL in their classrooms.

Another study by Bell et al. (2009) found that principal support and leadership were associated positively with teacher buy-in and implementation of PBL in middle school science classrooms. They found that when principals provided teachers with professional development opportunities, resources, and planning time, teachers were more likely to implement PBL successfully in their classrooms.

**Time Management**

Supporting teachers with time management strategies is essential when creating extended PBL professional development. Participants in a PBL professional development...
series stated time management and collaboration are essential to implementing PBL successfully. The topics of time management or time constraints came up in 100% of the sessions for this MMAR study. Before and after implementation, teachers felt that PBL requires “lots of planning” and is a “huge and exhausting process.” Ms. Childs pointed out, “trying to find time and comprehensively plan” for the PBL process is “not easy,” and one must be “flexible.” Another teacher, who had missed a session and was behind, reported feeling “overwhelmed” by the PBL planning process.

Research suggests providing teachers with ongoing support and feedback is essential for successfully implementing PBL. Simons et al. (2004) found that giving teachers more time to prepare for PBL allows them to develop creative and effective projects. Ertmer and Simons (2006) and Nariman and Chrispeels (2016) found educators often need more time or freedom to adopt the PBL approach due to pressures from standardized testing, demanding grade-level standards, and other accountability measures. Farrow et al. (2022) determined that participating teachers found their planning process became more intentional and complex as they layered multiple standards into PBL, in contrast to the more singularly focused lesson plans they used in the past.

During the extended PBL professional development series, several teachers expressed concern that creating and implementing a PBL lesson would take time away from teaching state standards. According to Bae et al. (2021), the emphasis on high-stakes testing has caused many districts to mandate particular curricula and establish strict pacing guides (Dole et al., 2016), which can make it difficult for teachers to balance teaching required standards with involving students in PBL (Hung, 2011). This is particularly true for those who have never seen or experienced PBL before and may not
be sure where to begin when planning their own PBL units (Tamim & Grant, 2013). The three sixth-grade teachers who participated in my study were concerned particularly about having enough time to cover their standards for this very reason, as they are the only middle school grade level participating in mandatory state science testing.

As the professional development sessions progressed, participating teachers found their planning process became more intentional and complex as they layered multiple standards into the PBL, in contrast to the more singularly focused lesson plans they may have used in the past. Ms. Childs shared using PBL “made students more engaged and more likely to retain the information,” indicating she felt PBL increased student mastery and retention of the standards covered during the project. These results parallel the findings of Mehalik et al. (2008), who determined the use of project-based programs for middle school students improved science achievement, student engagement, and retention of science concepts.

**Support during Implementation**

Implementing PBL can pose a challenge for teachers. Extended and supportive professional development is crucial for teachers to utilize PBL effectively in their teaching, as it enables them to gain the necessary skills and understanding, as the National Research Council (2012), Salinitri et al. (2015), and Walton (2014) have all noted. Teachers also need access to a variety of resources, such as online databases and support groups, that can help them stay informed and succeed in PBL (Bae et al., 2021). Farrow et al. (2022) found that PBL often requires more skills and resources to implement successfully; thus, teachers need and must receive more resources, guidance, and training to help them design and facilitate effective PBL units.
Participants in the MMAR study’s extended PBL professional development reported receiving ongoing support during implementation was a positive experience. Mrs. Childs wrote, “Thanks again for your guidance and support throughout this PBL process. I truly believe we took a project that we already did and refined it to make it more authentic for our students.” Tamim and Grant (2013) confirm this finding, having determined PBL requires extensive guidance to help teachers successfully implement PBL in their classrooms. Mrs. Williams wrote, “Our wheels are already turning as to what we can do for our next PBL.” Mrs. Wall noted,

I would never have made it through this PBL without your support. You were always available whenever I was having a meltdown. I would have just quit if I hadn’t had your help. PS My students can't stop talking about when we will do another PBL!!! (Wall)

RQ2: To what extent, if any, do middle school science teachers’ perceptions of students’ use of 21st-century skills in the classroom change when they implement PBL in their instruction?

Current research suggests that 21st-century skills—in particular, of critical thinking, creativity, problem-solving, communication, and collaboration—are necessary for educational and career success in the 21st century (Pellegrino & Hilton, 2012). These skills can coalesce into cognitive, intrapersonal, and interpersonal domains (Pellegrino & Hilton, 2012). The National Research Council (2009) also has emphasized the need for science instruction to mirror real-world investigative practices to prepare students for future global challenges.
PBL is an instructional approach that starts with an ill-structured real-world project that students actively must solve (Merritt et al., 2017; Bae et al., 2021). An ill-structured problem is an open-ended problem with more than one clear solution (Bae et al., 2021). These projects require students to collaborate, communicate, and consider multiple perspectives to support a reasonable and creative solution (Bae et al., 2021).

For this MMAR study, it was appropriate to offer extended professional development in PBL to support our students’ 21st-century skills. PBL has been proven consistently to improve 21st-century skills, providing students with the problem-solving, collaboration, critical thinking, and creativity skills necessary for future careers (Ertmer & Simons, 2006; Nariman & Chrispeels, 2016; Ravitz et al., 2012).

The MMAR extended PBL professional development study findings indicate PBL effectively increases the frequency teachers perceive students using 21st-century skills in the classroom. Each participating teacher completed a pre/post-survey using the Measuring 21st-Century Teaching and Learning survey with 23 questions about how frequently they observed students using specific 21st-century skills. All seven teachers reported an increase in how often their students used 21st-century skills in their classrooms. On the pre-survey, the overall mean score for the Measuring 21st-Century Teaching and Learning survey found that, on average, teachers asked students to use 21st-century skills “a few times per month” or less (M = 2.68). However, while implementing PBL, the mean across skill sets increased to “almost daily” (M = 4.63) on the post-survey. A paired t-test (p = 0.0000018) showed statistical significance between the pre- and post-responses, providing evidence for the effectiveness of extended PBL professional development.
In the MMAR study, seven out of seven participating teachers reported in the Teacher Opinions on PBL and Professional Development post-survey that they felt this extended PBL professional development impacted their students’ success and academic growth “to a very great extent.” Another area with a significant variance in the pre/post-survey results was the question about professional development’s impact on student success and academic growth. The pre-survey results were mid-range \((M = 3.0)\), while the post-survey results were beneficial “to a very great extent” to all respondents \((M = 5.0)\). A paired t-test score of \((p = 0.0111)\) validated this response shift. These results parallel the findings of prior research who determined project-based learning directly contributes to increased academic achievement (Chen & Yang, 2019; Balemen & Özer Keskin, 2018).

During PBL implementation, the teachers observed shifts in their students’ behaviors. They shared students were “becoming active participants in their own learning” and fully engaged with the PBL inquiry process. Teacher journal reflection entries noted that, starting with the entry event, students became more “talkative” and “attentive” and began expressing “genuine” interest. Students began taking initiative in the following ways: (a) seeking ways to do more research, (b) bringing in items from home, (c) suggesting ideas, and (d) “productively” collaborating with their peers.

Teachers expressed the belief that providing students with a choice and a voice in their learning process led to an increase in the use of 21st-century skills. The teachers noted increased social interaction as the students collaborated with their peers to (a) brainstorm, (b) provide feedback, and (c) problem-solve. Teachers also reported their
students appeared to be highly motivated when completing a project of their choosing. It challenged them to be critical thinkers open to failure, changes, and creativity.

**RQ3: How do middle school science teachers’ self-efficacy levels change, if at all, after participating in an extended PBL-focused professional development series?**

Research suggests teachers with a higher sense of self-efficacy tend to be organized, open to innovative ideas such as PBL, have a greater capacity for dealing with disciplinary disruptions, and are less likely to exhibit signs of stress (Allinder, 1994; Jerald, 2007; Jerusalem & Mittag, 1995; Witt-Rose, 2003; Tschannen-Moran & McMaster, 2009). Studies also suggest positive teacher self-efficacy can increase teachers’ willingness to try new skills and techniques they have learned during professional development in their classroom setting (Eden & Kinnar, 1991).

Evidence from prior research suggests teachers who take part in professional development programs that provide ongoing support and opportunities for reflection have higher levels of self-efficacy than those who do not do so (Darling-Hammond et al., 2017; Overbaugh & Lu, 2008; Mouza & Barrett-Greenly, 2015). Allinder (1994), Guskey (1988), and Stein and Wang (1988) suggested increased teacher self-efficacy correlates to exploring new teaching methods, taking risks, and trying new instructional techniques.

Prior studies suggest teachers' beliefs are crucial in shaping students' academic performance. Several studies have demonstrated that teachers who believe they can directly impact student learning and engagement are more likely to positively affect students' academic outcomes (Allinder, 1994; Capraro et al., 2016; Witt-Ross, 2003). These findings underscore the importance of cultivating positive teacher beliefs and attitudes to enhance students' academic achievement. As Takahashi (2011) stated,
“teachers’ efficacy beliefs are critical to improving student learning” (p. 212).

Conversely, low self-efficacy can impact teachers negatively, leading to lower student engagement and academic performance, which can lower teacher self-efficacy further (Bandura, 1997; Capraro et al., 2016; Hoy & Davis, 2006).

Effective professional development should focus on content knowledge, active learning, active participation, extended duration, collaboration, and consistency to influence teacher self-efficacy and increase student academic outcomes. However, the MMAR study I conducted found that the self-efficacy of participating middle school science teaching remained the same. The pre-survey overall PSTE mean was \( M = 4.35 \), the post-survey mean was \( M = 4.45 \), and the paired t-test for statistical significance was \( p = 0.6531 \), which is greater than the threshold of .05. These findings imply there were no meaningful changes in science teacher self-efficacy during the MMAR study. These findings do indicate the seven participating teachers already had a high sense of teacher self-efficacy, which I will discuss in greater detail. Drawing from the Science Teacher Efficacy Belief Instrument, Table 5.1 presents 5 of the 25 questions that merit further discussion. The scale was as follows: 1 = strongly agree; 2 = agree; 3 = uncertain; 4 = disagree; 5 = strongly disagree.
Table 5.1 Science Teacher Efficacy Belief Instrument – RQ3 Discussion

<table>
<thead>
<tr>
<th>“Indicate the degree to which you agree or disagree with each statement below.”</th>
<th>Mean Pre-Survey</th>
<th>SD</th>
<th>Mean Post-Survey</th>
<th>SD</th>
<th>Paired t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am continually finding better ways to teach science.</td>
<td>1.43</td>
<td>0.53</td>
<td>1.00</td>
<td>0.00</td>
<td>0.0781</td>
</tr>
<tr>
<td>When the science grades of students improve, it is most often due to their teacher having found a more effective teaching approach.</td>
<td>2.14</td>
<td>0.53</td>
<td>1.29</td>
<td>0.49</td>
<td>0.0453</td>
</tr>
<tr>
<td>If students are underachieving in science, it is most likely due to ineffective science teaching.</td>
<td>3.57</td>
<td>1.51</td>
<td>3.43</td>
<td>0.53</td>
<td>0.7882</td>
</tr>
<tr>
<td>The inadequacy of a student’s science background can be overcome by good teaching.</td>
<td>1.57</td>
<td>0.79</td>
<td>1.00</td>
<td>0.00</td>
<td>0.1030</td>
</tr>
<tr>
<td>The teacher is generally responsible for the achievement of students in science.</td>
<td>1.86</td>
<td>0.38</td>
<td>2.43</td>
<td>0.53</td>
<td>0.0006</td>
</tr>
<tr>
<td>Students’ achievement in science is directly related to their teacher’s effectiveness in science teaching.</td>
<td>1.86</td>
<td>0.38</td>
<td>1.71</td>
<td>0.49</td>
<td>0.6036</td>
</tr>
</tbody>
</table>

As study participants reported high levels of teacher self-efficacy on the pre-survey, I was unsurprised the overall results on the post-survey indicated little change had occurred. However, in my data analysis of the Science Teacher Efficacy Belief Instrument, six of the survey responses were of interest, and I discuss them further here.

**Statistically Significant Findings**

The following two survey questions indicated positive changes in science teacher outcome expectancy with statistical significance. First, the teachers indicated by a pre-survey mean of (M = 2.14) that they “agree” utilizing more effective teaching approaches...
influenced student grades in science, while their post-survey mean response (M = 1.29) indicated they “strongly agree” that more effective teaching strategies influence student grades in science. This finding suggests the teachers may have learned new and more effective teaching strategies during the extended PBL professional development and used them during their PBL implementation. Research supports the findings that PBL teaching strategies can lead to improved student understanding of science concepts, increased student engagement, and motivation, and higher achievement on science assessments (Barkley et al., 2014; Hmelo-Silver et al., 2007). Additionally, studies have found PBL to support the acquisition of 21st-century skills such as problem-solving, critical thinking, and creativity (Barkley et al., 2014; Hmelo-Silver et al., 2007).

Second, the pre-survey indicated that teachers felt “uncertain” by a mean of (M = 2.43) about the statement that teachers are generally responsible for students’ science achievements. The post-survey indicated their belief had changed, and they now “agreed” (M = 1.86) with that statement. This finding suggests teachers felt an even greater sense of direct responsibility for their students’ academic growth after implementing a PBL lesson. Prior research supports the finding that teachers play a significant role in students’ science achievement correlates with this shift in teachers' opinion (Penuel et al., 2007). Studies have found effective teaching practices, such as PBL, can improve student understanding and science performance (Alemdar et al., 2018; Lavonen et al., 2017). According to Guskey (2017), teachers may need to witness a change in student learning before they are willing to modify their own pedagogical beliefs. In a recent study, teachers reported observing the positive effects of problem-based learning (PBL) on their students and were able to recognize the difference this teaching method made. As
reflected in the STEBI responses, the post-survey results indicated a shift in the teachers' outcome expectancies. These findings suggest that experiencing positive outcomes with new teaching approaches, like PBL, can encourage teachers to adopt more student-centered and effective instructional practices. Additionally, research has shown that effective teachers provide more opportunities for student engagement, collaboration, and scaffolding (Darling-Hammond et al., 2017; Inan & Lowther, 2010).

**Significant Findings**

First, the teachers indicated by a pre-survey mean of (M = 1.43) they “agree” they continually were finding better ways to teach science, while their post-survey mean response (M = 1.00) indicated they “strongly agree” that more effective teaching strategies influence student grades in science. This finding suggests that the teachers unanimously believe they are continually seeking new ways to teach middle school science more effectively. Research has indicated teachers demonstrating high self-efficacy are more likely to seek professional development opportunities, try new teaching methods, and continuously reflect on their practices to improve their teaching (Tschannen-Moran & McMaster, 2009). Furthermore, teachers who engage in continuous professional development and reflect on their practice are more likely to improve their teaching and student learning (Henderson & Mapp, 2002; Darling-Hammond et al., 2009).

Second, the pre-survey indicated teachers “agree” by a mean of (M = 1.57) with the statement that good teaching can overcome a student’s inadequate science background. The post-survey indicated their belief had changed, and they “strongly agreed” (M = 1.00) with this statement. Research has indicated teachers can make up for
prior deficits in science education by offering high-quality and rigorous PBL instruction, leading to more noteworthy academic achievement (Chen & Yang, 2019). Other studies suggest students attain higher academic growth when their teacher utilizes and is knowledgeable about PBL instructional design (Capraro et al., 2016; Han et al., 2015).

**Non-Significant Findings**

For this MMAR study, I collected quantitative data on teacher self-efficacy and outcome expectancy, which I measured using the STEBI. PSTE and STOE are important constructs impacting teaching practices and student academic outcomes. The STEBI results were overwhelmingly non-significant, with ten of the thirteen (77%) PSTE questions yielding no significance and eight (67%) of the STOE yielding no significance.

These findings indicated no prevailing changes during the MMAR study impacting PSTE or STOE. The sub-scores translated into a pre-survey overall mean for the PSTE was \( M = 4.35 \), the post-survey mean was \( M = 4.45 \), and the paired t-test for statistical significance was \( p = 0.2835 \), greater than the stated threshold of a \( p\)-value of less than .05 for reliability. The STOE pre-survey had an overall mean of \( M = 3.68 \), the post-survey mean was \( M = 3.86 \), and a paired t-test value of \( p = 0.5568 \), also greater than the stated threshold.

These findings indicate that the participating teachers began the extended PBL professional development series with a high level of PSTE and STOE. Therefore, it is unsurprising that the results showed little change throughout the study. Additionally, research has shown that teacher self-efficacy and outcome expectancy are interrelated and can have a reciprocal effect on one another (Tschannen-Moran & Hoy, 2007). Teachers with high self-efficacy tend to have higher outcome expectancies, believing
they have the skills and resources necessary to achieve positive student outcomes (Bandura, 1997; Capraro et al., 2016).

The following two survey questions indicated uncorrelated findings in science teacher outcome expectancy. First, the teachers indicated by a pre-survey mean of (M = 3.57) that they were “uncertain” if students were underachieving in science due to ineffective science teaching. The participant post-survey mean response of (M = 3.43) indicated they continued to feel “uncertain” about whether more effective teaching strategies influence student achievement in science. This finding suggests teachers need to be more reflective about whether ineffective teaching practices play a role in their student’s lack of academic achievement. It is common for teachers to report feeling uncertain about why students may be underachieving in science. As studies often cite ineffective science teaching as a possible cause for underachievement (Bender et al., 2015; Penuel et al., 2015), this survey result does not surprise me.

Second, in seeming opposition to the above survey item, the pre-survey indicated teachers “agree” by a mean of (M = 1.86) with the statement that students’ achievement in science relates directly to their teacher’s effectiveness in science teaching. The post-survey indicated that their belief had not slightly changed, as the teachers again reported they “agreed” (M = 1.71) with this statement. Research supports this belief, having demonstrated a strong correlation between teachers’ instructional practices and students’ academic performance in science (Darling-Hammond et al., 2009).

**Implications**

This research has implications for me as a member of the district’s curriculum and instruction team and for other scholarly practitioners and researchers interested in
exploring extended PBL professional development and its role in student acquisition of 21st-century skills. I consider three types of implications here: (a) personal implications, (b) implications for extended professional development, and (c) implications for future research.

**Personal Implications**

Carrying out this action research study has influenced my comprehension and appreciation of the research process significantly. It has enhanced my knowledge about designing professional development, research design, data collection, and data analysis. Additionally, the MMAR study emphasized the significance of fostering a culture of trust, collaboration, and continued support when implementing extended PBL professional development. The findings showed that teachers who attended the extended PBL professional development felt more comfortable implementing PBL in their classrooms knowing they had a supportive CoP. Teachers also reported feeling empowered to design and implement PBL lessons when they received extended support beyond the professional development time. A study by Deng et al. (2017) found that, after participating in a PBL professional development program, teachers reported both an increased ability to design and implement PBL and an improved understanding of PBL’s principles and benefits.

Research on PBL professional development suggests successfully implementing PBL can increase teacher knowledge, skills, and confidence in using PBL as an instructional approach (Darling-Hammond et al., 2017). Alongside the teachers’ increased confidence, I also experienced increased job satisfaction and a sense of empowerment as they took ownership and pride in their success when implementing their
PBL lessons. Research on professional development and PBL suggests that leading a successful extended PBL professional development program may have positive personal implications for the leader. According to Marks (2000), who conducted a study of professional development leaders, those who led successful programs reported a sense of accomplishment and satisfaction, increased confidence in their ability to lead and facilitate professional development, and potential opportunities for further professional development or leadership roles. I found this to be true for me personally as my self-efficacy has risen in relationship to how confident I feel in providing effective and well received extended PBL professional development.

The extended PBL professional development’s success and the increases I noted in teachers’ perceptions of students’ use of 21st-century skills may lead to improved student outcomes. Encouraging teachers to create PBL lessons that improve student academic outcomes is a personal goal for me as a district instructional leader; moreover, it may impact Green Mountain School District positively as a whole. Additionally, the middle school science teachers’ attitudes toward in-district professional development and perceptions of 21st-century skills in students both increased, adding even more support to continue examining how best to implement extended PBL professional development. These findings prescribe the need for future research into extended PBL professional development for Green Mountain School District and within the larger context of effective professional development.

**Implications for Extended Professional Development**

The MMAR study’s findings indicated teachers who attended the extended PBL professional development were more likely to implement the new teaching strategy being
shared. PBL requires support and guidance in designing, implementing, and assessing student projects. To achieve this, teachers must receive adequate support and guidance, including professional development, mentoring, and collaboration with other educators (Dole et al., 2016). According to Hajan (2019) and Brion (2020), for teachers to implement PBL effectively in the classroom, they must be equipped with the necessary skills, receive sufficient training time, and have ongoing support.

Districts such as Green Mountain should provide teachers with both the necessary resources for implementing PBL and the autonomy to design their units (Hung, 2011). Some examples of these resources include (a) dedicated time to plan (Mitchell et al., 2009), (b) ample resources (Tamim & Grant, 2013), (c) collaborative learning environments (Garet et al., 2001), and (d) support from administrators (Brand & Moore, 2011). Simons et al. (2004) also suggested that to implement PBL effectively, teachers need professional development, dedicated planning time, and access to a wide variety of resources.

**Time**

Participants in the extended PBL professional development series shared that having dedicated time to plan and collaborate was essential for implementing their units successfully. Giving teachers more time to plan and prepare for PBL allows them to develop creative and effective student projects (Simons et al., 2004). Ertmer and Simons (2006) and Nariman and Chrispeels (2016) found that educators often need more time or freedom to adopt the PBL approach due to pressures from standardized testing, demanding grade-level standards, and other accountability measures. Farrow et al. (2022) determined that teachers found their planning process became more intentional and
complex as they layered multiple standards into PBL, in contrast to the more singularly focused lesson plans they used in the past. Future extended PBL professional development sessions in Green Mountain School District need to consider the best way to plan dedicated time for participants to learn about the PBL process, plan for implementation, and have ongoing support. Based on the results of this study, it is my suggestion that a yearlong PBL professional development program, with weekly meetings scheduled during the teacher's CoP's, may be a more effective model for replication. In addition, having a professional development facilitator who can offer flexible support outside of regular meetings would likely enhance implementation success.

**Resources**

Participants in the extended PBL professional development series shared that having access to ample resources and a professional developer with knowledge of PBL lesson planning was crucial for implementing their units. Nariman and Chrispeels (2016) found that even when teachers are enthusiastic about PBL, they often need more skills and resources to implement it successfully in their classrooms. Farrow et al. (2022) also mentioned people interested in using PBL often lack the skills and resources to do so successfully, and teachers need more resources, guidance, and training to help them design and facilitate effective PBL units. Providing teachers with access to resources such as online databases and support groups also can help them stay informed and succeed in using PBL (Bae et al., 2021). Thus, facilitators of future extended PBL professional development sessions in Green Mountain School District need to consider the best way to provide digital and physical resources for participants. The findings from
this study suggest that creating a shared virtual platform that provides access to videos, online support tools, and best practices would be a valuable resource for teachers implementing PBL. Furthermore, to ensure that all students have access to necessary materials, a fiscal budget is recommended to accompany future extended PBL professional development programs. In the present study, teachers relied on families to provide supplies, resulting in some student groups having better quality materials than others, potentially negatively impacting the learning experience.

**Communities of Practice**

Participants in the extended PBL professional development series shared that receiving ongoing support during implementation was a positive experience and vital for their success. PBL requires extensive guidance and support to implement successfully, and teachers must receive adequate training, resources, and support to facilitate PBL effectively (Tamim & Grant, 2013). PBL also requires participant buy-in. Teachers must be involved in the professional development visioning process. This is why I held the extended PBL professional development in the same format as the district-initiated CoPs. Selecting a format with which the teachers were familiar was essential for aiding collaboration among the participants. Also, allowing teachers to be involved in designing PD can encourage ownership of the process and create a culture of trust and collaboration (Garet et al., 2001). Darling-Hammond (2017) recommended that PD include opportunities for teachers to work together, collaborate in meaningful discussions and problem-solving, and develop a collective vision of quality instruction. Guskey (2017) also emphasized the importance of a collective vision that allows teachers to discuss and reflect on their practice in a supportive environment. Thus, facilitators of future extended
PBL professional development sessions in Green Mountain School District must consider sustainable ways for teachers to work within PBL-focused CoPs. Based on the findings of this study, here are some suggested ways to achieve sustainability with PBL-focused CoPs:

1. Build the culture: Encourage collaboration among teachers, administrators, and coaches to promote and celebrate PBL-focused CoPs.
2. Build a professional development team: Develop a team committed to PBL-focused CoPs with the skills and expertise to support its implementation.
3. Evaluate and inspect: Regularly evaluate and observe the teachers who participate in the PBL-focused CoPs. Be ready to make necessary adjustments to ensure sustainability, including gathering stakeholder feedback and using data to inform next steps.

**Administrative Support**

Participants in the extended PBL professional development series shared their concerns that building administrators were not part of the PBL process. This lack of awareness could cause problems with implementation if not addressed. District and school-level administrators should be trained in PBL so school leaders can provide teachers with the appropriate feedback and support needed for success.

The support of stakeholders, such as administrators and school boards, is vital to the success of PBL professional development. When teachers have stakeholders’ support, they are more likely to take risks, try new strategies, and reflect on their practices. When stakeholders show they are invested in and care about supporting teachers, it motivates teachers to join in a shared learning experience (Garet et al., 2001; Smith, 2001).
According to a study by Bell et al. (2009), principal support and leadership were associated positively with teacher buy-in and implementation of PBL in middle school science classrooms. They found when principals provided teachers with professional development opportunities, resources, and planning time, teachers were more likely to implement PBL successfully in their classrooms. Thus, facilitators of future extended PBL professional development sessions in Green Mountain School District need to consider the best way to include principals, coaches, and other leaders in the implementation process. Based on the findings of this study, some suggested ways to include principals, coaches, and other leaders in the PBL process:

1. Provide professional development: Offer opportunities specifically designed for school administrators and coaches to help them understand the principles of PBL, its benefits, and best practices. These could include workshops, seminars, and online courses.

2. Involve school leadership in planning: Include school administrators and coaches in the planning process for PBL implementation.

3. Encourage Classroom Visits: Encourage administrators and coaches to visit PBL classrooms regularly to observe the implementation process and provide feedback to teachers.

4. Celebrate Successes: Celebrate successes and highlight the positive impact of PBL on student learning outcomes.

Implications for Future Research

The present study’s findings provide implications for future research on the potential impact of PBL on students’ development of 21st-century skills. However, the
study’s limitations, including a small sample size and a narrow focus on one subject area, suggest that replication and expansion are necessary to increase the findings’ validity and reliability.

One potential approach for replication would be to conduct the study in a single school-wide setting across multiple disciplines and involve all building administrators and coaches. A more extended study period, such as an entire school year, would allow for continued follow-up and monitoring. Future researchers also could elect to increase the study’s rigor using an experimental design, which would involve (a) random participant assignment, (b) active manipulation of the independent variable, and (c) control of extraneous variables.

In another potential approach to acquire a comprehensive perspective of PBL’s impact on students’ 21st-century skills, future research could include student-centered data collection methods, such as surveys, focus groups, and interviews. This would provide insight into how students perceive and experience PBL, which would complement the teacher perceptions this present study collected.

The findings of this study suggest that extended PBL professional development may not significantly impact middle science teacher self-efficacy levels as indicated by the STEBI results. As such, future research should explore alternative approaches for improving teacher self-efficacy when implementing PBL. For example, researchers could investigate the impact of CoPs or coaching on self-efficacy levels. Additionally, studies could explore the role of teacher feedback and reflection in enhancing self-efficacy beliefs.
Limitations

As with all research studies, this study has limitations. Although action research is a valuable method for studying and enhancing practice, in education, it also has certain drawbacks that one must consider. In this study, I carried out and explored the implementation of extended PBL professional development for middle school science teachers; however, there are areas that future research could improve.

One limitation was the researcher’s subjectivity. Practitioners conduct action research, which can lead to bias in the study’s design, data collection, and interpretation. According to Creswell (2014), the researcher’s presence may affect participant responses. Throughout this work, I acted as an insider researcher as I “collaborate[d] with other insiders as a way to research,” which “not only might have [had] a greater impact on the setting but also [had] the potential to be more democratic” (Herr & Anderson, 2015, p. 45). Given my position at the district office, however, I was mindful of the advice Herr and Anderson (2015) have given about “power relations.” Their use of this term refers to how power is distributed and exercised in a particular social context or relationship. The concept of power is central to their work, as they argue that power dynamics significantly shape social interactions and how individuals and groups relate.

According to Herr and Anderson (2015), power is not necessarily a fixed or static concept. Instead, it is a fluid and dynamic process a variety of factors, including social, cultural, and historical context, can shape. They argue power relations are not always visible or explicit; they can be subtle and unconscious, shaping how people think, feel, and act. Herr and Anderson’s (2015) work highlights the importance of understanding
and respecting the “power dynamics” that exist due to my position at the district office and taking this into account as I proceeded with my study.

Another limitation is the participant sample. It was my original intention to include all twenty middle school science teachers in the study. However, gaining 100% participation entailed making the professional development series mandatory, and I was not able to accomplish that. Instead, I presented the professional development series as voluntary, resulting in a smaller sample size, which may not be representative of all middle school science teachers in Green Mountain School District. This study’s findings are limited to the seven participating middle school science teachers. In this study, the sample size is small, and the paired t-test results are high, which could indicate the sample size is too small to detect accurately any meaningful differences or similarities among the groups being compared. I would recommend future studies have a sample size of at least 30 for a paired t-test to ensure reliable results. Creswell (2014) noted that action research typically involves small, carefully selected sample sizes, which limits the generalizability of the findings beyond the study. Therefore, readers should exercise caution when extrapolating this study’s results to other contexts.

Additionally, the participating teachers all volunteered, showing they already were interested in learning more about PBL and, therefore, may have been more invested in the project and the potential outcomes. Working with teachers from across the district or all middle school teachers within one school may have yielded different results.
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teacher professional development in the next generation science standards.


APPENDIX A: LETTER OF INVITATION TO PARTICIPATE IN RESEARCH

Dear Middle School Science Teachers:

My name is Margrett Caroline Upchurch-Ford (Caroline Ford), and I am a doctoral candidate in the Education Department at the University of South Carolina. I am conducting a research study as part of the requirements of my degree in STEM education, and I would like to invite you to participate.

I am studying the impact of extended professional development in Project-Based Learning on teacher efficacy and 21st-century student skills. If you decide to participate, you will complete two (2) surveys via Google Forms, attend seven (7) professional development sessions that will occur during your weekly TLT time, and complete six (6) 200-word reflective journal entries.

In particular, you will be asked questions about your professional development experience, your science teaching efficacy beliefs, and about teaching 21st-century skills.

Participation is confidential. Study information will be kept in a secure location at the School District’s, district office. The results of the study may be published or presented at professional meetings, but your identity will not be revealed. All survey responses and reflective journal entries are anonymous, which means that no one will know what your responses are.

During our in-person professional development sessions, others in the group will hear what you say, and it is possible that they could tell someone else. Because we will be talking in a group, I cannot promise that what you say will remain completely private, but I will ask that you and all other group members respect the privacy of everyone in the group.

You are not required to participate in this study. Your participation in this study is entirely voluntary. If you choose to participate, you may discontinue participation at any time with no penalty.

I am happy to answer any questions you have about the study. If you would like to participate, please respond to the Google Form I will provide as a follow-up to this meeting.

Thank you for your consideration,

Margrett Caroline Upchurch-Ford
Coordinator of School and Community Partnerships, Grants, and Special Projects
APPENDIX B: PROFESSIONAL DEVELOPMENT LESSON PLAN

Professional Development Session One

Objectives

• Increase awareness that content has less impact on student retention than process
• Increase 21st-Century Skills and Career Integration
• Exploring the variety of online resources available for teaching students

Process

• Pre-Session activity – Three-part Pre-Survey
  o Basic demographical information
  o Past professional development perceptions
  o Science teacher efficacy
• Icebreaker activity
• Introduction to the professional development series
• Elevate Science informational video
• Agenda
• Why is Project-Based Learning Important?
  o Table top activity on 21st-century skills
  o Gallery walk
  o Quick write activity
  o PBL lends itself to authentic assessment
• PBL promotes lifelong learning

• What is Project-Based Learning?
  o Projects and Project-Based Learning video
  o Tabletop activity on PBL case studies
  o Expert stand and share activity

• How does Project-Based Learning work?
  o Overview the PBL Gold Standards
  o Watershed Project: Overview video

• Exemplary PBL projects to review on your own
  o PBLWorks – Projects
  o Utah State University – College and Career Awareness

• Exit ticket – Survey for measuring 21st-century teaching and learning skills

Resources

• Videos
  o https://www.youtube.com/watch?v=9sAzJA8g3mk&feature=emb_imp_woyt
  o https://www.youtube.com/watch?v=dhwuQU2-g5g&t=3s
  o https://www.youtube.com/watch?v=spv7SEAQsxM&feature=emb_imp_woyt

• Images
  o https://www.aeseducation.com/blog/what-are-21st-century-skills
  o https://www.pblworks.org/what-is-pbl/gold-standard-project-design

• Websites
  o https://my.pblworks.org/projects
  o https://ccapbl.org/resources/category/plans/
Professional Development Session Two

Objectives

- Construct learning experiences by considering the link between authenticity and the expected outcome so the public product is a meaningful, integral part of the learning process
- Increase 21st-Century Skills and Career Integration
- Explore inquiry strategies to support students’ ability to comprehend inquiry at all levels, the ability to answer and ask critical questions, and the ability to engage in higher-level thinking and discussion

Process

- Pre-Session activity
  - Watch Watershed: Develop a project idea video
  - Identify specific standards to address in a PBL lesson
- Introduction to session two
  - Discuss the importance of aligning with the state standards
  - Design and plan for the PBL lesson
- Authenticity
  - Article Review – Two Groups each read one article
    - Four ways to think about authenticity – through the lens of Gold Standard PBL Videos
    - Authenticity: How to move projects from engaging to empowering
  - Tabletop activity on authenticity
  - Group Socratic seminar to discuss authenticity
• Challenging Problem or Question
  o Gold Standard PBL: Challenging Problem or Question video (6:50 – 13:50)
  o Quick write – A challenging problem or question that would be authentic for your students
  o Sit-Share-Stand
    ▪ Exit Ticket – Reflection Journal
  o Journal Prompt – How are you feeling about including authenticity into your PBL lesson plan? What resources will you need? What limitations do you feel that you have? What specifically makes a project authentic?
  o Journal Prompt – How are you feeling about starting this lesson with a challenging problem or question?

Resources

• Videos
  o https://www.youtube.com/watch?v=FmH9Docfk0Q&t=4s
  o https://www.youtube.com/watch?v=-mBhhTSWRu4&t=473s

• Articles
  o https://www.pblworks.org/blog/authenticity-how-move-projects-engaging-empowering
  o https://www.pblworks.org/blog/four-ways-think-about Authenticity through lens-gold-standard-pbl-videos

Professional Development Session Three

Objectives

• Learn the importance of student voice and choice in building an authentic lesson
• Using Backwards Mapping as a successful planning tool for project-based learning, keeping the public product as the focal point

• Explore inquiry strategies to support students’ ability to comprehend inquiry at all levels, the ability to answer and ask critical questions, and the ability to engage in higher-level thinking and discussion

• Increase students’ ability to successfully communicate their understanding of materials and ideas and to engage in probing conversations to work through ambiguity

Process

• Pre-Session activity
  o Watch Watershed: Map the project video

• Introduction to session three
  o Discuss current scaffolding techniques used in the classroom
  o Discuss how student choice and voice are currently used in the classroom

• Sustained Inquiry
  o Website review – Harvard Project Zero Toolbox
  o Tabletop activity
    ▪ Find one strategy on the website that is unfamiliar and learn about it
    ▪ Sit-Share-Stand

• Student Choice and Voice
  o Article review – Elbow Partner
    ▪ Gold Standard PBL: Student Voice and Choice
  o With elbow partner find top two take aways
o Team shares out

- Exit Ticket – Reflection Journal
  o Journal Prompt – How are you feeling about including student choice and voice into your PBL lesson plan? What concerns, if any, do you have? What limitations do you feel that you have?
  o Journal Prompt – How are you feeling about having multiple activities going on in the classroom at one time?

Resources

- Videos
  o https://www.youtube.com/watch?v=WUmJEqrhyMM&feature=emb_imp_yt

- Websites
  o http://www.pz.harvard.edu/thinking-routines

- Article
  o Gold Standard PBL: Student Voice & Choice | PBLWorks

**Professional Development Session Four**

Objectives

- Explore inquiry strategies to support students’ ability to comprehend inquiry at all levels, the ability to answer and ask critical questions, and the ability to engage in higher-level thinking and discussion

- Increase 21st-Century Skills and Career Integration

- Exploring the variety of online resources available for teaching students

Process
• Pre-Session activity
  o Watch Watershed: Manage the process

• Introduction to session four
  o Discuss current norms and culture in their classrooms
  o Discuss current management of activities

• Reflection Journal
  o Journal Prompt – Describe what a typical day in your classroom looks/sounds like. Give as much detail as you can. What are the students doing? What are you doing?

• Reflection
  o Article review – Jigsaw

• Strategy guide: Reflection
  o Review assigned section
  o Create 30 second speech
  o Share out in order of the article

• Critique and Revision
  o Build the Culture – Student voice and independence video
  o Advancement via Individual Determination strategies review

• Exit Ticket – Google form
  o What support do you need?
  o Would you like a classroom visit?

Resources

• Videos
• Project Based Teaching Practices: Build the Culture - Student Voice & Independence - YouTube

(https://www.youtube.com/watch?v=gW7YBA4rjZA&t=16s)

• Article
  o PBLWorks_Reflection_Strategy Guide_0.pdf
  o AVIDStrategies.pdf (gccisd.net)

**Professional Development Session Five**

**Objectives**

- Increase students’ ability to successfully communicate their understanding of materials and ideas and to engage in probing conversations to work through ambiguity
- Increase awareness that content has less impact on student retention than process
- Explore inquiry strategies to support students’ ability to comprehend inquiry at all levels, the ability to answer and ask critical questions, and the ability to engage in higher-level thinking and discussion

**Process**

- Pre-Session activity
  o Watch Watershed: Plan the Assessment
- Introduction to session five
  o Discuss on formative vs summative assessment
  o Discuss current strategies of coaching students
  o Discuss proposed public products
- Assess student learning
• Article review – Marking the text
  ▪ Gold Standard PBL: Assessing Student Learning
• Read the article
• Number the paragraphs
• Circle unfamiliar terms
• Highlight most important claim
• Underline key information

• Engage and coach
  o Engage and coach video
  o Reflection Journal
    ▪ Journal Prompt – Describe how you engage and coach students in your classroom. Give as much detail as you can. What are the students doing? What are you doing?
  o Growth mindset self-talk handout

• Public Product
  o Tiny House Project video

• Next Steps
  o Email your lesson plan and timeline

• Exit Ticket – Google form
  o What support do you need?
  o Would you like a classroom visit?

Resources

• Articles
- Gold Standard PBL: Assessing Student Learning | PBLWorks
  (https://www.pblworks.org/blog/gold-standard-pbl-assessing-student-learning)

- Videos
  - Tiny House Project - YouTube
    (https://www.youtube.com/watch?v=B2gBFtPEZ2Q)

- Handouts
  - Microsoft Word - Growth Mindset Self Talk.docx (unc.edu)

**Professional Development Session Six**

**Objectives**

- Construct learning experiences by considering the link between authenticity and the expected outcome so the public product is a meaningful, integral part of the learning process
- Complete PBL lesson plan

**Process**

- Asynchronous
  - Refine PBL lesson plan
  - Refine PBL timeline

- Reflection Journal – Prior to implementation
  - Journal Prompt – How are you feeling about implementing a PBL lesson?
    What aspects make you nervous? What aspects are you looking forward to too?
Journal Prompt – What are your thoughts on this extended professional development?

Professional Development Session Seven

Objectives

• Deliver inquiry-based instruction to elevate the level of rigor, critical thinking, and student engagement

• Increase students’ ability to successfully communicate their understanding of materials and ideas and to engage in probing conversations to work through ambiguity

• Construct learning experiences by considering the link between authenticity and the expected outcome so the public product is a meaningful, integral part of the learning process

• Increase 21st-Century Skills

Process

• Asynchronous
  
  o Conduct PBL lesson

• Reflection Journal – Post-implementation

  o Journal Prompt – Explain how the PBL lesson went. What went well? What went poorly? What was unexpected? Were you able to finish the lesson?

  o Journal Prompt – What are your thoughts on this extended professional development? Did this form of professional development aid or hinder your classroom practice?
- Journal Prompt – Do you think the PBL lesson was well received by the students? Give as much detail as possible.

- Post-Session activity – Four-part Post-Survey
  - Basic demographical information
  - Perception of the extended PBL professional development
  - Science teacher efficacy
  - Survey for measuring 21st-century teaching and learning skills
APPENDIX C: TEACHER SURVEY MATERIALS

Research Study Pre-Survey
Thank you for volunteering to participate in my research study. As I mentioned, participation is completely optional and all of the responses will be 100% anonymous. Thank you for providing your most honest responses to the questions that follow.

* Required

1. What grade do you teach?

   Mark only one oval.
   
   ☐ 6th
   ☐ 7th
   ☐ 8th
   ☐ 6-8

2. How many years have you been teaching? (total)

   Mark only one oval.
   
   ☐ 0-3
   ☐ 4-10
   ☐ 11-15
   ☐ 16+

3. How many years have you taught middle school science?

   Mark only one oval.
   
   ☐ 0-3
   ☐ 4-10
   ☐ 11-15
   ☐ 16+
4. How comfortable do you feel about implementing PBL in your classroom? *

*Mark only one oval.*

Not really

1

2

3

4

5

To a very great extent

**Past Professional Development Experiences**

In this section you will encounter a series of questions about your personal perception of professional development. All answers are anonymous and voluntary.
5. Have previous professional development opportunities been beneficial to you as a middle school science teacher?

*Mark only one oval.*

Not really

1

2

3

4

5

To a very great extent

6. If you marked 4 or 5 above, please share the title and location of the most beneficial professional development session you have attended.
7. Has information from professional development in the past led to changes in your teaching practice?

Mark only one oval.

Not really

1

2

3

4

5

To a very great extent

8. Has information from past professional development impacted the success and the academic growth of your students?

Mark only one oval.

Not really

1

2

3

4

5

To a very great extent
9. What do you think makes PD effective? *

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

10. What do you feel is the best way to learn about new content, programs, or initiatives? *

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

11. Based on your professional development experiences, how would you design an ideal professional development?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

12. How do you feel about your growth as a teacher based on your experience with professional development? *

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
13. Do you like attending professional development hosted by your school district? *

Mark only one oval.

☐ Yes
☐ No

Science Teaching Efficacy Belief Instrument

The following set of questions are on your individual science teaching self-efficacy. Your response are completely anonymous and you participation is appreciated.
# Science Teaching Efficacy Belief Instrument*

Please indicate the degree to which you agree or disagree with each statement below by circling the appropriate letters to the right of each statement.

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
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<tbody>
<tr>
<td>SA</td>
<td>Strongly Agree</td>
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<tr>
<td>A</td>
<td>Agree</td>
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<td>UN</td>
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<td>D</td>
<td>Disagree</td>
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<tr>
<td>SD</td>
<td>Strongly Disagree</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Statement</th>
<th>SA</th>
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<th>SD</th>
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</thead>
<tbody>
<tr>
<td>1. When a student does better than usual in science, it is often because the teacher exerted a little extra effort.</td>
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<td>2. I am continually finding better ways to teach science.</td>
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<td>3. Even when I try very hard, I don't teach science as well as I do most subjects.</td>
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<td>4. When the science grades of students improve, it is most often due to their teacher having found a more effective teaching approach.</td>
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<td>5. I know the steps necessary to teach science concepts effectively.</td>
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<td>6. I am not very effective in monitoring science experiments.</td>
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<td>7. If students are underachieving in science, it is most likely due to ineffective science teaching.</td>
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<td>8. I generally teach science ineffectively.</td>
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<td>9. The inadequacy of a student's science background can be overcome by good teaching.</td>
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<td>10. The low science achievement of some students cannot generally be blamed on their teachers.</td>
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<td>11. When a low achieving child progresses in science, it is usually due to extra attention given by the teacher.</td>
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<td>12. I understand science concepts well enough to be effective in teaching elementary science.</td>
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<td>13. Increased effort in science teaching produces little change in some students' science achievement.</td>
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<td>14. The teacher is generally responsible for the achievement of students in science.</td>
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<td>15. Students' achievement in science is directly related to their teacher's effectiveness in science teaching.</td>
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<td>16. If parents comment that their child is showing more interest in science at school, it is probably due to the performance of the child's teacher.</td>
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<td>17. I find it difficult to explain to students why science experiments work.</td>
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<td>18. I am typically able to answer students' science questions.</td>
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<td>19. I wonder if I have the necessary skills to teach science.</td>
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</tr>
<tr>
<td>20. Effectiveness in science teaching has little influence on the achievement of students with low motivation.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21. Given a choice, I would not invite the principal to evaluate my science teaching.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22. When a student has difficulty understanding a science concept, I am usually at a loss as to how to help the student understand it better.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23. When teaching science, I usually welcome student questions.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24. I don't know what to do to turn students on to science.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25. Even teachers with good science teaching abilities cannot help some kids learn science.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CRITICAL THINKING SKILLS refer to students being able to analyze complex problems, investigate questions for which there are no clear-cut answers, evaluate different points of view or sources of information, and draw appropriate conclusions based on evidence and reasoning.

1. Here are some examples of practices that may help students learn CRITICAL THINKING SKILLS.

<table>
<thead>
<tr>
<th>In your teaching of your TARGET CLASS, how often have you asked students to do the following?</th>
<th>Almost never</th>
<th>A few times a semester</th>
<th>1-3 times per month</th>
<th>1-3 times per week</th>
<th>Almost daily</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Compare information from different sources before completing a task or assignment?</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>b. Draw their own conclusions based on analysis of numbers, facts, or relevant information?</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>c. Summarize or create their own interpretation of what they have read or been taught?</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>d. Analyze competing arguments, perspectives or solutions to a problem?</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>e. Develop a persuasive argument based on supporting evidence or reasoning?</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>f. Try to solve complex problems or answer questions that have no single correct solution or answer?</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
</tbody>
</table>

2. To what extent do you agree with these statements about your TARGET CLASS?

<table>
<thead>
<tr>
<th></th>
<th>Not really</th>
<th>To a minor extent</th>
<th>To a moderate extent</th>
<th>To a great extent</th>
<th>To a very great extent</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. I have tried to develop students’ critical thinking skills</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>b. Most students have learned critical thinking skills while in my class</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>c. I have been able to effectively assess students’ critical thinking skills</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
</tbody>
</table>

COLLABORATION SKILLS refer to students being able to work together to solve problems or answer questions, to work effectively and respectfully in teams to accomplish a common goal and to assume shared responsibility for completing a task.

1. Here are some examples of practices that may help students learn COLLABORATION SKILLS.

<table>
<thead>
<tr>
<th>In your teaching of your TARGET CLASS, how often have you asked students to do the following?</th>
<th>Almost never</th>
<th>A few times a semester</th>
<th>1-3 times per month</th>
<th>1-3 times per week</th>
<th>Almost daily</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Work in pairs or small groups to complete a task together?</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>b. Work with other students to set goals and create a plan for their team?</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>c. Create joint products using contributions from each student?</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>d. Present their group work to the class, teacher or others?</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>e. Work as a team to incorporate feedback on group tasks or products?</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>f. Give feedback to peers or assess other students’ work</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
</tbody>
</table>

2. To what extent do you agree with these statements about your TARGET CLASS?

<table>
<thead>
<tr>
<th></th>
<th>Not really</th>
<th>To a minor extent</th>
<th>To a moderate extent</th>
<th>To a great extent</th>
<th>To a very great extent</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. I have tried to develop students’ collaboration skills</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>b. Most students have learned collaboration skills while in my class</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>c. I have been able to effectively assess students’ collaboration skills</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
</tbody>
</table>
COMMUNICATION SKILLS refer to students being able to organize their thoughts, data and findings and share these effectively through a variety of media, as well as orally and in writing.

1. Here are some examples of practices that may help students learn COMMUNICATION SKILLS.

<table>
<thead>
<tr>
<th>In your TARGET CLASS, how often have you asked students to do the following</th>
<th>Almost never</th>
<th>A few times a semester</th>
<th>1-3 times per month</th>
<th>1-3 times per week</th>
<th>Almost daily</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Structure data for use in written products or oral presentations (e.g., creating charts, tables or graphs)?</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>b. Convey their ideas using media other than a written paper (e.g., posters, video, blogs, etc.)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>c. Prepare and deliver an oral presentation to the teacher or others?</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>d. Answer questions in front of an audience?</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>e. Decide how they will present their work or demonstrate their learning?</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

2. To what extent do you agree with these statements about your TARGET CLASS?

<table>
<thead>
<tr>
<th>To what extent do you agree with these statements about your TARGET CLASS?</th>
<th>Not really</th>
<th>To a minor extent</th>
<th>To a moderate extent</th>
<th>To a great extent</th>
<th>To a very great extent</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. I have tried to develop students' communication skills</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>b. Most students have learned communication skills while in my class</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>c. I have been able to effectively assess students' communication skills</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

---

CREATIVITY AND INNOVATION SKILLS refer to students being able to generate and refine solutions to complex problems or tasks based on synthesis, analysis and then combining or presenting what they have learned in new and original ways.

1. Here are some examples of practices that may help students learn CREATIVITY AND INNOVATION SKILLS.

<table>
<thead>
<tr>
<th>In your teaching of your TARGET CLASS, how often have you asked students to do the following</th>
<th>Almost never</th>
<th>A few times a semester</th>
<th>1-3 times per month</th>
<th>1-3 times per week</th>
<th>Almost daily</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Use idea creation techniques such as brainstorming or concept mapping?</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>b. Generate their own ideas about how to confront a problem or question?</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>c. Test out different ideas and work to improve them?</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>d. Invent a solution to a complex, open-ended question or problem?</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>e. Create an original product or performance to express their ideas?</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

2. To what extent do you agree with these statements about your TARGET CLASS?

<table>
<thead>
<tr>
<th>To what extent do you agree with these statements about your TARGET CLASS?</th>
<th>Not really</th>
<th>To a minor extent</th>
<th>To a moderate extent</th>
<th>To a great extent</th>
<th>To a very great extent</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. I have tried to develop students' creativity and innovation skills</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>b. Most students have learned creativity and innovation skills while in my class</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>c. I have been able to effectively assess students' creativity and innovation skills</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Research Study Post-Survey

Thank you for participating in my research study and for providing your most honest responses to the questions that follow.

* Required

1. How comfortable do you feel about implementing PBL in your classroom after our extended PBL professional development series?

   *Mark only one oval.*

   Not really

   ______

   1

   2

   3

   4

   5

   To a very great extent

   ———

---

In this section you will encounter a series of questions about your personal perception of the extended PBL professional development series you participated in. All answers are anonymous and voluntary.
2. Has this extended PBL professional development opportunity been beneficial to you as a middle school science teacher?

*Mark only one oval.*

- Not really

  1

  2

  3

  4

  5

  To a very great extent

3. Do you feel the extended PBL professional development will led to changes in your teaching practice?

*Mark only one oval.*

- Not really

  1

  2

  3

  4

  5

  To a very great extent
4. Do you feel the extended PBL professional development impacted the success and the academic growth of your students?

*Mark only one oval.*

- Not really
  - 1
  - 2
  - 3
  - 4
  - 5

- To a very great extent

5. Did you like attending the extended PBL professional development sessions for this study?

*Mark only one oval.*

- Yes
- No

The following set of questions are on your individual science teaching self-efficacy. Your response are completely anonymous and your participation is appreciated.
APPENDIX D: CLASSROOM OBSERVATIONS TOOL

Look-for Tool: Science
Supports walkthroughs and feedback on subject-specific instructional strategies

Purpose:
This tool is intended to help leaders provide feedback on practices associated with strengthening a teacher’s content knowledge as they shift to align with more rigorous standards and curriculum. It is based on the descriptors in the Teacher Content Knowledge indicator (noted below) within the NIET Teaching and Learning Standards Rubric and includes aligned, concrete “look-fors” for science.

The second descriptor in the Teacher Content Knowledge indicator defines look-fors in more detail in three subcategories – focus, questioning, and student work – that point to the primary shifts that occur as teachers align to the depth required by college and career readiness standards.

- Focus defines the overarching practices a leader should see for this subject.
- Questioning details what a leader should hear in classroom discussion to better ensure that specific subject depth is achieved.
- Student work describes the tasks that should be utilized as teachers shift to more rigorous expectations.

The look-fors provide suggestions of potential evidence; however, the lists in this tool are not exhaustive, and coaches should use their own context and understanding to consider other ways a teacher may demonstrate his or her content knowledge in practice. Additionally, there is a glossary at the end of the tool to help define science-specific terminology. Observers are encouraged to review this glossary to better understand key terms, which are highlighted throughout the document.

How to use this tool:
This tool can be used by school leaders and coaches during walkthroughs or observations to identify evidence of practices associated with strengthening teacher’s content knowledge as they shift to align with more rigorous standards and curriculum. It is intended to provide feedback to teachers as they work to deepen student learning. The tool provides a developmental continuum for the observer to provide an assessment of the teacher’s content knowledge as demonstrated in practice. Coaches and teachers are also encouraged to discuss the evidence from walkthroughs, observations, and analysis of student work in pre- and post-conference sessions and in professional learning communities as appropriate.

This tool uses the following descriptors from level 5 – exemplary practice – on the NIET Teaching and Learning Standards Rubric:

<table>
<thead>
<tr>
<th>Level 5 – Exemplary</th>
<th>Teacher Content Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consistent Evidence of Student-Centered Learning/Student Ownership of Learning – Teacher and Students Facilitate the Learning</td>
<td></td>
</tr>
</tbody>
</table>

1. Teacher displays extensive content knowledge and understanding of both state standards and instructional materials, including their curriculum, for all the subjects they teach.
2. Teacher consistently implements a variety of subject-specific instructional strategies to enhance student content knowledge.
3. Teacher consistently highlights key concepts and ideas and uses them as the basis to connect other powerful ideas.
### Focus in Science

1. **Displays extensive content knowledge and understanding of state standards and instructional materials, including curriculum**

   - **Look-fors: Examples of evidence**
     - Teacher engages students in resources and activities that are aligned with the rigor of the standard(s) and objective(s) and are anchored in explaining scientific phenomena.
     - Students demonstrate understanding of the lesson’s purpose throughout the lesson and connect purpose to each element of the lesson.
     - Teacher shares why and how lesson objective(s) connect to everyday lives, future learning in near term (tomorrow/next week), and long term (for the year) learning, with attention to the spiral nature of science instruction from year-to-year.
     - Teacher introduces new learning by providing clues and focus questions around a scientific phenomenon so that students can engage in the new learning as a scientist.

   - **Observation**
     - Yes
     - Some
     - Not Yet

   - **Comments:**

2. **Implements a variety of subject-specific instructional strategies**

   - **Look-fors: Examples of evidence**
     - Majority of the lesson is focused on students observing, using evidence, and creating explanations for the focus question(s) around a scientific phenomenon.
     - Students engage in science and engineering practices in order to make sense of new learning and make connections to scientific phenomena.
     - Teacher sequences the lesson to help students to make a claim, support with evidence, provide reasoning, and make rebuttals to counterclaims regarding scientific phenomena within a lesson or unit.
     - Students are applying crosscutting concepts to connect what they are learning to other scientific ideas.

   - **Observation**
     - Yes
     - Some
     - Not Yet

   - **Comments:**

### Questioning in Science

- **Look-fors: Examples of evidence**
  - Teacher sequences questioning strategies to elicit, support, and challenge scientific thinking.
  - Teacher scaffolds questioning to assist student understanding of scientific vocabulary with just-in-time support within the lesson or unit.

- **Observation**
  - Yes

### Student Work in Science

- **Look-fors: Examples of evidence**
  - Students engage in inquiry, share findings, and make connections to scientific data or phenomena as they work collaboratively.
  - Student work supports inquiry, self-monitoring of learning, seeking out next steps, and using feedback to construct scientific explanations and develop sensemaking individually or with a team.
  - Students are actively engaged in work that reflects what scientists do: reading, writing, and drawing; doing hands-on and/or digital investigations; modeling; and discussing findings.
  - Students engage in evaluating scientific data, text, or questions to develop sensemaking, leading them to explain scientific phenomena.

- **Observation**
  - Some
  - Not Yet

- **Comments:**

### Student's Work

- **Look-fors: Examples of evidence**
  - Teacher connects lesson ideas to key concepts within a unit to help students transfer knowledge to other related concepts/ideas and explain new phenomena.
  - Students make connections to essential ideas within and across disciplinary core ideas as appropriate.
  - Student learning is connected to crosscutting concepts to build knowledge of themes across disciplines of science and connect learning.

- **Observation**
  - Yes
  - Some
  - Not Yet

- **Comments:**
Glossary:

Crosscutting concepts: application across all domains of science and linking science domains together. These could include patterns; cause and effect; scale, proportion, and quantity; systems and system models; energy and matter; structure and function; and stability and change.

Disciplinary core ideas: fundamental scientific ideas grouped in four domains: physical science; life science; earth and space science; and engineering, technology, and applications of science. To be considered core, and the ideas must meet at least two of the following criteria:
- Have broad importance across multiple sciences or engineering disciplines or be a key organizing concept of a single discipline
- Provide a key tool for understanding or investigating more complex ideas and solving problems
- Relate to the interests and life experiences of students or be connected to societal or personal concerns that require scientific or technological knowledge
- Be teachable and learnable over multiple grades at increasing levels of depth and sophistication

Science and engineering practices:
1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using math and computational thinking
6. Constructing an explanation (for science) and designing a solution (for engineering)
7. Engaging in an argument stemming from evidence
8. Obtaining, evaluating, and communicating information

Scientific phenomenon (plural: phenomena): observable fact or event that occurs in the universe and that we can use our science knowledge to explain or predict

Sensemaking: the process of making sense of or giving meaning to something, especially new ideas
APPENDIX E: IRB APPROVAL LETTER

Margrett Caroline Upchurch-Ford
623 Pinney Lane
Duncan, SC 29334

Re: Pro00122688

Dear Margrett Caroline Upchurch-Ford:

This is to certify that the research study *The impact of Extended Professional Development in Project-Based Learning on Middle School Science Teachers* was reviewed in accordance with 45 CFR 46.104(d)(2) and 45 CFR 46.111(a)(7). The study received an exemption from Human Research Subject Regulations on 7/29/2022. No further action or Institutional Review Board (IRB) oversight is required, as long as the study remains the same. However, the Principal Investigator must inform the Office of Research Compliance of any changes in procedures involving human subjects. Changes to the current research study could result in a reclassification of the study and further review by the IRB.

Because this study was determined to be exempt from further IRB oversight, consent document(s), if applicable, are not stamped with an expiration date.

All research related records are to be retained for at least three (3) years after termination of the study.

The Office of Research Compliance is an administrative office that supports the University of South Carolina Institutional Review Board (USC IRB). If you have questions, contact Lisa Johnson at lisaj@mailbox.sc.edu or (803) 777-6670.

Sincerely,

Lisa M. Johnson
ORC Assistant Director and IRB Manager