We Observe, We Reflect, We Research:

Data-Driven, Job-Embedded Science Professional Development with Early Head Start Teachers

by

Eric Zachary Bucher

A Thesis Presented in Partial Fulfillment
of the Requirements for the Degree
Doctor of Education

Approved April 2019 by the
Graduate Supervisory Committee:

Josephine Marsh, Chair
Laura Martin
Lynne Watanabe Kganetso

ARIZONA STATE UNIVERSITY

May 2019

ABSTRACT

The purpose of this action research was to understand how reflective, job-embedded early childhood science professional learning and development (PLD) impacted Early Head Start (EHS) teacher learning and their perceptions toward science with toddlers. Limited content knowledge and lack of formal preparation impact teachers' understanding of developmentally appropriate science and their capacity to support children to develop science skills. In Arizona, limited availability of early childhood science coursework and no science-related PLD for toddler teachers showed the need for this project. Four literature themes were reviewed: teacher as researcher, how people learn, reflective PLD, and how young children develop scientific thinking skills.

The participants were nine EHS teachers who worked at the same Head Start program in five different classrooms in Arizona. The innovation included early childhood science workshops, collaboration and reflecting meetings (CPRM), and electronic correspondence. These were job-embedded, meaning they related to the teachers' day-to-day work with toddlers. Qualitative data were collected through CPRM transcripts, pre/post-project interviews, and researcher journal entries. Data were analyzed using constant comparative method and grounded theory through open, focused, and selective coding.

Results showed that teachers learned about their pedagogy and the capacities of toddlers in their classrooms. Through reflective PLD meetings, teachers developed an understanding of toddlers' abilities to engage with science. Teachers acquired and implemented teacher research skills and utilized the study of documentation to better understand children's interests and abilities. They recognized the role of the teacher to provide open-ended materials and time. Moreover, teachers improved their comfort with science and enhanced their observational skills. The teachers then saw their role in supporting science as more active. The researcher concluded that the project helped address the problem of practice. Future research should consider job-embedded PLD as an important approach to supporting data-driven instructional practices and reflection about children's capabilities and competencies.

Keywords: action research, *Arizona Early Childhood Workforce Knowledge and Competencies*, *Arizona's Infant and Toddler Developmental Guidelines* (ITDG), documentation, early childhood science, Early Head Start (EHS), Head Start *Early Learning Outcomes Framework* (ELOF), inquiry, job-embedded, pedagogy, professional development (PD), reflective professional development, teacher as researcher, teacher research, toddler science

DEDICATION

I dedicate my innovation project to the many personal and professional relationships that developed me into the researcher I am today. First and foremost, thanks to my father, Paul, for working to provide a better life and promoting the importance of education. I am a first-generation college student, and now I graduated with a Doctor of Education degree! You let us go out into the forests and marshes and play for hours; these experiences made me an observant, detailed, curious, and reflective researcher. I also appreciate Emily (for reviewing my writing), Nicole, Stephanie, and all my close friends who provided an ear to listen over and a mind to reflect with over several decades. You taught me how important positive relationships are to lifelong learning.

It is from my professional experience with a multitude of amazing colleagues and co-workers that I attribute my professional development. Thank you to my colleagues Christie and Ana for provoking me to become an "agent of change". You taught me that professional development can be innovative and reflective and must value a strong image of children, their families, and teachers. I am forever changed by attending early childhood courses at the college with you seven years ago.

Finally, I express my gratitude to the many children and families that I supported throughout my career. Your insight, resilience, and ability to problem-solve has helped me recognize your limitless potentials and capabilities. I look forward to continuing to strengthen an early childhood system in Arizona that is deserving of our amazing children, families, and communities.

ACKNOWLEDGMENTS

This dissertation is a culmination of collaborative support by many individuals who I would like to acknowledge. First, I am so grateful to my doctoral committee for their dedication to my study. Dr. Josephine Marsh, thank you for providing critical feedback to develop my ability to write more efficiently and concisely, which was a barrier to success that I identified. Your knowledge in practitioner inquiry helped enhance my literature review and informed my interactions as the facilitator of the project.

Dr. Laura Martin, thank you for believing in my scientific capacities many years ago at the science museum even if I did not yet believe in them myself. Your continued mentorship and insight helped me to see myself as a scientific researcher and was instrumental in my professional development.

Dr. Lynne Watanabe Kganetso, thank you for providing your keen eye for formatting and your expertise on educational psychology to increase my understanding of how context supports young children's developmental abilities.

Dr. Gigi Schroeder Yu, thank you for motivating me to study documentation of children's learning and to improve upon my professional development facilitation. Your research and Collaborative Planning Protocol served as a crucial foundation to the methods of this innovation. You taught me that it is important to challenge the status quo and to think about professional learning in an innovative way.

Next, I would like to give a special thank you to the Early Head Start Teachers who participated in my project. Your ability to risk-take in your professional learning and

your excitement to share your reflections about your work with me reinvigorated my commitment to lifelong learning.

Finally, I would like to recognize the local Head Start program for supporting my project and committing to the teachers' professional learning and development. Thank you for identifying the need for reflective, continuous professional development to promote quality improvement and school readiness for young children and their families. Head Start is a vital, nationally-funded early childhood program that provides comprehensive education, family support, and health services to help families develop lifelong learning skills and transcend poverty: www.acf.hhs.gov/ohs.

CONTENTS

Page

Page

Page

Page

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ADE	Arizona Department of Education
ADHS	Arizona Department of Health Services
AECWKC	*Arizona Early Childhood Workforce Knowledge and Competencies*
ASU	Arizona State University
AzELS	*Arizona's Early Learning Standards*
CDA	Child Development Associate Credential ™
CLASS®	*Classroom Assessment Scoring System*
CPRM	Collaborative planning and reflecting meeting
ECE	Early Childhood Education
EHS	Early Head Start
ELOF	Head Start *Early Learning Outcomes Framework*
FTF	First Things First
ITDG	*Arizona's Infant and Toddler Developmental Guidelines*
NAEYC	National Association for the Education of Young Children
NGSS	*Next Generation Science Standards*
NRC	National Research Council
PLD	Professional learning and development
TSG	Teaching Strategies® GOLD ™
USDHHS	United States Department of Health and Human Services

CHAPTER 1

INTRODUCTION AND LEADERSHIP CONTEXT

Children are Scientists

Young children's actions are the quintessence of scientific thinking and approaches to understanding the world. Strong skills in science set the foundation for children's future learning success. These science skills are visible through a variety of children's earliest interactions: a nine-month old infant scoots towards a flicker of sunlight glimmering from a reflective surface, a toddler throws a ball to discover how the body can be manipulated to make action, or a preschooler uses a magnifying glass to more closely see the details of a pine cone before sketching observations. The *Next Generation Science Standards* or NGSS affirm that children's skills related to science are integral to building a foundation for how they will approach learning for the rest of their lives (NGSS Lead States, 2018). Science skills – a sense of wonder, communication, problem solving, mental flexibility – support children in their education and future professional lives as they discover how to collaborate with others, engage in learning around their interests, and contribute to their communities and society (NGSS Lead States, 2018). Through play, children display scientific skills and a natural sense of wonder in a variety of actions including persistence in seeking answers to everyday problems, observing and predicting, and testing. In this way, children construct understanding about how the world works and develop lifelong learning skills (Arizona Department of Education [ADE], 2018).

According to the National Research Council or NRC (1996), children with a general base of experience and understanding in the science domain can much more effectively acquire complex skills because of their “natural proclivity” to experiment, investigate, and engage in learning (Worth, 2010, p. 1). The *Arizona Early Learning Standards* (*AzELS*) (ADE, 2018) state that learning through actions of scientific inquiry not only require the child’s curiosity but also the educator’s understanding of science content and strategies to promote scientific inquiry.

In twenty-first century early childhood education, teachers can see themselves as researchers in action – solving problems and improving their professional practices as they, together with children, investigate the world, uncover new ideas, construct theories, and explore with curiosity (Bucher & Hernández, 2016; Edwards & Gandini, 2015). This concept of teacher as researcher is similar to educational action research. It promotes teachers to engage in collaborative and reflective inquiry to impact curriculum planning and implementation (Edwards & Gandini, 2015). Reflective inquiry is when educators study their own work with children, connect practice to theory, and benefit their base of knowledge as practitioners (Sela & Harel, 2012). However, the approach of teacher as researcher more heavily emphasizes teacher attitudes towards seeing themselves as learners when collecting, analyzing, and discussing documentation (Edwards & Gandini, 2015). This, in addition to the professional development strategy of conducting child-centered research in classrooms, is also indicative of educational action research (Johnson, 1993).

To be effective practitioners, educators of young children are expected to have vast professional learning and development (PLD) experience both formally in college coursework as well as through frequent training. According to the National Association for the Education of Young Children or NAEYC (2010), PLD refers to activities involving the initial pre-service preparation and in-service learning experiences which are designed to improve the knowledge, skills, behaviors, attitudes and values of early childhood professionals. Through PLD, teachers keep current in their knowledge of child development research and best practices. Arizona's minimum training obligations (e.g., Arizona Department of Health Services [ADHS] *Statutes for Child Care Facilities*) require general areas of child development: cognitive, social and emotional, language and literacy, and physical. Local and national standards (e.g., ADE *Program Guidelines for High Quality Early Education – Birth to Age* 8, NAEYC *Standards for Professional Preparation*, the Office of Head Start's *Using the Early Learning Outcomes Framework to Inform Professional Development*) place a strong emphasis on PLD that specifically develops teacher content knowledge base around scientific inquiry.

Much like other professions such as careers in health, engineering, and K-12 education, the need for meaningful and relevant ongoing professional learning and development is integral to supporting early childhood educators. PLD has been shown to help educators develop their quality of teaching, improve their practices as they continue to grow as professionals within their field, and support the development of science skills in the young children that they serve (Bucher & Hernández, 2016; First Things First [FTF], 2013; NAEYC, 2010). PLD can improve scientific learning outcomes for children when it is meaningful and practical to their context, reflective, and continuous (Dunst, Bruder, & Hamby, 2015). The most effective PLD is reflective and integrates teachers' own learning and inquiry around their practices (Chalufour, 2010). When teachers engage in this type of iterative professional development, they become more skillful and more adept in supporting children and cultivating key aspects of scientific thinking (Worth, 2010).

Collaborative, reflective PLD emphasizes learning as a lifelong, continuous, socially-connected process that evolves within the context of everyday experiences. Lifelong learning connects science concepts and content between the learner, others, the environment, and the world. Theoretical perspectives and related literature reviewed in the next chapter will focus on the role of job-embedded professional learning to promote the concept of teacher as researcher, while illustrating a strong image of teachers as capable and competent in engaging in scientific teaching and learning.

The Problem of Practice: A Lack of Early Childhood Science PLD

Despite the abundant research around the importance of PLD, there are still challenges to educators engaging with early childhood science in the field. Limited science content knowledge and lack of formal preparation impact teachers' understanding of developmentally appropriate science for young children and their capacity to support children in developing scientific inquiry skills (Piasta, Logan, Yeager Pelatti, & Capps, 2015). For example, an examination of the Maricopa Community Colleges credit-bearing Associate of Applied Sciences degree programs indicated that each community college in the Phoenix metropolitan area offered at most one, one-credit early childhood science course in the early childhood curricula (Maricopa Community Colleges, 2018). Additionally, a review of the Bachelor of Arts in Education in Early Childhood Education course requirements at Arizona State University (ASU) revealed an even more striking condition; coursework for early childhood science is not included in the degree plan at all (ASU, 2018). Much of the coursework relates to early childhood mathematics and literacy (ASU, 2018). Though general education core classes, including three credits and eleven credits of science courses respectively, are required to attain an Associate or Bachelor in Early Childhood, such courses focus on adult-level science content rather than scientific skills relevant to teaching very young children. A benefit of engaging with scientific thinking as an adult is the opportunity to construct new knowledge and strengthen a teacher's ability to support scientific thinking skills in children (Bucher & Hernández, 2016; Chalufour, 2010). However, it can be difficult for early childhood teachers to translate coursework subject matter into practice in early learning contexts to support infants, toddlers, and preschoolers.

Another barrier to engaging with early childhood science PLD is an educator's perception of their own abilities to teach science. Research conducted consistently since the early 1990's suggested that educators sometimes have anxiety, even fear, of teaching and learning science concepts with young children (Katsampoxaki-Hodgetts, Fouskaki, Siakavara, Moschochoritou, & Chaniotakis, 2015; Lee, 2004; McClure, Guernsey, Clements, Bales, Nichols, Kendall-Taylor & Levine, 2017; Oakes, 1990; Piasta et. al, 2015). Gerde, Pierce, Lee, and Van Egeren (2017) discovered that the self-reported ability and enjoyment of Head Start teachers was much higher for literacy than for math and science. A lack of quality early childhood science training and preparation led to this perception along with an aversion to teaching and learning science (Gerde et. al, 2013). This challenge may emerge from the attitudes that teachers adopted when they themselves were children (Bucher & Hernández, 2016; Copley & Padron, 1998). For instance, some educators fabricate an image of themselves as incapable of science when given the message at an early age that science is difficult and complex or that only intelligent students can do it. These social and cultural messages impact the way in which teachers perceive their scientific inquiry skills and abilities; these internalized perceptions of science are closely associated with how these concepts were taught to them as children (Copley & Padron, 1998).

Teachers who developed research skills – the ability to take risks, an openness to engaging in new ideas, an understanding of how to implement inquiry-based learning in their classrooms – were more likely to engage in science with children (Crawford, 2006). An understanding of how to apply effective teaching and child development theories into practice is critical to teacher's attitudes towards science (Brown & Melear, 2006). Thus, if learning had not been scaffolded to support the individualized ability of teachers to practice scientific thinking skills, teachers identified it was beyond their realm of capability. This was especially true for teachers who identified as female (Can & Kaymaker, 2016). This research indicated that the perceptions of teaching and learning science varied significantly based on gender with males typically having a higher perception of their ability to engage with scientific content (Can & Kaymaker, 2016). Combined with the fact that most early childhood educators identify as females, some early childhood teachers may feel uneasy about teaching and learning science with children (Can & Kaymaker, 2016).

Moreover, an analysis of the available science-related professional development opportunities through the Arizona Early Childhood Workforce Registry (the Registry), indicated a need for additional early childhood science PLD (Arizona 8 PBS, 2018). The Registry is an FTF-funded initiative that serves as a hub for early childhood professional development options around the state. The more than 23,000 registrants, teachers and administrators of early learning programs, can use this system to access workshops, conferences, institutes, webinars, and other professional development from a variety of state and local early childhood agencies. The workshops in the Registry are aligned with *Arizona Early Childhood Workforce Knowledge and Competencies* (*AECWKC*) (FTF, 2015), core standards that define the skills and knowledge required to maintain quality preschool services by early childhood professionals working in the early childhood field statewide (FTF, 2015). Within the Registry, participants are assigned a lattice level based upon their experience. They can increase their level by participating in formal college coursework and PLD that bears a professional development certificate. The initial review in October 2017 revealed that only three workshops containing descriptions with the word *science* were listed in the Registry, compared to 32 PLD workshops around social-emotional development. The three science-related PLD workshops were focused on children ages three to five and offered only once. The workshops were not provided by the same facilitator and did not build upon each other as concurrent sessions. In addition, these workshops were aligned with lower lattice levels, meaning they were geared towards novice early childhood teachers with little experience in the content area (FTF, 2015). Likewise, there were even less PLD options for teachers of infants and toddlers. Few workshops were geared towards educators working with children birth to age three with virtually no science-related workshop options available (Arizona 8 PBS, 2018).

Even a year later, no workshops specifically addressed the need for infant and toddler cognitive or scientific thinking development statewide. In October 2018, there were still only three science-related workshops, all of which were offered as one-time, web-based options through a national vendor; no local options were available (Arizona 8

PBS, 2018). While the age range focus was not specified for the science-related workshops, more workshops related to infants and toddlers were offered by October 2018. This seemed to show a statewide increase in the effort to provide PLD for teachers of very young children. Albeit, the focus of most infant and toddler workshops was home visiting, early childhood trauma, screening and assessment, prevention of suspension and expulsion, and general development in the domains of learning for children birth to age five (Arizona 8 PBS, 2018). Though these workshops provide opportunities for teachers to develop a comprehensive understanding of their professional work with infants and toddlers, the deficiency of science-related content spurred the participant recruitment efforts that will be discussed in the third chapter.

Best practices in early childhood science PLD emphasize continuous, ongoing, reflective experiences for teacher skill development rather than one-time workshops (Hong, Torquati & Molfese, 2013). According to Hong et. al (2013), effective and quality professional development in science for teachers of children birth to age eight emphasized both content and pedagogical development. That is, providing practical science skills that could be implemented into the classroom was effective in creating transformative PLD experiences. Researchers also found that investing in time and focus on the efficacy of educators' skills and perceptions related to early childhood science improved their interactions with children (Hong et. al, 2013). Likewise, Dunst et. al (2015) recommended rigorous, consistent, ongoing, reflective PLD for teachers to develop their capacities to understand science. This should be conducted in accordance with educator understanding of typical child development research (Dunst et. al, 2015). When teachers have this foundational understanding of science knowledge, they can more effectively interpret children's understandings of the world and scientific thinking development (Worth, 2010). Then, in turn, educators can design more challenging and meaningful scientific thinking experiences for children (Hong et. al, 2013).

Therefore, the design of the currently available early childhood science PLD in the Registry are rudimentary nature, low in rigor, and insufficient in regularity. This is not conducive to best practices in early childhood science PLD. This community need and the lack of available science-related PLD in Arizona drove my interest in developing and implementing the early childhood science PLD innovation that became the focus of my action research project. Thus, the goal of my innovation was to enhance early childhood educators' understanding of scientific concepts and their perceptions of their own skills in providing effective science practices for young children.

Leadership Context

An increased demand for high quality early childhood care nationwide compelled educators and programs to increase the quality of their services through intensive professional development (FTF, 2013, United States Department of Health and Human Services [USDHHS], 2016). Federal funding such as the Child Care and Development Block Grant and Preschool Development Grant emphasized collaborative capacity building through infrastructure through ongoing training (United States Department of Education, 2015). Locally in Arizona, there were concerted efforts between state and national agencies such as the Arizona Association for the Education of Young Children, the Arizona Department of Economic Security, ADE, ADHS, FTF, Head Start programs, and local communities to increase the quality of early childhood care for children and families through quality PLD. The focus of this work was for more coordinated professional development systems to promote the importance of early childhood education and to increase professional growth opportunities for early childhood educators.

A child's experiences in the early years lays the foundation for success, in school and in life (Harvard Center on the Developing Child, 2007). Research shows that 90% of a child's brain develops before kindergarten (FTF, 2013). In fact, during their first few years of life, children develop more than a million neural connections each second when they are engaged in quality interactions and relationships with their caregivers (Harvard Center on the Developing Child, 2007; Lally & Mangione, 2017). Thus, well-prepared educators must have consistent, reflective PLD support to continuously improve the quality of their practice. Early childhood education professionals who have quality, supportive, and relevant college coursework and PLD are more likely to facilitate higher quality early learning experiences with children (FTF, 2013). An educator's knowledge of child development and quality of meaningful interactions with children is key to ensuring that children have early learning experiences that support their foundational science development.

My situated leadership context placed me at an advantage in supporting early childhood science PLD efforts. During the course of my project, I worked at a Head Start agency with the mission of ensuring quality school readiness services. Specifically, I designed, developed, and implemented early childhood professional development for more than a hundred Early Head Start (EHS) and Head Start teaching staff. The PLD was aligned with the Head Start *Early Learning Outcomes Framework* (*ELOF*) (USDHHS, 2015), *Arizona Infant and Toddler Developmental Guidelines* (*ITDG*) (ADE, 2014), and

AzELS (ADE, 2018) to support teachers and administrators who worked with young children birth to age five in EHS and Head Start classrooms. Since the Head Start *ELOF* emphasizes scientific inquiry as an important cognitive skill, these workshops promoted the pedagogical approach that children's inquiry can be guided by the teacher's explicit, skilled awareness of scientific learning concepts embedded in the activities, materials, and environment (USDHHS, 2015; Worth, 2010). To meet standards for professional development at a statewide level, the workshops were aligned with current research and best practices related to early childhood science skills and concepts. Also, the available training linked the participant outcomes for the development of professional skills to the *AECWKC*.

In addition to my full-time position, I served as a part-time faculty in early childhood education at a community college. Through this position, I supported the coordination of early childhood PLD at the college which was offered throughout the school year. The PLD was designed to foster scientific inquiry and approaches to learning skills in teachers. I supported teachers as they engaged in a cycle of inquiry through the notetaking guide (See Appendix A). The reflective notetaking guide fostered connections between scientific thinking skills and early childhood theories and practices. In turn, participants developed stronger understanding of children's competencies. By facilitating this PLD, I developed pedagogical skills necessary to supporting teaching and learning. These skills included prompting critical thinking, problem-solving, and reflective questioning of educators' classroom practices (Schroeder Yu, 2012; Stremmel, 2012). Furthermore, my early childhood science content knowledge developed when I worked as an early childhood science specialist both at a science museum and at a statewide education agency. My professional experiences placed me in a unique contextual situation to implement, collect evidence of, and analyze early childhood science PLD in the local community.

Purpose of the Study and Research Questions (RQ)

The purpose of this action research project was to more deeply understand how reflective, job-embedded early childhood science PLD impacted teacher learning and their perception toward integrating science teaching into their professional work with toddlers in the early childhood setting. Specifically, I researched two questions:

1. How does reflective job-embedded early childhood science professional learning and development (PLD) impact educator learning?
2. In what ways do educator perceptions and understandings of science change after participating in job-embedded early childhood science PLD?

To address these questions, I developed an innovation that consisted of three specific and integral professional learning and development (PLD) components: (1) science workshops, (2) technical assistance and coaching through collaborative planning and self-reflection about science teaching introduced during the workshops, and (3) electronic correspondence. The three components of the innovation are described in further detail in Chapter 3.

CHAPTER 2

THEORETICAL PERSPECTIVES AND RELATED LITERATURE

The theoretical perspectives, related literature, and research guiding this project are presented in four sections. First, literature related to teacher as scientist and researcher was considered. Second and third, information on job-embedded professional learning practices and teaching and learning science was reviewed. In the concluding section, implications for this action research project were analyzed.

Teacher as Researcher

Teacher as researcher is a contemporary approach to teaching and learning practices that promotes the idea that early childhood professionals are not only teachers but also learners (Bucher & Hernández, 2016; Henderson, Meier, Perry & Stremmel, 2012; Lewis et. al, 1999; Edwards & Gandini, 2015). Like the professional development approaches of *teacher inquiry* and *practitioner research*, teacher as researcher emphasizes key inquiry components: collaborative small group dialogue, collection and close examination of data related to classroom teaching, and opportunities for reflection about teacher practice and learning (Gordon, 2016; Newman & Woodrow, 2015; Marsh & Gonzalez, 2018b). The goal of teacher as researcher is for teachers to study their professional practice, connect theory to action, and hone their teaching craft through a cyclical inquiry process (Dana, 2013; Marsh & Gonzalez, 2018b).

Teacher researchers critically solve their everyday contextual problems and learn about themselves, about their practice, and about the strengths of children. They do this as they work together with children, investigate with openness and inquisitiveness, and construct theories about what children are thinking and learning (Bucher & Hernández, 2016; Henderson et. al, 2012; Rinaldi, 2003). Moreover, the role of continuous learning through professional development is integral to how teachers perceive their practice (Lewis et. al, 1999). Teachers are competent, and capable of participating in continuous and reflective PLD, but must also be willing to build their capacity in effective teaching practices to “learn and relearn their trade” (Lewis et. al, 1999, p. 5).

Teacher as researcher and learning theory. Understanding learning theory is significant to designing PLD to impact teacher attitudes, perceptions, and reflective skills. According to the NRC (2000), since the progression of more sophisticated technology and formalized educational systems through which learning can be studied, *how* people learn has been of interest to educational researchers in the past several decades. It would be irresoluble for a learner to capture the “sheer magnitude of human knowledge” (NRC, 2000, p. 5). Instead, an emphasis must be placed on the process of knowing (Piaget, 1964; Vygotsky, 1978). This means that a learner does not simply construct knowledge in isolation, but rather they come with previously acquired understanding, skills, and perceptions that influence how they will interact with their environments and how they will “organize and interpret” new information (NRC, 2000, p. 10). Teachers can pay close attention to children’s prior knowledge using documentation methods to identify, analyze, then plan to enhance young children’s scientific thinking skills (NRC, 2000; Edwards & Gandini, 2015). Additionally, this process of knowing can be supported through the teacher’s relationships with a child as they actively expand their critical cognitive tools, learning strategies, and approaches to acquire new knowledge (Piaget, 1964; NRC, 2000; Vygotsky, 1978).

In the field of early childhood, educators can be active explorers of research in their own classrooms and can engage in critical reflective processes (Scheinfeld, Haigh, & Scheinfeld, 2008). A strong image of teachers as researchers reflects their abilities to collaborate with colleagues to co-construct knowledge and have a desire to grow professionally (Scheinfeld et. al, 2008). Educators engage in a process of iterative research of their own practice when provided with professional development support that is reflective, relevant to their context and the children they serve, and capitalizes on children's curiosity. The concept of Piaget's (1964) constructivism mirrors teacher as researcher theory in the respect that children learn by action, constructing their own knowledge through interactive experiences and active engagement, not "passive acquisition" (Schcolnik, Kol, & Abarbanel, 2006, p. 12). Additionally, teacher as researcher mirrors Vygotsky's (1978) cognitive theories placing a strong emphasis on the importance of relational, social, and developmental factors in learning (Kozulin, Gindis, Ageyev & Miller, 2003; NAEYC, 2004).

Thus, the goals of teacher as researcher and previous iterations of my work, studying documentation of children's scientific learning with early childhood teachers, heavily influenced this innovation (Bucher & Hernández, 2016; Edwards & Gandini, 2015; Rinaldi, 2003). As described in Chapter 1, the ideals of teacher as researcher served as a foundation of my formal educational experience. By studying it, I linked practice with the educational theories of Dewey and Piaget. These experiences led me to view everyday experiences differently. I now perceive teachers as researchers when they implement and reflect on ideas and concepts that they uncover during early childhood conferences, workshops, and college coursework into their work with children. The forms of professional development as listed above strengthen teacher understanding, thinking, and perceptions of child development and of their own practices. Therefore, professional development increases professional capacities.

Teacher as researcher and reflection. Teacher as researcher is encompassed as an interwoven theme evident in the practices of the schools of Reggio Emilia in Italy (Edwards & Gandini, 2015). The schools of Reggio Emilia, often seen as the "gold standard for quality early childhood education" see the role of the teacher as similar to the role of a researcher (New, 2007, p. 5),. According to Edwards and Gandini (2015), the actions that teachers perform are like the actions in which researchers engage. This suggests that research is the everyday work that teachers actively perform as they make listening to children and documenting of children's learning central to their practices (Wein, Guyevskey, & Berdoussis, 2011). In part, their active engagement with children is transformed into a way of thinking and approaching knowledge and understanding relations with the world (Rinaldi, 2003). This research produces "the kind of innovation only derived from systematic pursuit of multiple perspectives on problems and rigorous examination of evidence at hand" (Edwards & Gandini, 2015, p. 92). In other words, teachers' continuous reflective practices – learning with and from their work – impacts their professional learning and growth. This was evident as Edwards and Gandini (2015) integrated the descriptions of Rinaldi, a professor at the University of Modena who was a prominent practitioner in the Reggio Emilia approach to education. They demonstrated that there is a strong connection between the intentional actions that teachers carry out when working within the theory of teacher as researcher and the work of people in scientific laboratories and university settings. Both engage in questioning, searching, and problematizing materials and experiences to promote co-problem-solving strategies. Problematizing means making the object of study into an actionable research project. The project should involve formulating related questions in association with background knowledge and other resources to help move insight forward (Roth & Månsson, 2011). Educators engage in two important researcher skills. First, they question how teacher knowledge and practice are constructed, evaluated, and implemented. Second, educators assume that part of the work, individually and collectively, was participating in educational and social change efforts (Edwards & Gandini, 2015).

Teacher as researcher and change. Teacher as researcher highlights the role of change in the learning process. Iterative experiences support teachers to evolve their practices over time. New theories about themselves and their world emerge, and teachers do not think the same way as they did before their experience. Change theory helps provide clues around important considerations to support change in teacher practice and how they might unfold. Change, though often critiqued as difficult, can certainly occur with intentionality and awareness even though it is often implicit in educational systems (Connolly & Seymour, 2015). Transformations can be realized when the change-agents "push, pull, and nudge" (Hargreaves & Fullan, 2012, p. 148). That is to say, there is not any one top-down or bottom-up approach. Instead, change efforts must integrate collaborative reflection to look at the system from multiple perspectives. In order to produce change, Fullan (2006) encouraged a synchronized focus on mutual support of teachers along with the systematic culture of their workplace.

For instance, change within an early childhood setting might transpire when those organizing and implementing professional development create a culture of inquiry (Pelo, 2006; State of Victoria Department of Education and Early Childhood Development, 2012). Pelo (2006) defended that all early childhood educators deserve a culture of inquiry which fosters opportunities for constant research and debate, an esteem for research aptitudes and dispositions, co-construction of knowledge, and professional challenge through PLD. Subsequently, early childhood programs can nurture this culture of inquiry by modeling, providing time for, and investing in mentorship system-wide that supports responsive and reflective practices (Epstein & Willhite, 2015; Martin, Ash, & Tran, forthcoming; Pelo, 2006).

Pelo (2006) was able to induce change in both the way that teachers interpreted their researcher skills as well as the way in which the organization ran its PLD. This inquiry focused on improving teacher research practices through consistent professional development that focused on observations of young children (Pelo, 2006). First, a group-wide research question was developed collaboratively to provide a framework for the ongoing PLD (Pelo, 2006). This intentional design created a shared purpose for investigation and promoted motivation through teacher interest and the pursuit of teaching and learning with colleagues (Hargreaves & Fullan, 2012; Wenger, 1998). Monthly staff meetings provided dedicated time for teaching teams to share observations, deconstruct and reconstruct meaning, and plan for impact on curriculum related to the group's research questions (Pelo, 2006). Teachers studied their documentation while the mentor teacher facilitated questions and conversations to provoke curiosity, challenge thinking, and help teachers to refine their understanding (Pelo, 2006). Pelo (2006) indicated the effects of this change in her reflection:

> This transformation required strong institutional support…and it required willingness by teachers to take risks, to see their work in new ways – to become researchers, observing closely, making meaning with each other, anchoring themselves in the revelations of each moment. A year into our effort to put observation at the heart of our teaching and learning, one of the teachers…commented that “This is making me a better teacher for sure – but it is more than that, it’s making me a better person. This is how I want to live in the world – paying attention, staying connected to what I see, thinking about big ideas with our people” (p. 53).

Here, reflective practices and mentorship (both described later in this section) and the use of observational documentation culminate into a transformative PLD experience (Pelo, 2006). These concepts were integrated into the Collaborative Planning and Reflecting Meetings (CPRM) that were part of my innovation and are described in Chapter 3.

Teacher as researcher and perception of self. The change I wanted to see in early childhood science PLD was that practitioners developed an image of themselves as having strong, reflective skills that promote iterative learning in their classrooms. This is the case for the approach of teacher as researcher. Considering this support around continuous and reflective PLD with early childhood educators provided context for the teacher as researcher. In one example, researchers sought to discover how the theory of teacher research could be integrated into a college practicum course and how participating could enhance students’ understandings of the concept of teacher research (Murphey, 2013). Influenced by many foundational theories including the Reggio Emilia approach to teacher as researcher, Murphey (2013) engaged with and studied teacher research with pre-service and in-service teachers influenced by previous inquiries in similar contexts (Hatch, Greer, & Bailey, 2006; Trent, 2010).

Murphey (2013) reviewed relevant literature and talked with colleagues about teacher research to enhance her own understanding of the theory. Then, a teacher research project was developed and incorporated into the practicum course materials. She collected data throughout the course including anecdotal notes, student work samples, reflections, and self-reflections.

The outcomes from this research project indicated that students effectively integrated their initial understanding of observation, documentation, and reflection skills to support their own teacher research processes. The innovation also supported a sense of knowing, the processes in which the students developed knowledge and were aware of the knowledge they constructed (Murphey, 2013). Murphey (2013) discovered that the reflective teacher researcher process helped students become generators of knowledge rather than consumers of knowledge. Not only did participating in the practices of teacher research deepen the knowledge and understanding of the college students, it also provided a richer experience for Murphey (2013) as indicated in her evolution of thinking:

> If you had asked me several years ago what I hoped for my students at the end of my program I would have said, “To be good teachers.” Today, after twenty years of being a community college teacher educator… I want them to know that they are good teachers, as well as *why* they are effective and what makes them good teachers. Only in this way will they have the confidence and the voice they need to go out and do what they know is right for young children. Teacher research is one of the most important strategies for making this happen (p. 11).

By structuring activities around teacher research, participant perceptions on their capacities to conduct classroom research and their self-efficacy skills were increased (Murphey, 2013). As an educator continuously investigates theories around teacher research while simultaneously integrating the theories into practice, they develop a stronger perception of their own skills as capable and competent teachers and learners. This perception can help them be more articulate in describing quality practices of what young children deserve. This was imperative to my innovation because it indicated that the teacher as researcher could potentially increase a teacher's understanding of their own reflective thinking and practice. This helped me hone my RQ1.

Ongoing, Reflective Professional Learning and Development (PLD)

Teachers are lifelong learners when they enhance their skills and influence their interactions with children through ongoing and reflective professional development (NAEYC, n.d.). Early childhood professional development, as defined by the NAEYC (n.d.), is a continuum of pre-service and in-service learning that is intended to improve the knowledge, skills, behaviors, attitudes, and values of the early childhood workforce. The methodological approaches for this action research project of connecting teacher-researcher with job-embedded professional development highlighted the consideration that teachers can practice and develop researcher behaviors. Additionally, the concept of in-service professional development elevated the role of the teacher as an active research scientist through specific researcher-related actions: (a) collecting and organizing data related to children's scientific learning and development, (b) analyzing data through reflective practice related to current research, and (c) constructing new understandings of their professional abilities and skills (NAEYC, n.d.).

Interwoven collaborative support for PLD such as ongoing coaching and reflection is also required. When early childhood educators had consistent coaching and PLD support in their early learning program, their retention rates increased (The Public School Forum of North Carolina, 1995) and the quality of their practices improved (FTF, 2013). My innovation focused on developing professional skills and capacities through job-embedded PLD. Schaffer and Thomas-Brown (2015) suggested that there should be alternatives to traditional professional learning called job-embedded PLD. job-embedded PLD is defined as teacher learning opportunities that are grounded in day-to-day teaching practices with the purpose of enhancing teachers' content-specific instructional practices and, therefore, outcomes for children's learning (Croft, Coggshall, Dolan, Powers, & Killion, 2010). My innovation drew on my previous work on job-embedded PLD that described the collaborative process of professional development facilitators supporting professional learning alongside early childhood educators as they work with children directly in the classroom setting or other learning environments (Bucher & Hernández, 2016). Job-embedded professional development should be guided by close observation, documentation of children, and opportunities for teachers to actively participate and reflect on this documentation (Henderson et. al, 2012; Wein et. al, 2011). Through job-embedded learning, educators enhance their practice, skills, and capacities as professionals.

Moreover, Brown-Easton (2008) and Wei, Darling-Hammond, Andree, Richardson, and Orphanos (2009) identified twelve components to job-embedded professional development that can take place in teachers' workplaces. These types of job-embedded PLD can effectively develop teacher capacity for self-reflection, critical thinking, improving practice, and improving the educational environment: (1) action research; (2) case discussions; (3) coaching, with a side-by-side support staff who has a specific expertise within the field; (4) critical friend groups which provide opportunities for teachers to reflect with colleagues; (5) data teams/assessment development; (6)

examining student work/tuning protocol, which can also be referred to as a study of documentation regarding children's learning; (7) implementing individual professional growth/learning plans; (8) studying research resources related to the content; (9) mentoring; (10) portfolios; (11) professional learning communities; and/or (12) study groups (Schaffer & Thomas-Brown, 2015; Wenger, 1998). For my innovation design, I integrated action research, coaching, study of children's work, and investigation of science-related resources and research. I describe the innovation model in Chapter 3. In short, these job-embedded practices can be employed during day-to-day experiences in classroom settings as educators work with young children. Job-embedded PLD promotes reflective practice and effective professional development and improves the quality of teaching skills and practices (Henderson et. al, 2012; Jones, 2008; Stremmel, 2012).

Professional learning and reflection. Dewey (1933) conjectured that learning occurs through reflection on experience, not simply the experience itself. The concept of learning with, from, and through reflection is critical to supporting PLD, even though reflective processes are complex in nature. In my study, reflective practices were integrated into the design and fit within the ongoing professional development context of early childhood education. Much like Dewey's (1938) theory of co-inquiry wherein the construction of knowledge is carried out by group rather than individual, job-embedded PLD promotes collaborative reflection between colleagues in school settings (Abramson, 2012; Epstein & Willhite, 2015). Indeed, reflective practice has proven instrumental as a key component of effective teaching practices (Epstein & Willhite, 2015; Maddux & Donnett, 2015; Marsh & Gonzalez, 2018b; Schaffer & Thomas-Brown, 2015). Reflective practice is consequential and integrates both action and thinking (Dewey, 1910; Schön, 1983). In other words, it is an operational process through which the learner sequences and orders ideas and determines solutions to address problems to make sense of their world (Dewey, 1910; Mitchell et. al, 2015). Reflective job-embedded PLD can help early childhood professionals collaborate, share ideas, and address real-life issues in their educational practices (Martin, et. al, forthcoming).

Building upon prior experiences and background knowledge, reflective practice brings about disequilibrium associated with learning (Piaget, 1964). It is that sense of puzzlement, skepticism, disinclination, and doubt that produces evidence to help a learner either validate or negate their understandings (Dewey, 1910). Instructional approaches and strategies can be problematized by teachers through reflective practice when there is a distinct concentration on educational experiences that are "puzzling, troubling, or interesting" (Martin et. al, forthcoming). Reflective practice and inquiry are intertwined; they are iterative thinking and learning behaviors (Dewey, 1910; Dewey, 1938). Martin et. al (forthcoming) explained this concept:

> Reflective practice requires a deliberate process of framing and reframing one's practice in the light of the consequences of one's actions, principles, beliefs, values, expectations, and experiences. Reflective exercises involve practitioners observing, reviewing, and talking with one another about what they do, and question why and how they do their work in order to learn from their work experiences (p. 10).

Professional learning and mentoring. Reflective practice develops over time and must be supported through dedicated time and consistent mentorship (Epstein & Willhite, 2015; Martin et. al, forthcoming). Specifically, Epstein and Willhite (2015) examined the role of reflective practices such as the concept that PLD requires continuous reflection by both experienced teachers and mentors through communities of practice (Holmes Group, 1990; Wenger, 1998). Additionally, the PLD mentorship research was influenced by “the role of collaboration and consistent communication and reflection between teacher-mentor and teacher candidate” (McCormick, Eick, & Womack, 2010, pp. 117-9). It was integral to the effectiveness of the mentorship program. The ability to communicate ideas about children’s learning and exchange ideas and perspectives is strengthened through this co-inquiry professional development process (Abramson, 2012).

The participating early childhood mentors in the Epstein and White research gave focus group responses about many factors: (a) individual relationships with students, (b) classroom management, (c) understanding of age-level content, (d) teaching strategies, (e) assessment, and (d) creativity (Epstein & Willhite, 2015). Mentors had a high level of self-efficacy, which impacted children’s experiences in the classroom. Data suggested that the mentors had a strong confidence in eleven out of the twelve teaching skills from the survey and their open-ended question responses echoed the theme of confidence in relation to their self-efficacy. Moreover, enhanced reflection skills emerged as the strongest skill developed over the time participating in the mentorship program between the pre- and post-study (Epstein & Willhite, 2015). This study indicated that the role of reflective practice in mentorship is important, not only to the teaching staff but also to the mentor educators supporting their capacities as reflective and confident teachers and learners within their context of job-embedded practices. Accordingly, opportunities for participants to consistently reflect on their practices were included in the CPRM and electronic correspondence components of my project which are described in the next chapter.

Professional learning and a common focus. Correspondingly, a system of continuous and collaborative professional development is key to the pursuit of a shared enterprise. Wenger (1998) describes the shared enterprise as a group of learners' stated goal that creates relations of mutual accountability for learning among the study participants. Humans are social beings which is integral to understanding how knowledge is constructed within professional development groups. As such, humans learn best by engaging as active participants with others and constructing identities as learners (Wenger, 1998). As the participants work collaboratively and consistently to reflect on their observations, discuss their perspectives, and construct deeper understandings of their work, they apply co-tenancy. Co-tenancy, or shared enterprise (Wenger, 1998), in my innovation was designed intentionally to support participant capacities as early childhood professionals. Teachers committed to study toddlers and scientific thinking, participate with full engagement in their own PLD, and mutually co-learn with their teaching partner.

My project design integrated shared meaning or understanding between participants around children's scientific thinking skills and contributed to the knowledge that participants constructed as part of the process. This was essential to social participation as a process of learning referenced by Wenger (1998). According to Wenger, participants can then translate this knowledge directly into their work with consistent and continued practice. Practice was promoted within my innovation using the job-embedded experiences supported by a reflective notetaking guide. This was intended to help participants reflect upon and think more critically about their work with toddlers. A sense of a learning community (Wenger, 1998) was provided through the consistent coming together of the participants with me to study their ideas and identities as teachers and learners, and to create a stronger sense of connection and working relationships (Wenger, 1998). Early childhood educators can create a learning identity grounded on their professional development of skills, dispositions, and capacities. In this way, teachers can better understand how learning changes their perception of self as an educator and enhances their practice and skills (Schaffer & Thomas-Brown, 2015; Wenger, 1998).

Early Childhood Science Teaching and Learning

To begin, children's scientific skills evolve over time, continuing to develop as a lifelong learning process. The progression of these skills is contingent upon factors such as a child's access to skilled caregivers and teachers and their developmental abilities and interests (NAEYC, 2009). Though scientific skills typically develop over the course of time through quality interactions, experiences, and relationships, it is also crucial to note that children are unique and complex learners that are diverse in their development, abilities, and needs (ADE, 2018). By the time children enter Kindergarten, they are expected to have developed certain foundational scientific behaviors: exploration, observation, hypothesis, investigation, analysis, conclusion, and communication (ADE, 2018). According to *Arizona's Early Learning Standards*, children exhibit these skills in a multitude of ways in the preschool classroom; they may use a variety of tools or materials to investigate plants in their outdoor garden, identify cause and effect relationships with ramps and pathways, then represent their understanding of relationships in conversation or through play (ADE, 2018).

As children advance through elementary school, they build upon these early skills and develop more complex thinking and understanding of the disciplines of science including physical, life, and earth sciences (NGSS Lead States, 2013). The concepts of observation, investigation, and communication that children developed in their preschool years form the basis on which children practice and refine their scientific thinking skills. These experiences ultimately enhance their learning not only in school but in college and career beyond (NGSS Lead States, 2018). Between Kindergarten and third grade, the science content standards reflect a developmental progression of scientific thinking and performance skills. This progression is embodied in children's actions as they ask questions to obtain additional information about a science topic, conduct experiments and record observations, and analyze and interpret data around disciplinary core ideas like motion and stability, molecules and organisms, or matter (NGSS Lead States, 2013).

The young child and science. Scientific skills are evident and can be fostered for very young children. As Vygotsky (1978) said, "children's learning begins long before they attend school" (p. 32) Essentially, science learning and development begins at birth (Vygotsky, 1978). Very young infants and toddlers understand scientific concepts such as physics related to cause and effect that serve as the impetus for sophisticated problem-solving and reasoning skills (Bucher & Hernández, 2016; NRC, 2000; USDHHS, 2015). For example, a two-year-old might roll a ball down a slide a few times to observe what happens. Then, the toddler might slide down, retrieve the ball, and test it out again. If the ball continues to bounce underneath the slide disappearing from view, the child may exhibit problem-solving skills by attempting to roll the ball up the slide instead. These careful observations and flexibility in thinking by the toddler exhibit understanding of cause and effect and the properties of materials. When paired with a sense of curiosity to explore and the openness of the teacher to allow these types of experiences, the toddler starts to figure out how things work and how they can use their body to make things happen.

Additionally, typical child development follows a path, dependent upon the quality of interactions and experiences they have as infants and toddlers (USDHHS, 2015). In my study, science content for toddlers refers to a focus on the approaches to learning and cognitive skills that are made operational through interactions on materials, objects, environment, and with caregivers and other children. For example, the Cognitive Standards in both the *Head Start ELOF* (USDHHS, 2015) and the *ITDG* (ADE, 2014) indicate that children birth to 36 months actively explore their environment, acquire and process new information, experiment with causal relationships and the different uses for objects, and eventually begin to imitate and represent their knowledge through play. During this timeframe, approaches to learning skills, or rather the way children orient and engage themselves in learning, are exhibited through their actions: managing behaviors and feelings with the support of caregivers; sustaining focus and engagement; persisting; using creativity; and participating with new experiences (USDHHS, 2015). Approaches to learning proficiencies in working memory, inhibitory control, and cognitive or mental flexibility, all referred to as executive functions, are crucial to children's success in school and life because they are the "crucial building blocks" of social and cognitive aptitudes (National Scientific Council on the Developing Child, 2011, p. 3). These skills are also closely associated with later scientific thinking and social-emotional capacity (NGSS Lead States, 2013). Table 1 shows developmental skills related to toddler science, the Domains of Learning, and observable behaviors of toddlers 12 to 36 months (ADE, 2014; USDHHS, 2015).

Table 1

Toddler Development Related to Scientific Thinking

Domain of Learning	Developmental Skills	Observable Toddler Behaviors
Approaches to Learning	Executive Functions	Persists; develops confidence; approaches new experiences and takes risks; maintains focus and sustains attention
	Initiative and Curiosity	Shows eagerness and curiosity as a learner; initiates actions with materials
	Creativity and Inventiveness	Experiments with different uses for objects; is flexible in actions and behavior
Cognition	Exploration and Discovery	Uses senses to explore; observes; makes things happen, watches for results, repeats; uses understanding of causal relationships
	Memory	Recalls and uses information in new situations
	Reasoning and Problem-Solving	Use a variety of strategies, imagination, and creativity to solve problems; uses spatial awareness to understand properties of objects and their movement in space; applies knowledge to new situations

Adapted from *Arizona's infant and toddler developmental guidelines* (pp. 29-33, 45-54), by ADE, 2014, Phoenix, AZ: ADE, and *Head Start early learning outcomes framework, ages birth to five* (pp. 12-15, 52-56), by USDHHS, 2015, Washington, D.C.: USDHHS.

How infants and toddlers communicate their thinking. For the purpose of my study, the philosophical perspective was that infants and toddlers have many expressive languages, not just verbal language, but also how they express their interests, curiosities, approaches, and theories. These many languages are a child's way of being that indicate even very young children are capable and competent of deep engagement and complex understanding (Edwards, Gandini, & Forman, 2012; Flavell, 1992). It is through children's often non-verbal, observable actions that we can understand their understandings of the world and where their scientific thinking becomes operational or more visible – smiles, hand and body movements, gestures, mimics, winks, furrows of the brow (Gambetti & Gandini, 2014). In my project, the participants collected and shared photographic and/or video evidence of children's interactions to study children's behaviors related to science rather than just what was expressed verbally.

There are noteworthy differences in development between infants and toddlers including their physical and verbal capacities. These contrasts are important to note as they help to define what scientific behavior may look like in a very young child. A one- to two-year-old toddler typically attained more coordinated movement and mobility than an infant over the course of their physical and perceptual motor development (USDHHS, 2015). Yet, an infant, within the context of positive caregiver relationships, can use perceptual information to organize a basic understanding of how objects can be used, adjust their balance in response to the environment, and can explore new ways of using their bodies from lifting their heads to crawling to sitting (USDHHS, 2015).

Additionally, an infant expresses language development and communication differently than a verbal toddler would; this may involve listening and responding to sounds and verbal communication of their caregivers as an infant birth to eight months then responding with words, utterances, or gestures as a six to eight-month-old (ADE, 2014). But as Flavell (1992) averred, it is this yet-to-develop language skill level that allows for researchers to more closely observe an infant's "nonverbal response patterns" to better understand their cognitive states and scientific ways of thinking and of approaching the world (p. 999). As they develop into toddlerhood, children typically become progressively verbal though also continue to represent their theories and understanding through a variety of languages (Edwards et. al, 2012). Even though infants and toddlers may not use speaking as a major form of communication in the way that a four- or five-year-old might, early childhood educators can understand a child's scientific thinking in an operational way through documentation of children's observable behaviors in conjunction with feedback from a mentor (Pelo, 2006).

Distinctively, Cheeseman and Sumsion (2016) used narrative stories, a form of observational documentation using videotaping of children's interactions along with researcher field notes and reflections, to "get closer to the infant's experience" and to better understand their perspectives, theories, and cues (p. 280). The researchers discovered that the narrative stories helped teachers to more intimately understand an infant's experience in play in lieu of verbal cues. Teachers conceptualized children's behaviors in relationship to complex thinking skills, such as seeing a child's understanding of physics through the way that the child manipulated and patterned materials, along with the interests and cognitive capacities of the infant (Cheeseman & Sumsion, 2016).

Despite their variances in development, the way that teachers interact with infants and toddlers and promote scientific thinking skills are still very similar. Therefore, a focus on scientific thinking skills of infants and toddlers is principal in ensuring that children can eventually develop according to age-expected science standards through preschool and elementary school (ADE, 2018; ADE, 2014; NGSS Lead States, 2013). Science for infants and toddlers is characterized by approaches to learning and cognitive skills rather than disciplinary science content, which becomes more effective to teach later in life (NGSS Lead States, 2013).

Scientific thinking. To capture evidence of toddlers' scientific thinking, educators can use a system of documentation by collecting photographs, anecdotal notes, and reflections of children's behaviors (Pelo, 2006). This documentation can then be evaluated and analyzed to determine children's potential understanding by integrating toddler cognitive and approaches to learning standards, as evidenced in Table 1 (ADE, 2014; USDHHS, 2015).

To stimulate infant and toddler development of scientific thinking skills, teachers must also practice effective science teaching. Effective science teaching, as Chalufour (2010) conferred, links scientific processes and skills with a multitude of opportunities for teachers to practice and apply. Educators are capable and competent of modeling scientific approaches like persistence, problem-solving, and questioning in their direct experiences with children (ADE, 2018). Teachers can observe, interpret, and reflect on evidence of children's learning through pedagogical reflection in response to children's, and their own, learning actions and initiatives (Scheinfeld et. al, 2008).

Quality professional development experiences must loop between the teacher's classroom experiences with children and external sources of content (Scheinfeld et. al, 2008), such as early childhood science. This guided the design of the consistent meetings discussed in Chapter 3. Through this integration of skills and pedagogy, teachers can learn how to exhibit science teaching and learning to support children's growth.

Teaching and learning science. In my innovation, science teaching and learning with referred to a teacher's ability to scaffold and demonstrate approaches to learning skills with children, not simply the conceptual understanding of science content like physics or biology. In the Head Start *ELOF* (USDHHS, 2015), scientific approaches would resemble natural skills in infants and toddlers: (a) actively exploring their environment, (b) understanding cause and effect relationships with materials, (c) using memory as a foundation for more complex actions and thoughts, and (d) using reasoning and a variety of strategies to solve problems. Consequently, according to Hong et. al (2013), teachers better support the development of children's cognitive skills when they participate in PLD that parallels both pedagogical approaches (e.g., the nature of science, research skills) and early childhood science (e.g., cause and effect, how things work, the properties of objects and materials) (USDHHS, 2015).

Ultimately, there needs to be a combination of teacher understanding of the child development content areas of science and approaches to learning and intentional instructional strategies based on developmentally appropriate practices. Teachers' implementation of this combination contributes greatly to children's abilities to transfer scientific thinking skills into a multitude of learning experiences (NRC, 2000). Teacher behavior, in turn, enhances a toddler's skills including working memory, stimulation and engagement, and cognitive flexibility (Hamre, Hatfield, Pianta, & Jamil, 2014; Thomason & La Paro, 2009).

To support the science development of infants and toddlers, early childhood educators could execute a variety of interactions: asking open-ended questions (e.g., what do you notice? Why do you think that happened); providing interesting, developmentally appropriate materials for children to investigate (e.g., placing mirrors on the floor for an infant's tummy time, or offering a basket of balls to toddlers outside); and modeling scientific vocabulary and conversations during interactions with children (e.g., describing the colors of paint a toddler mixed as the hue of a Palo Verde branch rather than just green, or narrating the teacher's actions during diaper changing) (ADE, 2014; La Paro, Hamre, & Pianta 2007). It is through these behaviors that teachers model such scientific thinking skills as inquisitiveness and wonder, observation of details, effective and descriptive communication, and an awareness of one's thinking and reflections, or metacognition.

Perceptions of teaching and learning science. Yet, understanding and implementing these scientific approaches in early childhood education does not come easy to all educators. This was especially significant in my leadership context due to the lack of available science-related college courses and workshops in Arizona. As described previously, early childhood teachers often feel inadequate, anxious, nervous, hesitant, and even fear in teaching and learning science with young children. This may be due to a variety of determinant experiential factors such as little to no formal experience with early childhood science coursework in college degree programs (Hong et. al, 2013). Unintended disconnects have been discovered between what science content teachers perceived that they were supposed to teach children and children's actual interests and relevant contexts (Jones, 2008). When teachers do not have formal educational experiences to understand children's scientific development, they may construct a hyper-focused identity as solely a teacher and not a learner of science (McKeown, Abrams, Slattum, & Kirk, 2016). Lack of professional learning support for observation, reflection, and analysis of data around children's learning makes science teaching and learning inaccessible. All these experiences impact the attitudes and beliefs that teachers hold about their capacities as teachers and learners of science (Jones, 2008).

Moreover, there are concerns that some pedagogical approaches to teaching and learning science are developmentally inappropriate and not responsive to children's interests, strengths, and lives (Goodrum, Hackling & Rennie, 2001). However, research also suggested that professional development experiences with teaching and learning science can transcend these challenges. For example, participating in inquiry-based professional development, a common cyclical approach to early childhood science, promoted teacher growth in self-efficacy (McKeown et al., 2016). That is, participating in science professional development increased the teacher's belief in their abilities to positively and meaningfully impact student learning and growth in science (Protheroe, 2008). In addition, knowledge and belief about teaching science to children (McKeown et. al, 2016), and participating in science learning themselves, enhanced teachers' disposition of confidence and scientific knowledge (Hong et. al, 2013). Teachers were more engaged with professional learning when they worked with mentor colleagues who have strong science content backgrounds (Jones, 2008). The link between science content as described in early learning standards and active teacher research heavily influenced the methodological approaches, design, and RQs in my action research project.

Implications for this Action Research Project

The research and best practices examined in this section indicated the importance of early childhood science PLD. These practices epitomized approaches inclusive of teacher as researcher, job-embedded practices, and teaching and learning early childhood science. Yet, a review of available science-related PLD in Arizona indicated a gap between research and implementation.

Professional development systems must recognize that both teachers and the children that they support can engage in scientific thinking. In the innovation, the word *science* is strategically used to describe infant and toddler development as well as the focus of the PD for a variety of reasons. First and foremost, it illustrates that very young children have the capacity to engage in complex scientific thinking which provides a foundation for their later ability to engage with science content (ADE, 2018; ADE 2014; NGSS Lead States, 2013; NRC, 2000; USDHHS, 2015). It also recognizes the capabilities of their educators in teaching and learning science (Chalufour, 2010; Scheinfeld et. al, 2008). Moreover, science becomes attainable and accessible to teachers and vital to their work with infants and toddlers. PLD not only relates to outcomes for educators but also outcomes for young children. As teachers develop their professional skills and knowledge in content through intensive PLD, they also improve their instructional practices and behavioral interactions with young children. Improved instructional practices have been shown to directly impact children's learning (Dunst et. al, 2015). Dunst et. al (2015) conducted a meta-synthesis of several professional development frameworks which indicated the key characteristics of effective PLD as authentic teacher learning and reflection, continuous feedback from a coach or mentor, and consistent follow-up in-between meetings. These key characteristics informed the design of my action research project and are discussed in the next chapter.

Subsequently, reflective inquiry practices in early learning PLD can help reinforce a teacher's capacity to "become increasingly proficient" at understanding and synthesizing content and making more informed, data-driven decisions (Broderick & Hong, 2011, p. 11; USDHHS, 2016). With consistent feedback and support from a mentor providing reflective opportunities through job-embedded support, educators can become more skilled at using documentation data related to children's development (Epstein & Willhite, 2015). In turn, this helps educators to understand what children know in terms of science content and then select activities and materials to scaffold learning (Broderick & Hong, 2011). At the same time, participating in this model of PLD helps teachers to be scaffolded in their learning around science. In this way, then, educators can strengthen their practices in getting to know young children's strengths as well as their own. They can use data from documenting and reflecting on learning to individualize instruction and help scaffold the development of children's scientific skills to create a more meaningful learning experience.

But this type of PLD does not happen in seclusion. Teachers, programs, and early learning providers must actively participate in early childhood science PLD that strengthens their capacities as local researchers of children's learning and offers support within their daily context to develop deeper understanding of the children that they serve. To ensure the PLD is relevant and meaningful to the context, it must include critical reflection around science through the study of documentation of children's behaviors through photographs, video and other evidence of their learning. This is a paradigm shift from focusing on the deficits of children and teachers when it comes to science. In contrast, emphasizing strengths-based approaches capitalize on methodologies that impact the self-perception of educators and their PLD skills. Typical, and often ineffective, professional development is characterized as prearranged sessions with little teacher input, lack of reasoning behind the approaches, and disconnection from teaching pedagogy and practices (NRC, 2000). My innovation offered a transformative type of learning opportunity designed to improve a teacher's ability to reflect on effective early childhood instructional strategies to support young children through developmentally appropriate science experiences. My action research project aimed to support reflective and relevant early childhood science PLD and to explore the impact of a job-embedded professional development model.

Conclusion

This chapter highlighted the current research and relevant studies related to the following three action research themes: (1) teacher as researcher; (2) ongoing and reflective job-embedded professional development; and (3) teaching and learning science. The literature review signified a common thread between early childhood science professional development and research-related behaviors and practices. Additionally, this chapter described the implications of these theories and perspectives on my action research project and its potential to impact the early childhood field in Arizona.

CHAPTER 3

METHODS

The purpose of this action research project was to more deeply understand how reflective, job-embedded early childhood science professional learning and development (PLD) impacted science teaching and learning and teacher perception towards science with toddlers. There were two RQs guiding the study:

1. How does reflective job-embedded early childhood science professional learning and development (PLD) impact educator learning?
2. In what ways do educator perceptions and understandings of science change after participating in job-embedded early childhood science PLD?

This chapter provides a description of the action research process and an overview of my methods. First, I describe the participants and setting. Then, I describe my PLD innovation including the use of science workshops, ongoing job-embedded reflective collaboration meetings. Finally, I provide my timeframe for implementation.

Participants and Setting

Participants. The participants were nine Early Head Start (EHS) teaching staff working with toddlers, ages one and two, at a Head Start program. Participation in my innovation was voluntary. Five education teams of two teaching staff each were recruited from center-based sites via email invitation sent to all EHS Teachers in the Head Start program. In response, the first five teaching teams to send in their permission and application together were selected: Kimberly and Ana Sofía (participants 1 and 2), Sally and Ada (3 and 4), Ellen and Adriana (5 and 6), Rosalind and Mae (7 and 8), and Marie (9). Marie engaged in the project individually and not in a teaching team. Her co-teacher, who may have been recruited to serve as Participant 10, was on medical leave during the time of my project. Eight of the participants were EHS teachers. Kimberly was a supervisor who served children and families directly in an EHS classroom. Kimberly worked in the role of EHS teacher during classroom hours but had additional supervisory duties over the EHS teacher in her classroom.

Four participants held an Infant/Toddler Child Development Associate Credential ™, the minimum qualification for an EHS Teacher position. Three held an Associate degree in Early Childhood, and two held a Bachelor in Child Development or Elementary Education. All participants were female ages 35-53, and the average age of participants was 42. The recruitment letter for participants is in Appendix B. Table 2 describes the recruited participants, their classroom teams, their job roles, and their previous experience with early childhood science PLD as indicated in their pre interview.

Table 2

Recruited Participants, Classrooms, Job Roles, and Previous PLD Experience

Toddler Classroom	**Participant Name**	**Job Role**	**Previous Experience with Early Childhood Science PLD**
1	Kimberley Ana Sofía	Supervisor/EHS Teacher EHS Teacher	1 PLD (science for ages 1-5) None
2	Sally Ada	EHS Teacher EHS Teacher	1 PLD (science for ages 1-5) 1 PLD (science for ages 1-5)
3	Ellen Adriana	EHS Teacher EHS Teacher	1 PD (robots for ages 3-5) None
4	Rosalind Mae	EHS Teacher EHS Teacher	None None

5	Marie	EHS Teacher	1 Conference (Head Start Science, Technology, Engineering, and Math Institute) Several webinars

EHS teacher job duties included providing experiences and materials to support children's development, implementing daily routines such as diaper changing and feeding, and meeting indicators for high quality early childhood practices and developmentally appropriate activities as measured by the *Classroom Assessment Scoring System*, or CLASS® (La Paro et. al, 2007). Using an evidence-based early learning curriculum, the teachers were responsible for implementing individualized and group lesson plans for eight one- and two-year-old children that supported development in accordance with the *ELOF*.

The EHS teachers had diverse experiences, interests, and knowledge and volunteered to participate in my project for a variety of personal and professional reasons. One reason they said they volunteered was to improve their teaching practices as professionals. For example, Ana Sofía, Ada, and Rosalind described that this project could help them to conduct ongoing assessment as part of their job responsibilities. They referenced the need to more clearly understand science toddler development in order to successfully mark levels of development on the program's early childhood assessment tool. Participation also helped the teachers attain 6.5 hours of professional development for the Head Start requirement of 15 hours (USDHHS, 2016).

Another reason they volunteered was to improve the science experiences for toddlers in their classrooms by implementing what they learned about toddler science directly into their everyday classroom environment. As Rosalind stated, they hoped to “work it in” (interview, October 25, 2018) to the classroom to enhance the experience for toddlers through new materials or different strategies for interaction. Mae wanted to help toddlers develop scientific thinking skills for their future learning while Marie expressed an interest in “understanding some new ideas about how toddlers especially can learn science” (interview, October 25, 2018). In the results section of Chapter 4, I explain how participation met their PLD interests and impacted their learning and perceptions of early childhood science.

Setting

Research was conducted on-site within one Head Start agency at five different EHS center-based toddler classrooms where the teachers worked. The agency was funded by federal Head Start monies. Administered through the USDHHS Administration for Children and Families (2018), EHS programs are designed to promote school readiness skills of children birth to age three from low-income families. EHS programs are required to integrate PLD into staff continuous learning and quality improvement processes. Two co-teachers served in each classroom (see Table 2) and spent their typical day directly in the classroom environment serving eight one- and two-year-old children. They had planning time before and after class and during naptime each day to gather materials, plan lessons, and review and document children’s learning. EHS programs met rigorous performance standards around programmatic structure that made them ideal settings for professional development research. Continuous, reflective PLD is required to meet the professional standards for Head Start requirements, and, thus, it was determined that EHS programs had the infrastructure to support PLD that went beyond compliance and served as an appropriate site for my innovation.

The professional development meetings were held every other week, either in the classroom space during naptime between 1-2 p.m., before class between 7-8 a.m., or after class between 3:30-4:30 p.m. after children had been picked up for the day. If a meeting occurred during naptime, the EHS teachers had to both focus on the content of the meeting as well as the supervision of children sleeping.

Role of the Researcher

I was considered an insider in terms of my relationship to the participants because I was employed by the program during the time of my project. My job responsibility as a program administrator was to strengthen the system of PLD for teaching staff. I developed policies and procedures around training, technical assistance, and professional learning. Furthermore, I managed budgeting for PLD, served as a mentor for PLD strategies, and aligned programmatic efforts with the *Head Start Performance Standards*, local, and national standards. As the researcher, I conducted the pre- and post-project interviews, facilitated the job-embedded collaborative planning meetings, and collected and analyzed the data. Qualitative data sources included researcher observational notes, transcripts of the job-embedded meetings, and interview responses. The data sources, corresponding RQ, and method of analysis are described in detail in Chapter 4.

Innovation

Action Research. I designed my innovation as an action research project. Action research is a cyclical, not a linear, process that focuses on a specific issue within an educational context (Mertler, 2014). The action researcher seeks resources and collects and analyzes data to enhance understanding of issues related to their own practice (Mertler, 2014). As Mertler (2014) explained, action research processes provide a method for investigating problems, answering questions, and helping design ways to improve education systems. As suggested by Brydon-Miller, Greenwood, and Maguire (2003), theory can be generated by action research practice that is collected and analyzed in an informed and critical way. Action research is characterized by the interconnection of action and reflection to construct a practical solution to a problem of practice (Reason & Bradbury, 2001). The intent is to make an impactful difference in the local community and construct new knowledge that impacts and moves forward the work (Brydon-Miller et. al, 2003; Mertler, 2014). Additionally, action research differs from traditional research in that it is driven by the improvement of local educational practice through concrete applications whereas traditional research typically focuses on building theoretical knowledge about the field and evaluating statistical significances (McMillan & Wergin, 2010). Action research is comprised of four stages: (1) the planning stage, (2) the acting stage, (3) the developing stage, (4) the reflecting stage (Mertler, 2014).

In my project, the planning stage involved identifying and refining the problem of practice topic, gathering additional information, and reviewing relevant literature (Mertler, 2014). I conducted the planning stage by compiling the first three chapters of this dissertation while simultaneously reviewing action research methodology. I also conducted cycles of research wherein I developed, tested, and refined interview questions that provided a foundation for the pre- and post-data collection methods eventually employed in my innovation. The acting stage involved implementing the innovation proposal and collecting and analyzing data (Mertler, 2014). An action plan, referred to as the implications in this project, was constructed from the results during the development stage (Mertler, 2014). The results were communicated through a reflection of the process in Chapter 5 (Mertler, 2014). The results would then inform future planning. In Table 3, I align the action research stages with in the implementation steps in my project as described above.

Table 3

Action Research Stages

Action Research Stage	**Description**
Planning	Identified and limited my problem of practice topic Gathered information and resources related to the topic Reviewed relevant literature related to the topic Developed and refined my research plan
Acting	Implemented the innovation Collected data Analyzed data
Developing	Developed an action plan (implications)
Reflecting	Shared and communicated research results Reflected on the action research process Used reflection and results to inform future planning

Adapted from *Action research: Improving schools and empowering educators, 4th edition* (p. 31), by C. Mertler, 2014, Thousand Oaks, CA: Sage Publications.

Procedure: A Three Component Approach to the Innovation

The innovation consisted of three integral components: participation between researcher and participants in (1) early childhood science workshops, (2) collaborative planning and reflecting meetings (CPRM), and (3) electronic correspondence. The three components were job-embedded, meaning they related to the teachers' work with toddlers and supported their ongoing professional practices. Figure 1 is a depiction of the process through which the three parts of my innovation relate to one another. The innovation began and closed with an early childhood science workshop. The collaborative planning and reflection meetings took place approximately bi-weekly depending on holiday and other scheduling conflicts. Electronic correspondence in Google Drive among participants was encouraged but not required throughout the innovation. Electronic correspondence was offered concurrently with the CPRM.

Figure 1

The Reflective, Job-Embedded Early Childhood Science PLD Innovation

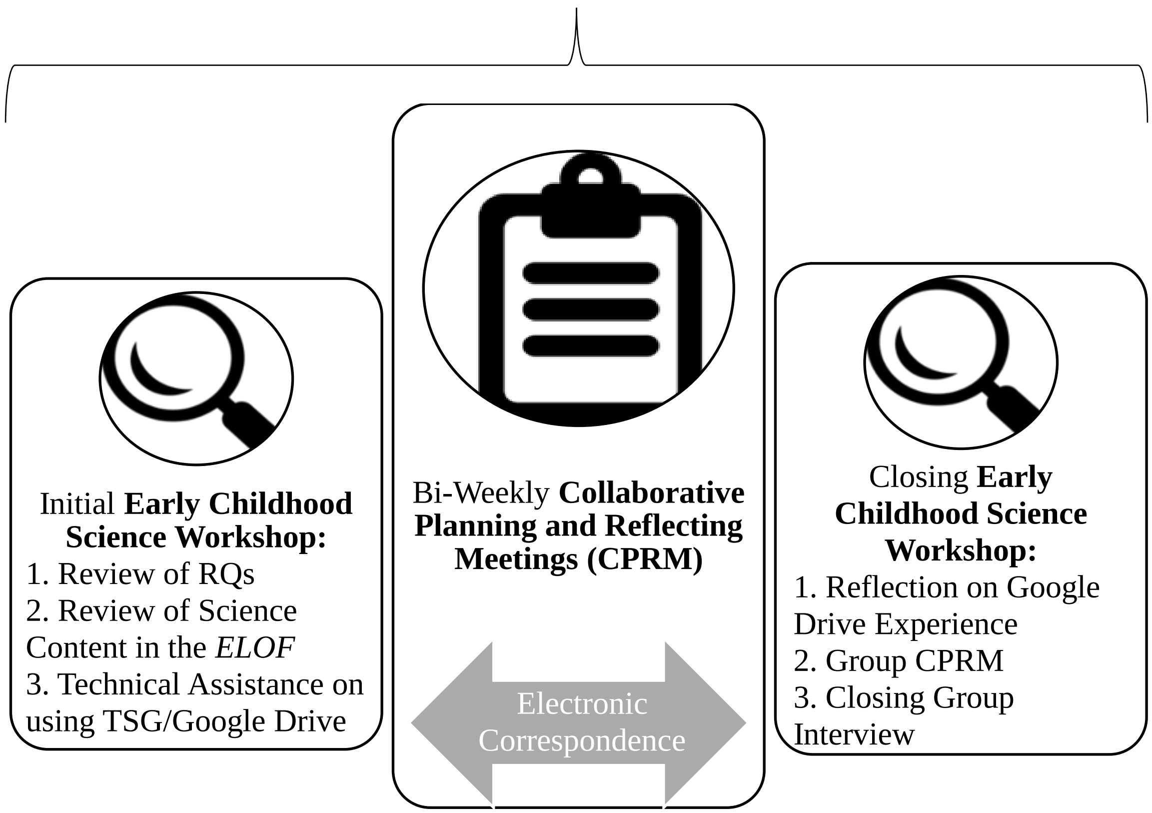

Figure 1: The innovation design featured three evidence-based components that informed one another and were integral to the overall early childhood science PLD experience for participants: science workshops, collaborative planning and reflecting meetings, and electronic correspondence.

Early childhood science workshops. Two early childhood science workshops of 90-minutes each were offered. One took place at the beginning of implementation in early November 2018 as an introduction to the overall project and general early childhood science skills. The second took place in early February 2019 at the end of the innovation and included a closing and final focus group interview. During both workshops, I connected the conversation to toddler science content as indicated in the cognitive and approaches to learning domains of the *ELOF* and *ITDG* (see Table 1).

The first workshop introduced participants to my innovation and the research questions. For the first fifteen minutes, I provided an overview of the three components with descriptions around the purpose of the innovation, how I will interact with participants in each component, the responsibilities of the educators in terms of participation, and the data sources. For forty-five minutes, we focused on early childhood science content and methods. During which, I asked participants to chart together in small groups: What do you think of when you hear ECE science? Next, we reviewed Cognitive and Approaches to Learning Standards (see Table 1) to note specific information related to scientific development of infants and toddlers. I prompted: what did you discover about children and science from the materials? I then presented on the research about children as scientists (see Chapter 1). I took notes on the discussion that followed my presentation in my researcher journal. These notes provided information about the participants' early childhood science knowledge and contributed to my understandings of the EHS staff. For the final thirty minutes, I provided technical assistance on the use of the online tools Teaching Strategies® GOLD ™ (TSG) and Google Drive. This portion included a walk-through of the digital platforms and step-by-step instructions on how to generate and download documentation reports from TSG use in the CPRM and how to upload and post documentation and comments in Google Drive for electronic correspondence in-between the job-embedded meetings. This ensured that the teaching staff knew how to use the digital tools effectively to share their data.

The closing workshop was designed as a forum to clarify why participants did not post in the Google Drive, conduct a group collaborative planning meeting, and provide an opportunity to share lessons learned and insights through the post-innovation interview. For five minutes, I asked participants to provide any additional insights into their Google Drive experience to better understand their why none of the participants uploaded photographs, anecdotal notes, or responses and to critically probe teacher attitude towards their experience with the innovation.

My actual implementation of the closing workshop differed from my original plan in two ways. First, I planned to spend more time clarifying any uploads and/or comments from Google Drive. Because the participants did not use Google Drive at any point throughout my innovation, I reduced the allotted closing workshop slot from 30 minutes to five minutes. Second, I resigned my position at the Head Start program in late January towards the end of the CPRM sessions. At this point, I did not have access to the EHS teachers during their work time. In order to provide an additional opportunity for job-embedded PLD, I conducted a final 60-minute whole group CPRM session during the closing workshop (see description of previous CPRM sessions below). I provided photographs and anecdotal notes of children's learning from a previous science activity with toddlers (Bucher & Hernández, 2016). The teachers helped facilitate the conversation using the notetaking guide.

For the final 25 minutes through the post-innovation focus group interview, I collected whole group data related to teacher perceptions and understandings of science and how they believed their learning was impacted because of participation. I closed the final few minutes by asking participants to share more information about their plans after having participated in this innovation. I provided a written reflection handout called *I Used to Think/Now I* Think. I prompted with these directions based upon the Harvard Graduate School of Education Project Zero thinking routine:

> When we began this study [of ECE science], you had some initial ideas about it and what it was about. In a few sentences, write what it is that you used to think about ECE science. Then, think about how your ideas [about ECE science] have changed as a result of what we've been doing. In a few sentences write down what you think now [about ECE Science after having participated in this project] (Harvard Graduate School of Education: Project Zero, 2018, n.p.).

This handout was designed to gather participants' reflections about their newly developed understanding and their reasoning for their perceptions. The workshop agendas are available in Appendix C. The closing workshop handout is available in Appendix D.

Collaborative planning and reflecting meetings. The CPRM were reflective and collaborative in nature and guided by a protocol, called a notetaking guide in my project, as outlined by Schroeder Yu (2012). There were four total bi-weekly CPRM meetings for Kimberly and Ana Sofía and five for the other four classrooms. CPRM were held approximately every other week between November 2018 and January 2019. During these 60-minute meetings, the participants and I reviewed and discussed observations and shared reflections and ideas related to the science learning. I guided reflection to help teachers make connections between their observations of children to their emerging understanding of scientific thinking skills as a professional development loop (Scheinfeld et. al, 2008). I asked questions designed to help increase awareness of the science learning and exploration taking place. The prompts included the following questions: How does the child's behavior relate to the Head Start *ELOF* developmental skills in cognition? What do you think that the child was thinking? How does this relate to what we know about children's scientific thinking?

The goal of the CPRM was to engage participants in reflective dialogue, critical thinking and analysis, and iterative planning focused on facilitating scientific thinking (Schcolnik et. al, 2006). I collected data from the meetings via the CPRM notetaking guide in Appendix A. Participants were responsible for bringing to the meetings photographs, anecdotal notes, videos, and other documentation of children's scientific skills to study using the notetaking guide. The EHS Teachers had the choice of selecting which videos and photos would best tell the story of the experience they planned to offer from their participation in the CPRM.

The CPRM notetaking was adapted from an evidence-based process for reflecting on interactions with children that I used in previous PLD facilitation at the community college. It served as a form of PLD by helping teachers probe into their own thinking to reflect, analyze, and make connections (Schroeder Yu, 2012). The purpose of the protocol was to provide a structure and for meeting discussions:

> As a member of a collaborative… planning team, teachers were compelled to think, articulate, question, explain, and problem solve with one another. Collaboratively we discussed what we observed as children's interests and brainstormed ways to expand on them. As a result, there was a move away from considering one's own viewpoint toward considering the multiple perspectives of the other members of the team meetings. Teachers discovered how their ideas were part of each other's ideas, from individual to shared meaning… (Schroeder Yu, 2012, pp. 150-1)

As such, the notetaking guide was designed to facilitate a safe learning environment for educators to reflect critically, learn about scientific inquiry skills, and translate it in their classrooms (Chalufour, 2010; Schroeder Yu, 2012).

During the meeting, I recorded the participant responses on the notetaking guide according to the discussion prompts in Table 4 and Appendix A. The EHS teachers followed along with the notetaking guide to share documentation of children's learning including photographs and videos of children engaged in science activities or with science-related materials and their anecdotal notes. Documentation, including photographs and anecdotal notes, pulled directly from teachers' ongoing observations in the early childhood assessment system TSG was encouraged. TSG was a digital tool that the EHS Teachers used to document children's learning, associate children's skills with developmental levels, create lesson plans, and access resources and webinars (Teaching Strategies, 2018). Using TSG supported the EHS teachers in conducting standardized, structured assessments around children's developmental levels and school readiness outcomes (USDHHS, 2016). Teachers used the tool through this process: took photographs and recorded anecdotal notes of how children interacted with materials and with one another in the classroom; uploaded the documentation into the online tool; marked the developmental level at which the child exhibited skills based on the photographs, anecdotal notes, and the teacher's understanding of child development; and analyzed results at checkpoints throughout the year to develop lesson plans, improve curricular experiences, and share progress with families.

The CPRM notetaking guide served as a framework for discussion during the CPRM. It was intended to provide thoughtful discussion derived from the documentation that teachers reviewed, reflected on, and analyzed during their participation (Schroeder Yu, 2012). I facilitated the conversation through open-ended questions in each indicated section of the notetaking guide below. During our conversations in the probing and brainstorming section of the CPRM, I asked the teachers to look closely at their documentation to see evidence of children exhibiting scientific thinking skills: (1) exploration and curiosity, (2) cause and effect, (3) reasoning and problem-solving, (4) creativity and inventiveness, (5) symbolic and pretend play (ADE, 2018; ADE, 2014; USDHHS, 2015). These topics related to the components of children's cognition and approaches to learning skills per the *ITDG* and *ELOF*. Through reflective practice in the CPRM, the teachers critically reviewed experiences that occurred in their classrooms to "understand whether or not their practice is working to meet predetermined goals" (Martin et. al, forthcoming, p. 17) as indicated in the *ELOF*.

In my study, I served as the facilitator. The teaching teams were comprised of the five EHS co-teaching staff members recruited to participate in this action research project. The teaching teams met with me as classroom pairs which fostered co-construction of knowledge and a shared sense of purpose (Brown-Easton, 2008; Wei et al., 2009; Wenger, 1998). Each meeting included the same open-ended questions to provoke reflective processes. The 60-minute CPRM process steps, time, and description of the actions of the participants and the researcher are listed in Table 4.

Table 4

The CPRM Process

CPRM Step	Time	Description
1. Reflecting from our last meeting	5 minutes	I guided a reflective conversation about the last CPRM and inquired about what transpired with children and science since the last meeting. I asked questions to check in with the teaching team: What are your general questions and ideas related to children's scientific thinking development? What did you notice in general since the last meeting – either

		what you've noticed the children doing or what you've noticed yourself doing?
2. Sharing Documentation	10 minutes	The teaching team presented while I recorded notes and questions for a facilitated conversation. The EHS Teachers shared photos or videos related to the science topic that occurred in their toddler setting without interruption from the facilitator.
3. Asking Clarifying Questions	5 minutes	I asked questions to clarify the event or activity. The teaching team shared their responses.
4. Probing and Brainstorming	20 minutes	The teaching team and the I collaboratively discussed our observations related to the scientific thinking skills being observed in the documentation. This was a point in the conversation where I probed the team to share what questions they had about themselves or about the children and to share their ideas and experiences to co-construct knowledge. I asked questions to help the teachers connect their observations to science content as listed in the *Head Start ELOF* or *ITDG*: What do you think the child was thinking? What questions do you think the children might be trying to answer? What do you think children were interested in during this experience? How does this behavior relate to our group topic of study?
5. Focusing the Conversation and Dialogue	15 minutes	Together, the teaching team and I engaged in co-inquiry by developing an action plan based on their collaborative ideas and discussion. In the action plan, the teaching team determined which materials and experiences to offer next to children to scaffold scientific thinking. I prompted with questions intended to help the teaching team refine their ideas for the action plan: What did you learn about the children? What did you learn about yourself? What do you want to pursue next regarding scientific thinking, based on this evidence?
6. Making a Final Decision	5 minutes	The teaching team finalized the logistics of their future actions: hypothesis for what might happen, what materials and set-up are necessary, how the experience would be documented for the next CPRM, and the date and time.

Adapted from "Professional development through the study of children's interests: The use of collaborative inquiry and documentation protocol among early childhood teachers" by G. Schroeder Yu, 2012, *Research Gate*.

Subsequently, in-between the CPRM, the presenting team incorporated their action plan into their classrooms and collected photo and/or video evidence to share at the next meeting. Educators could choose to upload these notes, observations, photographs, and other documentation into the Google Drive for feedback from the other participants or the facilitator.

Electronic correspondence. Another form for capturing participants' experiences was the optional use of Google Drive. Participants were offered the option to upload reflections, photographs, and notes to maintain correspondence outside of the CPRM every two weeks. I uploaded CPRM meeting notes into the Google Drive in-between meetings. The intent behind this component was to ensure that discussion and dialogue extended beyond the in-person interactions. The data in the Google Drive was accessible by the participants at any time, and there was opportunity to record electronic notes back-and-forth between participants and the researcher in real time. Moreover, the participants were able to review and respond to each other's comments. This made the Google Drive a virtual shared learning space that hopefully would promote a community of practice (Wenger, 1998). There was no electronic correspondence uploaded into the Google Drive; however, the participants' responses about their experience with the electronic correspondence was collected during the group interview.

The Integration of Three Components in the Innovation

All in all, the project included pre/post interviews, two science workshops, and either four or five CPRM which totaled 1,378 minutes of face-to-face time with the EHS teaching staff not including electronic correspondence. It was intended that by combining the early childhood science, bi-weekly CPRM, and electronic correspondence, the participants had a holistic science PLD experience. Job-embedded PLD support efforts provided me an opportunity to better understand teachers' efforts to develop their practical application and thinking skills. Moreover, it provided a dedicated time to give participants feedback and support related to their classroom context. In sum, through job-embedded PLD, I facilitated reflection and encouraged professional development. Likewise, I utilized the CPRM in conjunction with the science workshops to form one systemic support that could help move evidence-based practices into real-world applications with the EHS participants. Through this process of co-inquiry and reflection, I hoped my participants would make connections among their reflections, ideas, and thoughts about their work uncovered by using the CPRM notetaking guide. Then, it was my goal that the EHS teachers could implement these reflections, ideas, and thoughts in practice as teachers and as learners within the classroom. The integration of these three components of the innovation, combined, provided data to answer both of my RQs.

Timetable

The implementation of this innovation took place between October 2018 and February 2019. I recruited and garnered permission for participation from educators in mid-October 2018. The pre-project interview was conducted between October and November 2018 at the sites of the recruited participants. The first in-person science workshop occurred in early November 2018 along with a total of four or five in-person CPRM for 60 minutes approximately every two weeks from November 2018 to January 2019. The final closing science workshop occurred in February 2019; the post-project interview was conducted as part of the closing workshop with participants as a group. Participants also completed the reflection handout *I Used to Think/Now I Think* at the conclusion of the workshop. During Spring 2019, I transcribed the audio recordings, reviewed the documentation and meeting notes, and analyzed data as part of the results and outcomes section of my dissertation. The timeline dates, activities, and data collection methods are displayed in Table 5.

Table 5

Timeline of the Action Research Project

Date and Sequence	**Actions**	**Procedures**
October 2018	Recruitment of all EHS teaching staff participants	Sent and collected invitation letters and consent forms
October 2018	Pre-Project Interview	Conducted qualitative interviews with participants individually
November 2018	Data Review	Transcribed audio from interviews; Began identifying themes from pre-project data
	Initial ECE Science Workshop	Facilitated introductory 90-minute workshop with participating staff group
	Bi-Weekly Collaborative Planning and Reflecting Meetings (CPRM)	Facilitated 60-minute CPRM with classroom teams
	Electronic Correspondence	Uploaded CPRM notes into Google Drive
December 2018	Bi-Weekly CPRM	Facilitated 60-minute CPRM with classroom teams
	Electronic Correspondence	Uploaded CPRM notes into Google Drive

January 2019	Bi-Weekly CPRM	Facilitated 60-minute CPRM with classroom teams
	Electronic Correspondence	Uploaded CPRM notes into Google Drive
February 2019	Closing ECE Science Workshop/ Post-Project Interview	Closed out innovation with lessons learned and participant plans for the future; Conducted qualitative focus group interview with participants
February and March 2019	Data Review/ Analysis Drafting	Transcribed data from interviews, closing workshop handout, and CPRM; Compiled data and reflected on experience; Analyzed innovation results

Conclusion

In conclusion, this chapter described the methodologies of this early childhood science PLD action research innovation including the recruitment of participants, the setting, innovation activities, and timeframe for implementation.

CHAPTER 4

DATA ANALYSIS AND RESULTS

The purpose of my action research project was to understand how reflective, job-embedded early childhood science PLD impacted Early Head Start (EHS) teacher learning and perceptions towards integrating science teaching into their toddler classrooms. Two questions guided my research: (RQ1) How does reflective job-embedded early childhood science professional learning and development (PLD) impact educator learning? (RQ2) In what ways do educator perceptions and understandings of science change after participating in job-embedded early childhood science PLD?

To address these questions, I designed an innovation with three professional learning and development (PLD) components: (a) science workshops at the start and conclusion, (b) collaborative planning and reflection meetings (CPRM) about toddler science introduced during the workshops, and (c) optional electronic correspondence in-between the CPRM. In this chapter, I explain the qualitative data sources, describe how data were analyzed, and produce the results and overall findings of the project.

Qualitative Data Sources

The data were collected through qualitative methods before, during, and after my innovation project. Qualitative data sources were included: pre/post interview transcripts, CPRM session notes, the reflection handout *I Used to Think/Now I Think*, and my memo-writing in a researcher journal. The data sources, corresponding RQ, and methods of analysis are listed in Table 6.

Table 6

Data Sources, Corresponding RQ, and Analysis Methods

RQ	**Qualitative Data Sources**	**Analysis Methods**
(1) How does reflective job-embedded early childhood science PLD impact educator learning?	a) CPRM Meeting Transcripts b) Researcher Journal/ Memo-Writing	Grounded Theory Analysis: Open Coding Focused Coding Selective Coding
(2) In what ways do educator perceptions and understandings of science change after participating in job-embedded early childhood science PLD?	a) Pre/Post Interview Transcripts b) *I Used to Think/Now I Think* handout c) Researcher Journal/ Memo-Writing	

Pre- and post-project interviews. Pre- and post-project in-person interviews were conducted to gather participant perceptions and understandings of science. These were audio-taped with participant permission. Both sets of interviews were transcribed verbatim by REV.com, an online confidential audio transcription service. I compiled the participants' responses from the *I Used to Think/Now I Think* handout into one document. This handout was provided at the final portion of the group interview in the closing science workshop. I used this handout to gather participant reflections as additional sources to triangulate with the interviews and CPRM session notes.

Pre-project interviews. Pre-innovation interviews were collected from all nine participants. The following questions were asked to participants individually prior to the innovation:

- What has been your experience with science? How do you feel about science?

- Define early childhood science.
- Describe what early childhood science professional development you've participated in.
- What is your understanding of teacher as researcher?
- What are your hopes for participation in an early childhood science professional development project?

***Post-project interviews*.** Seven of the nine EHS Teachers attended the closing science workshop and post-innovation group interview at the end of my innovation. The following questions were asked to participants in the group interview:

- Define early childhood science now.
- What is your understanding of teacher as researcher now?
- What did you learn about yourself from your participation in this project?
- What did you learn about your role as an EHS teacher from your participation in this project?
- How did it feel to participate in the Collaborative Planning and Reflection process?
- What do you plan on doing for early childhood science PLD in the next year?

CPRM notetaking guide and documentation. During the CPRM, teachers followed the notetaking guide (see Table 4 and Appendix A) to reflect on documentation of children's learning, connect their observations to early childhood science, and track ideas and responses. First, the EHS teachers shared an experience they observed in their toddler classroom. Next, I guided reflective conversation by asking questions about their observations which, then, we connected to toddler science development. Finally, the EHS teachers developed an action plan to implement before the next CPRM session. I handwrote field notes of their responses on the notetaking guide. The CPRM meeting notes provided data to understand the impact of reflective, job-embedded PLD on educator learning about their and their toddlers' learning. The written CPRM notes were compiled and analyzed after the innovation. In Google Drive, participants could optionally comment on the CPRM field notes in-between the meeting dates. Participants did not comment or post, therefore no Google Drive data were reviewed.

Researcher journal and memo-writing. I kept a record of my thinking and observations in a researcher journal. These were captured after the pre-project interview, after the initial science workshop, during the implementation of the CPRM, after the post-project interview, and during the coding process. Throughout implementation, I reflected on patterns in the participant responses and continuously connected them to the literature guiding this project in my journal. I highlighted the following words or closely related words: curiosity, explore, interpret, inquiry, learn, notice, observe, persist, problem-solve, question, reflect, research/ researcher, think, wonder. In this way, I connected significance within the participants' responses to early childhood science. While I analyzed, my researcher journal also served as my analytic memo-writing – a place to capture my observations of comparisons, connections, and consistencies as I coded. Memo-writing is an important part of qualitative research and "the engine of grounded theory," explained Gordon-Finlayson (2010, p. 164). Through memo-writing, I developed hypotheses about the connections I observed and compared them to the data categories that emerged from the coding cycles (Glaser & Holton, 2004; Saldaña, 2016). I concurrently reviewed the data and recorded my "evolution of understanding" (Saldaña, 2016; Weston et. al, 2001, p. 397). Ultimately, I generated theories about the data through the memo-writing process (Saldaña, 2016). These assertions are discussed in the results section of this chapter.

Qualitative Data Analysis

Analyzing the data was the next critical step in my action research process. It served as the acting stage of my own action research (Mertler, 2014). Using grounded theory to guide my analysis, I was able to evolve the raw data collected from participants into the results and interpretations (Ivankova, 2014).

Overview of grounded theory. Grounded theory is an inductive qualitative approach where theories are grounded or rooted in the data collected by the researcher (Charmaz, 2014). The difference between grounded theory and other methodological approaches is that grounded theories emerge throughout the process of reviewing data. I chose to employ grounded theory approach because, much like the theory of teacher as researcher, it recognized that theory is an "ever developing entity" and is iterative (Glaser & Strauss, 2006, p. 32). I engaged in a rigorous process of continuous interaction between my data coding, connecting, and emerging analysis (Charmaz, 2014). This was done through simultaneous coding in the electronic coding analysis tool *HyperResearch* and memo-writing in my researcher journal.

For example, I noted after the pre-project interview that several participants related their perception of science to their previous early childhood or formal high school experiences with science. I posited that their responses during CPRM and the post-project interview might give me insight into how their participation in this project impacted their perceptions of early childhood science before and after. Thus, I made the following entry:

> Interviews seemed to reference a certain level of comfort with science. I will need to check back on this emerging theme once I collect the post-project interview responses. Will this be evident in the CPRM data as well? Tying earlier experiences with science seems to relate to RQ2 about teacher perceptions of early childhood science now as adults. How did the teachers think about early childhood science when they finished the project compared to when they came into it? Sally and Adriana referred to science as "scary" or "hard". Could be *in vivo* codes to highlight. These also may lead to code categories to pursue during the coding process – is there something about emotions related to science based on their previous experience? (researcher journal, November 2, 2018).

Throughout the implementation of the CPRM sessions, I analyzed the emerging themes in another entry. My continuous reflection and analysis of data exhibited the grounded theory approach as I developed theories rooted in what the EHS teachers said about their participation:

> Some trends I noticed in our conversations include…the teaching staff saying they are "seeing" science more often in their work (and perhaps different than their original interpretation of science). They seem more comfortable with science as they mentioned that they see it in toddlers' interactions everyday now. There are also some interesting descriptions of their observational skills which may relate to their teacher researcher skills. I saw [a level of comfort with science] in their interview responses. It appears that the teachers are becoming more confident in their abilities to support toddler science now that they are actively reviewing and reflecting on it through the CPRM. These are important themes I would like to revisit when I begin coding the CPRM note taking guides... (researcher journal, December 8, 2018).

During the coding process, emerging themes like this one were compared again to the post-project interviews and the CPRM field notes. I explain my grounded theory process in the next section about data analysis procedures.

Data analysis procedures. I used a constant comparative method, a method of analyzing data in order to develop a grounded theory. I simultaneously coded, compared codes to each other, categories, and properties, as well as the literature I had reviewed (Charmaz, 2014; Taylor & Bogdan, 1998). Constant comparative analysis is a method that uses every part of the data collected by the researcher to make sense of and refine my theories about what participants learned and perceived (Charmaz, 2014, p. 182). I identified meaning units, or codes, from the data. The coding categories were teacher as researcher skills, pedagogy development through PLD, and toddler science.

The three levels of coding I used were open initial, focused, and selective. Through this process, I moved from highlighting verbatim responses in the first level of coding to finding recurring categories. Then, I refined the categories into subcategories by saturating the data, subsequently finding the deepest level of core patterns and relationships (Charmaz, 2014; Willig, 2008). I compared my memo-writing observations to the literature review. I triangulated my memo-writing, the CPRM session transcripts, interview transcripts, and the data that I coded to verify consistency and patterns in the responses (Patton, 2015). Triangulation contributed to the credibility of my findings (Patton, 2015). I concluded that my data collection methods were sound because they stayed true to the participant voices through *in vivo* coding triangulated with the quality of data from multiple sources concerning the participants' perceptions (Noble & Smith, 2015; Saldaña, 2016). I constructed the theme-related findings listed later in this chapter based on what I discovered through grounded theory analysis with the three cycles of coding. An example of the data analysis process from coding to theme is in Appendix E.

Open coding. In my first level of coding, I employed open coding line-by-line and focused on phrases that seemed pertinent in both the interviews and the meetings. I utilized my background knowledge of early childhood science development and PLD to interpret which data were crucial in answering my RQs and pursuing further analysis (Böhm, 2004). Because my RQs involved trying to understand participants' perceptions about toddler science and their learning through job-embedded PLD, it seemed appropriate to examine evidence of their thinking using direct quotes. This meant that I highlighted participants' words and phrases related to the following categories: how the participants described children's scientific development, how the participants described their own professional learning and development, and how the participants explained their view of science. I started my open approach with *in vivo*, or verbatim, coding to capture the participants' voices in their own words (Saldaña, 2016). *In vivo* coding helped me encompass the language that the participants used to describe their experiences with job-embedded early childhood science PLD (Saldaña, 2016). I created a codebook in *HyperResearch* to track these codes.

By comparing data across sources, I found common categories around view of science, professional learning through teacher as researcher skills, and descriptions of toddlers' scientific development. For instance, my *in vivo* coding highlighted several phrases from the pre/post project interviews amongst the participants such as amazed, excited, extremely doable, girls weren't, hard, high school science, lack, math-based personal experience, and scary. Through memo-writing, I determined that these codes indicated a common category of the participants' view of science. As noted in my researcher journal, there was reference "to personal experiences with science in high school and college and early experiences. Through these phrases, the teachers referred to their perceptions before and after the project" (February 10, 2019). Additionally, I added several codes to my codebook while reviewing the CPRM including words/phrases like ask questions, clarity, intention, looking for details, observe, plan better, reflection of self, see things differently, and teacher researcher. I noted that the teachers exhibited their inquiry process, "learned teacher as researcher skills, and identified their own changes in thinking [and] their approach to teaching" (February 15, 2019). I connected these phrases to how reflective, job-embedded PLD impacted educator learning. From my memo-writing, I determined that the common category among these multiple references was professional learning through teacher as researcher skills. A few examples of my open coding process using *in vivo* codes, coding categories, and memo-writing are provided in Table 7.

Table 7

Examples of Open Coding Process

Teachers	***in vivo* Open Codes**	**Common Category**	**Memo-Writing**
Adriana Ana Sofía Ellen Marie Sally	amazed, excited, extremely doable, girls weren't, hard, high school science, lack, math-based personal experience, scary	View of Science	… Referred to personal experiences with science in high school and college (e.g., not fond of it) and early experiences (loved it) …these codes relate to my RQ2…how participation changes perception of science. Through these phrases, the teachers referred to their perceptions before and after the project. There seems to be a separate category I'll want to pursue about teacher perceptions of toddler science [not themselves as adults] …
Ada Adriana Ana Sofía Ellen Kimberly Mae Marie Rosalind Sally	ask questions, clarity, intention, looking for details, observe, plan better, reflection of self, see things differently, teacher research	Professional Learning through Teacher as Researcher Skills	…Teachers are practicing research skills here, learning teacher as researcher skills, and identifying their own changes in thinking/their approach to teaching (pedagogy). This relates to RQ1 about how reflective job-embedded PLD impacted educator learning.

Focused coding. Second, I applied focused coding to the coding categories developed through open coding. Through focused coding, I refined emerging subcategories and themes from the qualitative data (Charmaz, 2014; Saldaña, 2016). I chose to use focused coding to keep the coding process “simple, direct, analytic, and emergent” (Charmaz, 2014, p. 19). According to Saldaña (2016), a focused coding approach follows *in vivo* coding well. During this process, subcategories not previously determined became visible. I compared codes with other codes to determine patterns. I assessed the codes to the overall data and defined their relationships using memo-writing (Charmaz, 2014). I maintained my grounded theory approach by rooting the codes in what participants said about their own learning and perception and assessed codes for their “adequacy and conceptual strength” (Charmaz, 2014, p. 140). Codes were then combined to form subcategories that served as the next step towards identifying key themes and patterns in the data (Charmaz, 2014; Saldaña, 2016).

For instance, I developed the focused code that professional learning through teacher as researcher involved specific inquiry skills. Through memo-writing, I noted that the consistent codes of “question”, “going back”, and “thinking about” were related to what they learned about reflective practices as teacher researchers. I determined that the teachers reflected on their work, questioned their interactions with children, and exhibited curiosity about their next steps. Additionally, frequent descriptions of children’s abilities emphasized the important learning that occurred about toddlers and science. I re-evaluated the codes that were sorted under this subcategory and noticed that the teachers often referred to their surprise or awe of how toddlers problem-solve, engage, and persist. Because this became more frequent by the final CPRM sessions, I developed the focused code that teachers established more detailed phrases to describe toddlers as capable researchers. Table 8 shows examples of the focused coding process using memo-writing to move from the common categories in the first cycle of coding into the focused codes I developed. The key focused codes that emerged related to teacher as researcher, early childhood science, and professional learning are bolded.

Table 8

Examples of Focused Coding Process

Common Categories from Open Coding	**Memo-Writing**	**Focused Codes**
Professional Learning through Teacher as Researcher Skills	The responses with the words “question”, “going back”, “thinking about” and the actual questions connect with the inquiry process (reflecting and thinking)	The teachers **questioned their interactions*** with children. The teachers were **curious** about next steps. Through the study of documentation, the teachers **reflected on their work**. The teachers used **questions to guide their inquiry** process.
Descriptions of Toddler Scientific Development	Here, the participants describe the scientific skills that toddlers exhibit. They are much more detailed now than they were in the pre-project interviews. There seems to be a consistent theme of surprise with the capacities of toddlers. This occurs during the conversations in the “probe and brainstorm” and “engage in conversation and dialog” sections of the CPRM. Are the teachers seeing cognitive and scientific thinking development as a result of observing children through play? References to focus, attention, and engagement support this emerging	The teachers started with a **general idea** of what toddler science skills could look like in action. The teachers established **more detailed phrases** to describe toddlers as **capable researchers**. Their **learning** was evident in phrases of toddlers’ **observable actions**.

	code…Also referenced in the closing interview that toddlers speak through their actions and are capable of doing science.	

Table 8: Bolded words are the focused codes that emerged related to teacher as researcher, early childhood science, and professional learning.

Selective coding. In the selective coding phase, I generated larger "theoretical schemes" to construct assertions around what the teacher participants learned and impacts on their perceptions (Bulawa, 2014, p. 157; Glaser & Strauss, 2006). Using Code Weaving, I condensed the primary codes generated from *in vivo* and the "categories, themes, and concepts" that emerged from focused coding into just a few, brief sentences (Saldaña, 2016, p. 276). Codeweaving provided me with a birds-eye view of the data and prompted more detailed evidence to generate my theories (Saldaña, 2016; Glaser & Strauss, 2006).

For example, my selective coding pulled out a theoretical theme around the teachers' learning about toddler science. The keywords that teachers used to describe toddlers as capable researchers along with their frequent references to observable science behaviors led me to write the words *capable, researchers, learning*, and *observable actions* in my researcher journal. I asked myself to consider what the collective data were telling me about the teachers learning through job-embedded PLD and their perceptions of science. In my memo-writing, I also indicated my analytic thinking through this process by rearranging the key focused codes to try and make sense of the themes. I arranged those keywords in several variations which made me realize "teachers saw toddlers as capable scientific thinkers now. Teachers understood how observable toddler behaviors showed them that toddlers were doing science" (February 20, 2019). I followed the Codeweaving process of evolving my memo-writing field notes into a summarizing overarching sentence (Saldaña, 2016). Table 9 provides an example of the notes between my focused coding, selective coding with Code Weaving, and the assertions I developed from the data.

Table 9

Example of Selective Coding Process

Focused Code Notes	**Selective Coding Memo-Writing**	**Assertion**
The teachers established more detailed phrases to describe toddlers as **capable scientific thinkers**. Their **learning** was evident in phrases of toddlers' **observable actions**.	(capable, scientific thinkers, learning, observable actions) = Teachers saw toddlers as capable of learning science. Teachers understood how observable toddler behaviors showed them that toddlers were "doing science".	**Teachers learned about toddler science development.** They included details of observable actions which illustrated their increased awareness of toddler science development. They applied the toddler cognitive domain to specific, observable behaviors in their classroom.

Results and Findings

The results and findings from my qualitative data analysis are categorized into two main sections. The first section describes the impact of reflective, job-embedded professional development on EHS teacher learning (RQ1). The second section explains the ways in which the participants' perceptions and understandings of science changed after participating in my job-embedded, early childhood science PLD opportunity (RQ2). In each section, the main themes along with supporting subcategories are presented.

Results for RQ1. RQ1 focused on the impact of job-embedded professional development on EHS teacher learning. In my innovation, the job-embedded PLD was provided through consistent collaborative planning and reflecting meetings (CPRM) wherein teachers studied documentation of toddlers' science experiences using the notetaking guide. I pulled two major findings: teachers learned about and acquired tools to become "teachers as researchers" (Henderson et. al, 2012; Lewis et. al, 1999; Edwards & Gandini, 2015) and teachers learned about toddler scientific development.

Teachers learned about and acquired tools to become teachers as researchers. The EHS teacher research capacities of observing, questioning, reflecting, and documenting were deepened and progressed by participating in my project. Results indicated that the EHS teachers engaged in teacher research, or their own professional learning through the reflective CPRM process. In the CPRM, the teachers described and shared documentation such as photos and videos, responded to questions that clarified the event or activity, collaboratively discussed observations related to scientific thinking, reflected on their learning related to the data, then used reflection and results to inform action planning. While their practical learning involved implementing more meaningful science experiences for toddlers (discussed later in this section), I noted in my memo-writing that the teachers seemed to be reflected on the pedagogy of their teaching. In other words, the CPRM provided a space for inquiry where the teachers learned teacher research skills such as observing problems in their classrooms, pausing and reflecting, and implementing solutions to support children's learning (Marsh & Gonzalez, 2018a). This process was reflective and built upon their previous experiences through the CPRM. Through each session, the teachers increasingly developed their observing, questioning, and reflecting skills and moved into a deeper, more refined practice of teacher research.

Teachers developed their teacher research skills. The EHS teachers developed teacher research skills through a set of actions that they carried out during the CPRM – noticing, pausing, observing, discussing, questioning, reflecting for next steps, and implementing the action plan. First, the teachers made observations, paying "close attention" (Kimberly & Ana Sofía, November 13, 2018) and "looking for details" (Rosalind & Mae, December 14, 2018) in the photos and videos. Next, they discussed their observations, which the participants explained made them more aware of what was happening with children's development in their classroom. They asked several questions of their work: "Is [the experience] engaging?" (Kimberly, November 27, 2018); "how do they solve problems?" (Sally & Ada, December 11, 2018); and how do my practices impact children's learning? Then, through reflection, the teachers hypothesized, connected, and planned for their next action steps. "Reflection brings clarity and intention" (Rosalind, January 14, 2019) towards effective teaching practices. Reflection grew teachers' thinking since they "started to see [teacher interactions] differently" (Ana Sofía, November 27, 2018). Having developed theories about what the data in their observations meant, the teachers planned to scaffold the experience to "see what happens next" (Sally, December 11, 2018) and to reassess and adjust the environment based on what they learned. The outcome of the inquiry process was the capacity to "plan better" (Kimberly, December 11, 2018) then "implement [plans] into the classroom" (Kimberly & Ana Sofía, November 27, 2018).

Ana Sofía summed up her inquiry process, "I found myself being a researcher more" (November 27, 2018). Framed by a sense of curiosity about the toddlers' thinking, the teachers learned that their research was "something to be explored and ask questions about" (Marie, December 14, 2018) and needed to be discussed in detail for "reflection of self" (Kimberly & Ana Sofía, November 27, 2018).

Teachers improved their observational skills. The EHS teachers improved their observational skills through the CPRM sessions. Refining observational skills helped them to become teacher researchers that studied documentation of children's learning. The EHS teachers overwhelmingly agreed that observations were a critical part of their pedagogy. Nevertheless, the development of observational skills came with some challenge. The teachers overcame this challenge by strategically and intentionally honing this skill. Kimberly divulged, "It was hard not to do teacher things and interject" (December 19, 2018). Accordingly, Marie developed a goal for herself to "just sit and observe" (December 19, 2018). Marie described she "got caught up in the plans of the teacher" (December 7, 2018) and wanted to remember to notice children's reactions. Ada and Ellen both realized they wanted to practice observational skills instead of intervening and interrupting children's engagement. A strategy that emerged for this challenge was to use guiding questions from the CPRM to focus and progress their research skills. During the final CPRM, all nine EHS teachers practiced some of the questions they used in their reflective process: What did the children say or do? How did they interact with the materials and/or one another? Did they do anything unexpected with the materials? How do their interactions relate to cognitive development?

As they asked themselves these questions, the teachers paused mentally and physically to let toddlers explore. As Kimberly reflected, "I had to check myself" (November 27, 2018) a few times. During a CPRM session, Kimberly and Ana Sofía shared their observations of toddlers investigating soil. Several children scooped soil from a larger bin and poured into other plastic containers. Soil spilled out onto the floor. Another child used a hand-held shovel to pile soil on top of the table. Kimberly explained, "It took everything within me not to just sweep it up" (November 27, 2018). She told herself that "even though it's messy, it's science" (November 27, 2018). She realized the toddlers were interested in the texture of the soil and in the act of scooping, pouring, and repeating. "Fixing" (November 27, 2018) and adjusting her interactions showed Kimberly's increased comfort level and her commitment to observation as a way to understand the toddlers' thinking. Such pausing to notice children's interactions impacted teachers' observations of toddler scientific thinking development.

Teachers learned reflection skills that impacted their teaching. Throughout the CPRM, the EHS teachers developed the teacher research skill of reflection. The probing, brainstorming, and dialogue prompts helped them connect their learning of toddler science with how they planned to support toddlers in their classrooms. Interactions on the part of the teacher along with physical environment set-up were key conclusions from the CPRM sessions. Teachers learned that open-ended materials promoted engagement and scientific thinking. Throughout their investigations, the classrooms offered a variety of learning materials from sand and water to natural materials and flowers to cardboard boxes. "Availability of materials" (Sally, November 19, 2018) gave "freedom to explore" (Kimberly & Ana Sofía, December 19, 2018), which in turn provided multiple possibilities for teachers to observe children's interests and skills. Plus, the teachers selected materials based on their reflections during the CPRM. Questions that funneled their choice for materials included, "What can they do with the materials?" (Sally & Ada, November 19, 2018; Marie, November 16, 2018) and "What is interesting about the materials?" (Sally & Ada, November 19, 2018; Marie, November 16, 2018). Toddlers' sustained interests led the teachers to select variations of the same materials over the course of their CPRM sessions. For instance, Kimberly and Ana Sofía tried out containers and recycled materials made from plastic, metal, and wood. Sally and Ada used sand or water with various measuring, stirring, and sifting tools. Ellen and Adriana continued to offer fresh flowers and fabric flowers to children with a light table, in the sandbox, and in the classroom. Rosalind and Mae focused on how children move their body indoors and outdoors. Marie provided toddlers with modified shapes, sizes, and types of cardboard boxes. The EHS teachers discerned their strengthened abilities to follow the lead of the toddlers in selecting the next iteration of science materials because "the ideas come from the children" (Sally & Ada, November 19, 2018).

In addition, the teachers learned that their teaching role was to provide both open-ended support and open time for children to explore. This was evident in the consistent description that teachers needed to be flexible, let toddlers have time to explore, and "see how far they can go" (Marie, December 28, 2018). The EHS teachers found themselves implementing "more in-depth questions" (Ellen & Adriana, December 4, 2018 & December 20, 2018) and responding to toddlers' non-verbal cues as effective teaching strategies. They also reasoned that their strategic interactions went beyond the science activities studied during the CPRM. Rosalind explained building relationships with children throughout the year and "knowing their background helped [teachers] understand them better and meet them where they are" (November 29, 2018) in their development. Setting up the environment to promote open-ended play was conducted in conjunction with scaffolded teacher interactions that emerged from the teachers' observations during the CPRM. Through intentional classroom environment design, the EHS teachers understood what drove children's scientific interests, which uncovered "a lot about who they [were] as individuals" (Kimberly & Ana Sofía, November 27, 2018). Marie explained how her participation in reflective, job-embedded study of documentation improved her ability to "maneuver with children" (Marie, October 25, 2018):

> …I learned…that they are asking questions. And I never thought of it that way. I would think, oh, I want to teach you something, I'll present this, and we'll ask questions about what you think is happening… But what are the questions that are generated from them? What do they want to know because… they don't always care about learning about what we want to teach them, they want to learn something on their own – and that's the most organic way of learning, the pure interest. So, you have to ask yourself, what are they asking? What do they want to know about? Observe, and then plan again. And that was kind of the process, and I had never done that process before (Marie, October 25, 2018).

Teachers integrated the study of documentation with their ongoing early childhood assessment. Furthermore, the teachers learned how toddler science contributed to their ongoing assessment of children's learning through TSG. The EHS teachers referenced how the study of documentation supported their responsibilities as EHS teachers. Documentation helped teachers "have evidence of the work [children] are doing" (Mae, January 17, 2019) in order to "push them forward to have their needs met" (Rosalind, January 17, 2019). Additionally, their experience with developing and asking questions to the toddlers supported "CLASS® Facilitation of Learning and Development goals with [their] professional development coach" (Ellen & Adriana, December 20, 2018; La Paro et. al, 2007).

Teachers learned about toddler scientific development. The EHS teachers also learned about the capacities of toddlers to be scientific thinkers who exhibited their understanding of the world through their actions with materials, the environment, and each other. This learning occurred through the study of documentation at the CPRM. Going through the reflective process with documentation was an “empowered” and “rewarding experience” (Marie, December 28, 2018).

Teachers learned that toddlers are capable and competent learners. The EHS teachers recognized the capacities of toddlers to be scientific thinkers. “The children were always doing science, we’re just focused on it now,” Ana Sofía pronounced (November 27, 2018). The participants noticed – repeatedly with surprise and awe – that toddlers were “intentional” (Kimberly & Ana Sofía, December 11, 2018; Sally & Ada, November 19, 2018), “competent” (Ada, January 8, 2019), and have their own ideas. For example, teachers learned that children were engaged for long periods of time when materials and support from teachers was relevant to their interests. Ellen clarified that when children are interested in the materials and the experience, “it captures [their] attention for the time” (January 15, 2019). “People say [toddlers] will get bored” (Kimberly & Ana Sofía, November 27, 2018) or have short attention spans. However, the toddlers were engaged and persisted, therefore “capable of more than we think sometimes” (Marie, November 16, 2018). Through the reflective planning sessions, Ana Sofía became “fascinated with their attention span” (November 13, 2018). Being “busier than [people] anticipate” (Marie, December 14, 2018), the EHS teachers were “surprised that [they] stayed that long and that engaged” (Rosalind & Mae, November 29, 2018) and impressed that they “persisted” (Rosalind, January 17, 2019). The time during which toddlers persisted in any given experience ranged from 15 minutes to over an hour. The intentional selection of materials seemed to be a key learning point for the EHS teachers; as Ellen and Adriana reflected, “even though it was 15 minutes, it was an intense learning experience” (January 3, 2019). The toddlers focused on their investigations because they were “real curious” (Kimberly & Ana Sofía, November 13, 2018 & November 27, 2018), “amazed” (Ada, November 27, 2018; Ellen, January 3, 2019), and “seemed to be thinking” (Sally & Ada, January 8, 2019) about what they could do with the materials. The teachers learned about toddler capacity to stay focused and engaged with science experiences.

Teachers learned that toddlers communicate their scientific thinking skills through action and play. The EHS teachers learned that toddlers’ cognitive and approaches to learning skills became more visible through action and play in the CPRM documentation. Sally and Ada explained, “They don’t have to be able to talk for us to understand they’re exploring” (November 19, 2018). By reflecting on the photos and videos together with me during the CPRM, the teachers honed their observations of how toddlers communicated through body and facial expressions. For example, before my project, Ellen used to think science “was not appropriate for younger children” because it involved experiments. After my project, she learned that the toddlers exhibited science “through play” (February 6, 2019). Recording anecdotal notes of how the children moved or what they said, if anything, “helped it sink in” (Mae, January 17, 2019). Rosalind and Mae thought about the “non-verbal communication” (December 14, 2018) of how children move their bodies. For example, when they babbled and grunted while playing in sand, the co-teachers wondered if the children might be communicating that they discovered the sand filtered through the sieve. Likewise, children giggled and laughed when splashing in water which the teachers presumed meant they were engaged and interested in the sensory experience. At one point while investigating play sand, Sally and

Ada “couldn’t tell what their facial expressions were” because the toddlers’ heads were down “they were so engaged” (December 27, 2018). As Rosalind and Mae remarked, “We can see their abilities based on the documentation” (January 17, 2019).

The EHS teachers learned that problem-solving was an observable, often non-verbal characteristic of toddler science. References to problem-solving, finding out, figuring out, and other “mental engagement” (Ellen & Adriana, November 20, 2018) were frequent. The teachers noted problem-solving skills in a variety of toddler interactions whether it was “figuring out how to move their bodies” to rock a wooden boat together (Mae, December 14, 2018) or “critical thinking to put hands out” (Ada, January 8, 2019) to balance on a beam.

Marie reflected on an example of problem-solving in her classroom. Studying the video documentation during the reflective process brought to light the toddler’s problem-solving abilities. She disclosed, “I keep thinking about how the video helped me catch what I didn’t see in the moment” (December 14, 2018). Marie selected large, un-taped boxes and differing sizes and shapes of plastic containers with lids to offer to the eight toddlers in her EHS class. Most of the toddlers pushed the boxes around or sat inside of them. One two-year-old, Alfonso, stacked them as high as he was tall. Marie pondered, “I think he’s thinking about what he wants to do next” (December 14, 2018). He pushed the boxes down then placed them sideways one on top of another. An older one-year-old, Eddie, came and handed Alfonso a plastic lid which he held up to his face and looked through. Behind him, Eddie knocked down the block structure. Alfonso turned back around with a look on his face as if to say, “What happened?” (Marie, December 14, 2018). Alfonso restacked; however, Eddie came and swatted it down again. The two-year-old Alfonso grunted and held his arms out to push Eddie. Marie responded, “I think he’s going to help you build” (December 14, 2018). This same exchange occurred a second time between the two toddlers. Alfonso began to pull his hands upwards as if to push the other child but stopped himself. He looked down at the ground, picked up a red container lid, and handed it to Eddie. Marie speculated that this was his way of problem-solving. It was as if Alfonso was telling the other child that he didn’t want to be interrupted, so Eddie could play with the lid instead. This was one of many examples in which the EHS teachers connected the children’s non-verbal interactions with materials and with each other to the skills of problem-solving and critical thinking.

Teachers learned differences in development between one- to two-year-old children. Using their reflective teacher research skills, the teachers recognized developmental progression and compared how one- and two-year-old children approached their interactions with science. Among the teaching teams, age level and ability became a topic of interest to the EHS teachers. Even though almost all the toddlers engaged with materials that were of interest to them for long periods of time, the participants learned that there are key differences in the way that one-year-old children interacted with materials compared to two-year-old children. In the first sets of CPRM field notes, several teaching teams thought that younger toddlers, as Ada stated, had “short attention spans” (November 27, 2018) or lost interest simply because they were not touching the offered items. By the end of their sessions, the teachers learned that younger toddlers engaged as they “splashed with their hands” (Ada & Ellen, December 11, 2018), sat and observed other toddlers or the teacher, and “explored at their own pace” not the teacher expectation (Ellen, December 20, 2018). In the meantime, the teachers also examined older toddler development. They learned that two-year-old children were “more controlled” (Ana Sofía, December 11, 2018) with their use of scientific tools like shovels and magnifying glasses, “more mature and imaginative” (Sally, December 11, 2018) in pretend play, and would verbally “respond to questions from the teacher” (Ellen, December 4, 2018).

Teachers increased their use of science-related vocabulary with toddlers. The teachers learned that their use of science-related vocabulary was instrumental; the toddlers “blossomed” (Adriana, January 15, 2019) and “opened up with language because it’s repetitive” (Ana Sofía, November 13, 2018). Strategies for developing language and vocabulary were evident as important areas the teachers wanted to integrate into their pedagogy. It was noted that, by the end of the CPRM sessions, children who were verbal labelled their science experience using a variety of words such as descriptions of the properties of the materials (e.g., wet for sand or “fix it” when a problem was encountered) or “look, *mira*” (Adriana, December 20, 2018; Ellen & Adriana, January 15, 2019). The toddlers even repeated some of the words that the teachers modelled. As Kimberly, Ana Sofía, and Ada reflected, they tried “to include some language and science vocabulary” November 27, 2018), to “[give] children words” (Ellen & Adriana, November 19, 2018; Ellen & Adriana, January 3, 2019), and to make the experience more science-rich for the toddlers. The EHS teachers attributed this language and vocabulary development to their intentional interactions developed through observing and reflecting in the CPRM sessions. In example, all nine participants practiced open-ended questions to better understand children’s thinking. Their questioning techniques were emergent and integrated their observations of children’s interests in the moment.

Ellen sought to "extend their conversations" by evaluating what the toddlers were communicating and responding with relevant questions or statements. She modeled with phrases such as *I wonder,* and *I notice*. Ana Sofía said she felt more confident "calling it like it is – using science words like gravity" (November 27, 2018). By the final CPRM session, many of the participants noticed themselves using more science words like action/reaction, cause and effect, classification, compare, force, motion, movement, patterning and physics to describe their observations of the content toddlers explored. Their use of science-related vocabulary with toddlers indicated that the EHS teachers learned that toddlers were capable of understanding scientific terms at such a young age.

The EHS teachers' pedagogical approaches to teaching and learning were improved as they engaged in reflective, job-embedded professional development. The teachers "saw this as an opportunity to learn" (Ellen, December 4, 2018) about their work and their practices. Additionally, the EHS teachers learned about toddler scientific thinking development which occurred through the reflective study of documentation during the CPRM. This was a process that required teachers to develop teacher research skills. They observed closely, questioned, connected, and reflected. "We are missing the opportunity if we don't look closely," advised Marie (December 14, 2018). The reflective, job-embedded PLD also impacted teacher learning about the toddlers they served. Kimberly and Ana Sofía said they saw the toddlers in their classroom as "more inquisitive. They're learning and being curious" (December 19, 2018).

Results for RQ2. In this section, I explain the ways in which the participants' perceptions and understandings of science changed after participating in my job-embedded, early childhood science PLD. Three themes exemplified the ways they said they changed: improved comfort level with science, more visibility of toddler science in the classroom, and enhanced perception of the role of the EHS teacher in supporting science.

Teachers improved their comfort level with science. Participants developed an improved comfort level with science as they participated in my innovation. Those who already felt comfortable maintained comfortability and developed a deeper understanding of toddler science. Those who felt that they were scared or incapable of doing science became more comfortable in the perceptions of their abilities to support toddler science.

Teachers who already felt comfortable with science reinforced their understanding. Four EHS teachers described their memories of science ranging from informal childhood memories to grade school to high school. With Kimberly and Marie, science evoked fond memories of watching a Jacques Cousteau television show, falling in love with the ocean, and writing science observations in a nature journal. From this data, I discerned some level of comfort with the topic of science for these two participants going into my project. During the closing interview, Kimberly explained that she moved from having tunnel vision by thinking that children were too young to do science into a broadened lens that toddlers can engage in science in meaningful ways. This aligned with Kimberly's goal from the pre-project interview to "broaden [her] horizons" (October 24, 2018). Rosalind, who came into the project with curiosity and a level of comfort, described that this experience helped her see science as "extremely doable every day in [her] classroom" (February 6, 2019). Marie still enjoyed science and perceived it as more emergent and less prescriptive.

Teacher perception evolved from science as scary and hard to science as doable. In contrast, Sally attributed her discomfort with science to their experiences in high school related to the difficulty in understanding the vocabulary and math involved with those subjects. Before the innovation Sally said science was “scary, hard, and math-based” (October 25, 2018). She expressed that her participation in this project changed her perspective as “science from this big scary thing to a very doable, small thing” which supported her implementation of science experiences with toddler to “become easier” (February 6, 2019). By the end of my innovation, a higher level of comfort with preschool science was achieved.

Other participants labeled their teacher anxieties around toddler safety and security as their initial discomfort with science. They expressed worries that science-related materials may pose choking hazards for toddlers or that toddlers would throw the science materials they offered and hurt each other. The participants realized that they must “let them explore” (Ellen, February 6, 2019), take risks, and “be investigators themselves” (Rosalind, February 6, 2019) because that’s how toddlers learn. The participants advised that, while they recognized the need for toddlers to engage in risk-taking and problem-solving to promote their scientific thinking skills, it was ultimately the responsibility of the EHS teacher to get to “know your kids” (Ada, February 6, 2019) and create a safe space for toddlers to explore, engage, and develop. During the closing workshop, Ana Sofia and Ellen used words like “excited” and “amazed” (February 6, 2019) to describe how they felt about the work they had accomplished in this project. Their shifts in perception about their own capacities suggested that all the EHS teachers became more comfortable with science when it related to their work supporting toddlers.

Teachers perceived science as more visible in toddler development. Remarkable shifts occurred in the teachers' understanding of toddler science through observable scientific behaviors. Participants developed a heightened understanding of toddler cognitive development and how it practically applied in their classroom contexts.

The teachers began the project with a general awareness around what toddler science might look like in action. Their state of understanding at the pre-project interview encompassed the idea that science was an important domain of learning that included exploration and hands-on experiences but with little description of specific toddler behaviors. Ana Sofía, Ada, Ellen, Adriana, and Marie recognized that scientific thinking would look different for toddlers than it might for older children. However, their responses also showed that they were interested in finding out more about "age appropriate" (Ellen, November 1, 2018) toddler science experiences. Ada hoped to learn how to bring science into the classroom for younger children. Initially, descriptions of toddler science experiences were isolated, one-time experiences facilitated by the teacher. Several participants referenced that toddlers developed science skills through certain activities that teachers offered such as measuring and mixing ingredients for play-dough, taking "ice out of the freezer to let it sit" (Sally, October 25, 2018), and other "basic concepts" that toddlers can "wrap their minds around" (Rosalind, October 25, 2018). Ana Sofía acknowledged that she thought she was implementing science activities only "one time" or "when we have to fill in our TSG," but she wanted to make "sure that it's…part of daily learning as well" (October 24, 2018).

At the end of the project, the participants' perceptions of toddler science seemed to have changed; they included stronger details of observable actions. For example, before my project Kimberley thought that "toddler science was limited to playdough" because they weren't "capable to understand or grasp science concepts" (February 6, 2019). After, she comprehended that she needed to go "beyond playdough" because science is in "everything that these children are doing" (February 6, 2019). Ellen, too, saw toddler science as "only making playdough" (February 6, 2019) in her initial thinking. Post-project, she shared a real-life observation of toddlers on the playground that showed a practical application of how she now perceived toddler science:

> We were outside, and it had rained, so one of the buckets that had marble sensory balls, and I was trying to throw the water out, and I put it in the picnic table. And the kids like, stormed to it, and I was like, "Okay, I'll let them." I thought, "Oh, they'll play with it." And the picnic table, there was, like, a little hole like something like that we put the umbrella. And they started dropping them in there. And so then, um, what, the, when the [toddler] went and got a bucket, and he was trying to squeeze the bucket, but he couldn't, it couldn't fit. So, we're like, they were like helping each other, and they like tipped the big tables and they, but they did it. They put it in the middle, and the marbles went in the bucket…the logic for them was like they knew that it can go in the little hole...They were thinking… (February 6, 2019).

Participants responded that the children were problem-solving, exploring cause and effect, and trying to figure it out together. This was demonstrated through the specific verbs used to describe how children exhibited their scientific thinking skills – investigated the properties of materials, problem-solved and used logic, worked with each other, asked questions, and showed their understanding. The teachers referenced that children explored science concepts through everyday classroom play such as "cause and effect" (Ada, February 6, 2019) with the marble sensory balls, "physics" (Sally, February 6, 2019), while stomping on acorns on a walk in the rain and motion with cars and tunnels. The analysis showed teachers' cultivated understanding that scientific skills were involved in toddlers' everyday interactions and that children were "natural explorers"

(Ana Sofía, February 6, 2019). As Ada reflected, "Now, all we do is connected. Now, I think [toddlers] are always exploring, always observing cause and effect, asking questions with nonverbal ways" (February 6, 2019).

Teachers perceived their role as more active supporters of toddler science. Through their participation, the EHS teachers perceived their roles as more active supporters of science in the toddler classroom. Before the project, science was perceived as important for the toddler classroom environment but was comprised of teacher-imposed, one-time activities. After the project, they perceived themselves in the role of an observer and learner. In this way, the teachers recognized the importance of observation and reflection to understand children's thinking and their interests. They used these observations to develop relevant, contextually-appropriate experiences for the toddlers they served. This moved them into a new understanding of seeing science as an open, inquiry-based opportunity based on children's interests. Their teacher research skills developed through close and careful documentation, reflection, and analysis.

The reflective, job-embedded CPRM helped the teachers develop a perception of their role as active observers, listeners, documenters, and, thus, teacher researchers. Starting my project, the teachers had a general understanding of toddler science but sought to find more ways to incorporate experiences into their everyday work. In the initial interview data, the participants perceived science experiences as something that the teacher provided to toddlers rather than a set of skills toddlers have innately. Children's natural scientific skills can be nourished by the teacher through intentional action planning that includes a focus on science materials and activities. After completing the innovation, "now we have a scientific lens," said Ana Sofía (February 6, 2019). "The most organic way of learning is their pure interest," explained Marie (February 6, 2019). Ada added, "We're researching what the children are interested in" (February 6, 2019). They described their responsibilities as the need to listen, observe, reflect, research, and develop activities based on the data. They used this reflective process to "organize thoughts" (Marie, February 9, 2019) as a method to look at what children were doing and to "meet the kids where they're at" (Rosalind, February 9, 2019). This indicated that even with four or five experiences with CPRM, participants had a consistent opportunity to reflect on their work with toddlers and think critically about what science experiences were being offered. Paired with their improved comfortability and increased awareness of toddler science, I surmised that the teachers developed a deeper perspective of their capacity to actively and practically promote science learning in their classroom.

Summary of Results

Taken together, my analysis showed that the EHS teachers' participation in my project moved them into a deeper, more refined level of understanding of toddler science learning and their role in supporting it. EHS teachers developed their teacher as researcher skills, increased their awareness of how toddlers develop scientific thinking, and engaged in reflective practices that informed their work as toddler teachers.

With respect to the impacts of reflective, job-embedded PLD on educator learning, the EHS teachers learned about themselves and about the toddlers in their classrooms. They learned teacher research skills as they participated in the innovation. This included the ability to observe closely and to reflect on and analyze documentation to better understand children's interests and abilities. In addition, the teachers learned that toddlers engaged for long periods of time when interested, thought critically and approached their learning in unique ways, and exhibited their scientific thinking skills through their play.

With respect to the ways that the educators' perceptions and understandings of science changed over the course of the study, the data suggested that teachers either improved or maintained their comfortability with science. In addition, their awareness of toddler science in their classrooms became heightened. They developed understanding of observable scientific thinking and cognitive skills in toddlers. The teachers began to see their role in supporting science as more active, often citing their observations of children in the classroom and their participation in the reflective planning sessions as key in developing those skills.

CHAPTER 5

DISCUSSION AND REFLECTION

"We do not learn from experience. We learn from reflecting on experience" (Dewey, 1933, p. 78). Analyzing then reflecting on the data served as a culminating step on my action research journey. It advanced my conceptual insight into the EHS teachers' thinking, my learning as a researcher, the outcomes in the local context, and how this PLD approach can potentially benefit the early childhood field in Arizona (Charmaz, 2014). My action research sought to understand how reflective, job-embedded early childhood science PLD impacted educator learning and teacher perception towards science with toddlers. In this chapter, I describe how my problem of practice was addressed. I reflect on my research, what I learned, and what I might do differently next time. I share what I discovered related to my theoretical perspectives and literature review. I describe implications on my practice and provide recommendations for future research. Finally, I present my conclusion about my innovation.

Outcomes Related to Theoretical Perspectives

The outcomes provided a framework for me to understand what the theories I reviewed looked like in practice. In this section, I relate the outcomes of the study to theoretical perspectives and literature. First, I discuss the results related to teacher as researcher and ongoing, reflective professional development. Second, I explain how the outcomes tie in to teaching and learning early childhood science. Third, I describe job-embedded, reflective professional development as a helix.

Learning by being a teacher researcher. Theories about how people learn and specifically the approach of teacher as researcher were supported by the outcomes of my job-embedded science PLD project. The goal of including the teacher as researcher approach was for teachers to study their professional practice, connect theory to action, and hone their teaching craft through an inquiry process (Dana, 2013; Marsh & Gonzalez, 2018b). I created a culture of inquiry by emphasizing the reflective questions listed in the CPRM guide. The CPRM provided multiple opportunities for the EHS teachers to develop teacher research skills (Pelo, 2006; Schroeder Yu, 2012). The EHS teachers in my project learned about their work as they actively paid close attention to children. They used documentation methods to identify, analyze, then plan to enhance the toddlers' scientific thinking skills (NRC, 2000; Edwards & Gandini, 2015). They pinpointed relationships between what the children communicated and what it meant for science development. Learning occurs when new information is organized and interpreted through the context of relational, social, and developmental factors (Kozulin et. al, 2003; NAEYC, 2004 NRC, 2000, p. 10; Vygotsky, 1978). The EHS teachers organized and interpreted the information from the CPRM to expand their teaching strategies and approaches. Thus, they learned through their inquiry process of planning, acting, developing, and reflecting on their work (Mertler, 2014; NRC, 2000; Piaget, 1964; Vygotsky, 1978). The educators engaged in a process of iterative research of their own practice because they were provided with opportunities for inquiry that were job-embedded – reflective and relevant to their context and the children they serve.

Consistent with literature on teacher research, the EHS teachers learned and acquired inquiry skills to critically reflect on their work. I learned that the participants refined their observational skills, linked documentation to ongoing child assessment practices, and continuously developed teacher research skills – noticing, pausing, observing, discussing, reflecting, and implementing action plans. Through the CPRM, the teachers engaged in key inquiry components: collaborative dialogue, collection and close examination of evidence related to classroom teaching, and opportunities for reflection about teacher practice (Gordon, 2016; Newman & Woodrow, 2015; Marsh & Gonzalez, 2018b; Schroeder Yu, 2012). This "intense awareness" was what influenced the participants to select their instructional strategies, approaches, and provocations for the toddlers (Reggio Children, 2016, p. x). For example, the teachers used their inquiry skills to gather information that helped them adjust their interactions with toddlers. All nine EHS teachers practiced open-ended questions to better understand toddlers' thinking. Their questioning techniques were emergent and integrated observations of children's interests. For instance, Ellen and Adrianna asked, "What do you see and notice?" (December 4, 2018 & January 15, 2019) when toddlers peered at flower petals on a light table and through colored lens blocks. And Ada started asking, "What do you think will happen?" (November 27, 2018) when she noticed toddlers seemed to recall their previous experiences with sand.

Furthermore, Ada said in the closing interview, "The kids are interested in the cars, and so, we're watching the children to see, we're researching what the children are interested in, and bringing that one step further" (February 6, 2019). This statement showed her teacher research skill of observing, "listening organically" (Ada, February 6, 2019) to children's non-verbal communication, and planning activities to encourage cognitive engagement. Her observations influenced her next steps, "I put the car [on the ramp] because I'd seen them put the cars in other places. And I was wondering if they would notice how it would roll down, and if they would do it again" (February 6, 2019).

Based on the children's interests, the teachers "altered [their] instruction" and therefore their approach to teaching science (Marsh & Gonzalez, 2018a, p. 466). They learned from experience and adjusted practice based on their new understanding. Likewise, the participants' professional development mirrored the research from Pelo (2006). Pelo (2006) was able to induce pedagogical change in the way teachers implemented their researcher skills by focusing continuous professional development on observations of young children. A year into the job-embedded PLD, teachers commented, "this is making me a better teacher…paying attention, staying connected to what I see, thinking about big ideas" (Pelo, 2006, p. 53). Their use of teacher research skills, much like those developed by participants in my project, impacted how they taught.

The results reaffirmed the critical role that the teacher as researcher approach played in moving the teachers to a new level of understanding about toddler science and their work. I argue that the EHS teachers became teacher researchers and professionally developed through their participation in the CPRM. It provided a structure for professional learning and development through reflective inquiry practices (Epstein & Willhite, 2015; Martin et. al, forthcoming; Pelo, 2006). In the context of my project, the process of inquiry helped the teachers to develop a common focus, a scientific lens, through which they observed, reflected, and discussed toddler science. "My scientific lens has been broadened," reflected Kimberly (February 6, 2019). Ana Sofía termed, "I found myself being a researcher more" (November 27, 2018). Ada said, "I feel like we're always researching…as we're observing, we're researching the children to see what they're…interested in" (February 6, 2019). Within the Head Start context, consistent, reflective, inquiry-based PLD like this could help meet *Head Start Program Performance*

Standard requirements. Ongoing child assessment, referred to as the study of documentation in my project, must be used regularly by Head Start programs to determine a child's strengths, "inform and adjust strategies to better support individualized learning, and improve teaching practices" (USDHHS, 2016, p. 30). The EHS teachers incorporated teacher researcher practices into their pedagogical approach accordingly adjusting and improving their teaching to support toddler development.

Teaching and learning early childhood science. According to Crawford (2006), teachers who developed inquiry-based, teacher researcher skills were more likely to engage in science with children. The outcomes from my project closely align with Crawford's notion and other literature that promotes teaching and learning early childhood science (Hamre et. al, 2014; Hong et. al, 2013; Jones, 2008; McKeown et al., 2016; NRC, 2000; Protheroe, 2008; Thomason & La Paro, 2009). My innovation sought to provide professional learning support for observation, reflection, and analysis of data around children's learning to make science teaching and learning more accessible. The EHS teachers in my project exhibited a variety of comfort levels about teaching and learning science with young children from excitement to anxiety to fear. Factors such as their early experiences with science and formal middle school and high school coursework may have impacted their perceptions of their ability to do science (Hong et. al, 2013). Those experiences also may have impacted the perceptions and beliefs that teachers hold about their capacities as teachers and learners of science (Jones, 2008).

Through the CPRM, the EHS teachers developed a new perception of toddlers and themselves as capable and competent learners of science. Their reflections supported them to begin to view toddlers as curious, engaged, observant problem-solvers. The EHS teachers realized toddlers were intentional in their interactions and "competent" (Ada, January 8, 2019; Kimberly & Ana Sofia, December 11, 2018) in solving problems. Child development theories backed these impressions of toddlers as young scientists. Scientific thinking skills are evident in young children's sophisticated problem-solving and reasoning and can be fostered for very young children (Bucher & Hernández, 2016; NRC, 2000; USDHHS, 2015, Vygotsky, 1978). The cognitive standards in both the *ELOF* (USDHHS, 2015) and the *ITDG* (ADE, 2014) indicated that children birth to 36 months actively explore their environment, acquire and process new information, and experiment with causal relationships. Approaches to learning skills are exhibited through actions such as sustaining focus and engagement, persisting, using creativity, and participating with new experiences (ADE, 2014; USDHHS, 2015).

The results that teachers learned about toddler scientific development mirror the concept that children have many expressive languages, not just verbal, to communicate their interests, curiosities, approaches to learning, and theories (Edwards et. al, 2012). These many languages indicate toddlers are capable of deep engagement and complex understanding beyond their verbal skills (Edwards et. al, 2012; Flavell, 1992). The documentation of children's interactions teachers studied in the CPRM became the data they used to study children's behaviors related to science and get to know the interests and identities of the toddlers. By reflecting on data, the EHS teachers became more comfortable with teaching science and more familiar with the abilities of even very young toddlers to show their scientific thinking. In Ana Sofia's reflection, "The children were always doing science, we're just focused on it now," (November 27, 2018).

Job-embedded professional development as a helix. In my project, inquiry was a cycle that translated into a three-dimensional helix, or a spiral. This expressed that I learned that teachers ended up in a different, deeper level of understanding based on their participation in reflective, job-embedded professional development. Figure 2 illustrates job-embedded professional development as a helix.

Figure 2

Professional Development as a Helix

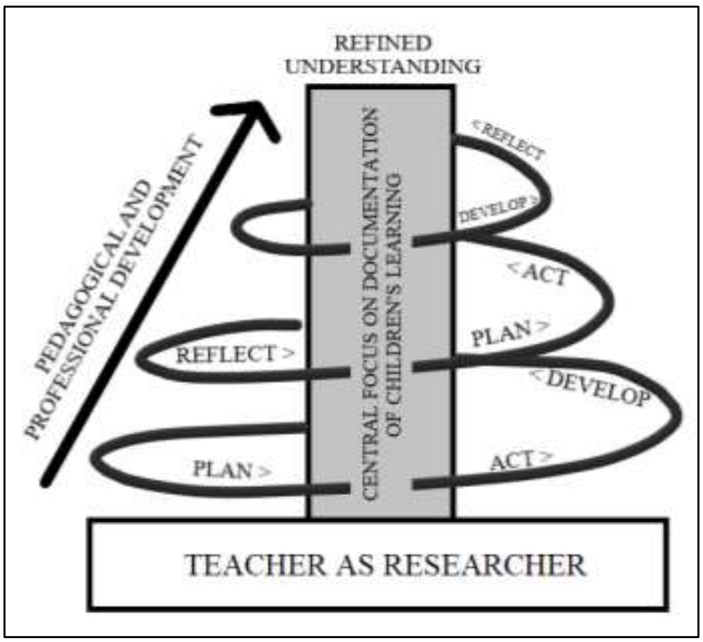

Figure 2: A helix represents the concept that teachers ended up in a different, deeper level of understanding based on their participation in reflective, job-embedded professional development

As I reflected upon the results of my action research project, I wanted to find a way to visually represent what I learned. After several sketches based on iterations from previous professional development experiences, I discovered that PLD could be represented as a helix. As they planned, acted, developed, and reflected, the EHS teachers moved upwards and refined and deepened their understanding of several key learning areas: the toddlers as capable and competent scientists, themselves as active supporters of science, and the way in which they adjusted their interactions based on what they knew about the toddlers. This process of inquiry was framed by teacher research practices of observing, documenting, questioning, and reflecting. At the core, the professional development maintained a central focus of documentation of children's learning (Henderson et. al, 2012; Pelo, 2006; Wein et. al, 2011). Altogether, the teachers professionally and pedagogically developed their skills.

Teachers engaged in a cycle of inquiry through studying documentation, reviewing their practice, and reflecting with colleagues. I imagined this cycle pulled upwards into multiple levels that develop upon each other. As the EHS teachers engaged in the CPRM, they moved up the spiral. The concept here is that their understanding did not remain motionless but rather evolved over time throughout this process. The EHS teachers constructed different, more complex, and deeper knowledge and understanding. This built upon the important foundational resources related to action research, processes of inquiry, and theories around how people learn (Brydon-Miller et. al, 2003; Dana, 2013; Herr & Anderson, 2015; Marsh & Gonzalez, 2018b; Martin et. al, forthcoming; McMillan & Wergin, 2010; Mertler, 2014; Pelo, 2006; Piaget, 1964; Reason & Bradbury, 2001; Vygotsky, 1978).

As I reflected on my new understanding of PLD, I found it essential to note that learning is also messy and multidimensional (Martin et. al, forthcoming; NRC, 2000). In my innovation, the EHS teachers continued upwards in the spiral because they focused on toddler science as their central area of documentation. Thus, a spiral image best captured the impact of this project on their learning and their perceptions within their context. Yet, a longer period of implementation could have indicated other connections outside of toddler science. Vecchi (2010) described the process of learning as a rhizome, "shooting off in new directions" (p. xviii). There is an "unpredictability of learning" in the dynamics of relationships and experiences which counters the idea of learning as linear (Vecchi, 2010, p. xvii). A rhizome, in the larger context of early childhood PLD, supports the assumption that learning does not have an ending, is "always in-between" (Vecchi, 2010, p. xviii), and evolves and adjusts based on experience (Dewey, 1938; Piaget, 1964; Vygotsky, 1978).

Lessons Learned

The outcomes related to my theoretical perspectives supported that learning is an iterative, collaborative inquiry process. In my project, learning occurred because the PLD was structured around reflective practice and inquiry, which are intertwined with thinking (Dewey, 1910; Dewey, 1938; Schön, 1983). Participation in my reflective, job-embedded PLD provided a forum for the EHS teachers to collaborate, share ideas, and address real-life issues in their educational practices (Edwards et. al, 2012; Martin, et. al, forthcoming; Mertler, 2014; Pelo, 2006; Schaffer & Thomas-Brown, 2015). Through reflection and constant comparison of my data with educational theories, I too engaged in a process of inquiry. Once I began analyzing the results, I realized that the teachers were doing action research like I was. In this section, I share my lessons learned about the process of being an action researcher and the need for me to develop PLD that supports teachers to do action research.

The study of documentation as action research. In future iterations, I plan to design PLD that intertwines researcher and teacher action research processes. Teachers can generate theories about what happened in their classroom through action research

(Brydon-Miller et. al, 2003). By designing PLD to include action research, PLD providers can support teachers to act and reflect, collect and analyze data in an informed and critical way, and construct practical solutions to a problem of practice (Mertler, 2014; Reason & Bradbury, 2001). The intent is to make an impactful difference in the classroom context and construct new knowledge that influences and improves the work (Brydon-Miller et. al, 2003; McMillan & Wergin, 2010; Mertler, 2014).

Effective action research is job-embedded. In my project, the study of documentation was job-embedded because it related to the real toddlers in the EHS teachers' real classroom contexts. I provided opportunities that were grounded in day-to-day teaching practices with the purpose of enhancing teachers' content-specific instructional practices and, therefore, outcomes for children's learning (Croft et. al, 2010). I conducted action research in my job, and the teachers did it in their jobs. The job-embedded PLD design included close observation, documentation of children, and opportunities for the teachers to actively participate and reflect on this documentation (Henderson et. al, 2012; Schaffer & Thomas-Brown, 2015; Wein et. al, 2011). Here is how the methodological design of my project echoed the four stages of action research: planning, acting, developing, and reflecting. The CPRM guide supported the EHS teachers to go through these action research stages together with me. First, they engaged in planning by deciding logistics for what materials they would offer to toddlers, what they would focus on, and how it might connect to the *ELOF*. An action plan was constructed. Second, they implemented their plan and gathered data via photographs and/or video. As the teachers observed and documented, they also analyzed the data in-the-moment; this was evident when the teachers paused themselves instead of interrupting a toddler's play or when they asked questions based on what they observed children doing. This was the acting stage (Mertler, 2014). Third, the teachers brought their data to the next CPRM in the developing stage (Mertler, 2014). The EHS teachers reflected on what transpired since the last meeting, shared their documentation, and clarified what they observed children doing and communicating. Fourth, we moved into reflecting during that same CPRM. The EHS teachers probed, brainstormed, and asked themselves questions of their work. The reflecting stage also included conversation about the teachers' thinking and learning. During this stage, participants wondered what they learned about children and themselves and described how their newly developed understanding impacted next steps. Finally, the EHS teachers moved back into the planning stage to design a provocation before the next CPRM. They continued action research through several CPRM. Table 10 shows the alignment of teacher action research stages with their study of documentation in the CPRM.

Table 10

Teacher Action Research Stages through CPRM

Action Research Stage	**Section of the CPRM – Description**
Planning	*Planned decisions for provocation* – finalized the logistics of their future activity or provocation Hypothesized what might happen Created an action plan for materials, set-up, date/time, documentation source, and design
Acting	*Conducted the Acting Stage In-Between CPRM sessions* – Implemented the action plan Collected data through documentation (videos, photographs, and/or anecdotal notes)

Developing	*Reflected from the last CPRM* – What has transpired with children since the last meeting? What did you notice when implementing your plan? *Described and shared children's work and documentation* – Presented the data. *Asked clarifying questions* – Responded to questions that clarified the event or activity.
Reflecting	*Probed and brainstormed* – Collaboratively discussed observations related to scientific thinking skills being observed in the documentation (e.g., What do you think the children were thinking? What questions were they trying to answer? What interested the children in the study? How does this behavior relate to early childhood science?) *Engaged in conversation and dialogue* – Reflected on their learning related to the data (e.g., What did you learn about the children? What did you learn about yourself? What do you want to pursue next regarding scientific thinking based on this evidence?) Used reflection and results to inform future planning

Adapted from *Action research: Improving schools and empowering educators, 4th edition* (p. 31), by C. Mertler, 2014, Thousand Oaks, CA: Sage Publications.

Limitations

Critical examination of my results included self-reflection on limitations, or potential challenges to data credibility and project success. In order to maintain an ethically sound project, I reduced biases by writing with intentionality and awareness about these limitations (Herr & Anderson, 2015; Mertler, 2014). I identified three limitations and offered solutions for next time: (a) the number of CPRM sessions, (b) the collection of qualitative data, and (c) researcher and participant biases.

The number of CPRM sessions. The outcomes of my project may have been different if the EHS teachers had additional time and interaction with the CPRM sessions. The nine EHS teachers participated in either four or five collaborative planning and reflection meeting (CPRM) sessions. I originally slated ten but had to reduce that number because the action research project received approval to start months later than anticipated. Once I resigned my position, I no longer had access to collecting the data through CPRM after the already-conducted four or five sessions. In an ideal design, the initial workshop would be offered at the start of the school year with the closing workshop at the conclusion of the school year. Additionally, the CPRM sessions would be offered consistently throughout the school year from August through May. This structure would help programs to align with the Head Start program requirement of conducting observation-based assessments “with sufficient frequency to allow for individualization within the program year” to “evaluate the child’s developmental level and progress” (USDHHS, 2016). A longer innovation implementation period could provide additional data related to teacher perception and learning.

The collection of qualitative data. In future research, I plan to audio record all interaction data as necessary and decide which key components might be the most relevant to code and which “fall to the cutting room floor” (Saldaña, 2016, p. 27). Then, during analysis, I will triangulate the data for consistency and comparison in order to “strengthen confidence in”, verify, and substantiate my conclusions (Patton, 2015, p. 661). The CPRM notes were handwritten during the sessions and analyzed in HyperResearch as scanned notes rather than transcripts. Audio recording could have been more efficient and accurate. It could allow for more personal connection with the participants as I would be looking at them while they responded rather than down at my writings. After the cycles of coding, I determined I was able to capture specific data pertinent to my RQs.

In addition, I learned that Google Drive, a virtual shared learning space intended to promote a community of practice (Wenger, 1998), was not used as I anticipated. I planned for Google Drive to serve as a method for interactive discussion and communication between EHS teachers and me in-between the CPRM sessions. The data in Google Drive was accessible by participants at any time, and there were opportunities to post and respond to comments. However, none of the nine participants used the Google Drive platform to upload documentation, comments, or feedback. In the closing workshop, I asked the participants to tell me about their experience with Google Drive. The consensus was that participants did not think about it as part of participation. They stated that they did not have questions in-between our meetings and that our sessions were consistent enough that they could share their ideas and thoughts during the CPRM. There was "no need for communication in-between" (Ellen, February 6, 2019). Nonetheless, my goal for a community of practice through Google Drive was not met. The participants described that they wished they could have been more connected to the other classrooms through a digital platform to see what studies colleagues investigated. Even though Google Drive was not used, Sally expressed a sense of accountability to implement the action plan between sessions. She explained that knowing the date and time of the next meeting made her "[think] about it more often" and stay "on top of it" (February 6, 2019). For future research, I will employ the use of another more active digital platform such as a closed Facebook group or a secured Tumblr feed for participants to post documentation, share feedback with each other, engage in virtual dialogue, and hold themselves accountable to their action plans.

My qualitative sources ended up still helping me effectively develop my data findings. The pre- and post-project interviews and CPRM session notes gave me a "more detailed picture of the learning process in context" (Stribling, 2013, p. 3). The limitation of the lack of data from Google Drive was reduced by the rich data from the participants in the other sources. Using *in vivo* coding, the data not only helped me become “privy” to the details of the EHS teachers’ inquiry process, but it also made visible the teacher’s evolving thinking through my project (Stribling, 2013, p. 3).

Researcher and participant biases. Non-biased qualitative projects are nearly impossible to design (Galdas, 2017). Initially, I considered potential researcher and participant biases as limitations. Instead, I realized the strengths in the trustworthiness of researcher and participant perceptions and the rigor of the data collection methods. To improve future research, I will explicitly include the role of early childhood mentor relationships to impact educator learning. In my project, I discovered that I served as a toddler science mentor with the EHS teachers. I guided the reflective conversations and helped teachers make connections using my experience with early childhood science and the literature related to child development. In the closing interview, the teachers explained that having me as the mentor provided an important perspective to the reflection process. Sally explained, “You didn't have that prior expectation…[or] that prior knowledge of the children. I found really helpful as well, to pull us out of our little boxes” (February 6, 2019). Reflective practice develops over time and must be supported through dedicated time and consistent mentorship (Epstein & Willhite, 2015; Martin et. al, forthcoming). My project was effective because the teachers had consistent opportunities to discuss, review, reflect, and get feedback. Likewise, teacher effectiveness was influenced by “the role of collaboration and consistent communication and reflection between mentor and teacher” (McCormick et al., 2010, pp. 117-9). The ability to communicate their theories about toddlers’ learning and exchange ideas and perspectives was strengthened through this co-inquiry PLD process (Abramson, 2012). As Jones (2008) pointed out, teachers were more engaged with professional learning when they worked with a mentor colleague like me who had science content background.

Job-embedded teacher action research is subjective because it deals with the relationships between teachers, children, and PLD facilitators. I worked with the participants for several months before conducting my project. Our working relationships provided a safe place for openness and honesty and a trusting environment. However, it also may have biased their responses wherein they implicitly responded in a way in which they thought I wanted to hear. This is referred to as demand characteristics, or the psychological response theory that participants pick up on researcher expectations and "cooperate…to obtain the desired results" (Chow, 2010, p. 453). Chow (2010) counters that "research participants bear goodwill toward researchers" and "may not and cannot fake responses to please the researcher" (p. 453). It is difficult for any education research to eliminate all biases between participants and researcher, especially acknowledging educational theories that learning is constructed within the context of relationships (Dewey, 1933; Vygotsky, 1978; Wenger, 1998). I addressed these limitations by intentionally and explicitly including literature about how people learn and communities of practice in my theoretical perspectives (Dewey, 1910; Dewey, 1933; Piaget, 1964; Vygotsky, 1978; Wenger, 1998). This strategy showed transparency that learning with and from each other was a foundational methodological approach to impacting teaching and learning practices. My project was shaped by the understanding that learning is complex (Martin et. al, forthcoming; NRC, 2000). Relationships cannot be separated from the qualitative study of documentation since the work is job-embedded and related to emotional ways in which teachers interacted with each other and with toddlers.

Implications for Practice

The outcomes from my PLD project conveyed implications for future research. The outcomes also clearly addressed my problem of practice, which was a community need around science professional development for teachers of infants and toddlers. In Arizona, limited availability of early childhood science college coursework and virtually no science-related PLD for teachers of infants and toddlers showed the need for this project (Arizona 8 PBS, 2018; ASU, 2018; Maricopa Community Colleges, 2018). In this section, I describe how the outcomes demonstrated action research as data-driven teaching and learning. I also define how the outcomes helped the teachers develop Arizona-specific knowledge and competencies. I explain why that will be critical for my future action research on job-embedded professional development.

Data-driven teaching and learning. The *Head Start Program Performance Standards* require Head Start teachers to construct "organized activities…lesson plans, and the implementation of high-quality early learning experiences that are responsive to and build upon each child's individual pattern of development and learning" (USDHHS, 2016, p. 26). Teachers can accomplish this when they "integrate child assessment data in individual and group planning" (USDHHS, 2016, p. 26). The EHS teachers in my project did both as a result of their reflective, job-embedded learning. Furthermore, Head Start programs must use "child-level assessment data…to direct continuous improvement related to curriculum choice and implementation, teaching practices, [and] professional development" (USDHHS, 2016, p. 60). This means that quality early learning experiences are data-driven and are built through teachers' understanding of child development in conjunction with their observational assessments of children's interests, ideas, and theories. In my project, the teachers collected data, or their observation and documentation of children's learning, through video, photographs, and/or anecdotal notes. By examining the documentation, the teachers used the data to drive their instructional practices and the activities they planned to offer in their classrooms. Effectively, most of the Early Head Start teachers began to supplement their CPRM action plans into their lesson plans. By the end of their sessions, Sally, Ada, Rosalind, and Mae developed their weekly lesson plans around the interests of the toddlers as gathered from the CPRM sessions. The teachers recognized that their observations and reflections contributed to their ongoing assessment of children's learning and could be used to document children's learning, associate children's skills with developmental levels, and build lesson plans (Teaching Strategies, 2018). Documentation helped the teachers "have evidence of the work [children] are doing" (Mae, January 17, 2019) in order to "push them forward to have their needs met" (Rosalind, January 17, 2019). Combined with the results that teachers had a heightened understanding of toddler science and practical applications in the classroom, it was apparent that the teachers used data to drive their teaching and instructional planning.

These results aligned with what research indicated about effective PLD. Reflective inquiry practices in early learning PLD helped the teachers to "become increasingly proficient" at making more informed, data-driven decisions (Broderick & Hong, 2011, p. 11). With consistent feedback and support from me as the mentor, the EHS teachers were provided with reflective opportunities through job-embedded support

(Epstein & Willhite, 2015). The data showed that they became more skilled at using documentation data to understand the toddlers' levels of scientific thinking development and then select activities and materials to scaffold learning (Broderick & Hong, 2011). Participating in this model of PLD scaffolded the teachers in their own learning around science. They exhibited inquiry skills and conducted action research through my project. As teacher researchers, they played an active role in collecting, reviewing, and analyzing data. They used the data to individualize instruction for the toddlers. This signified that they developed science-related activities and integrated their plans into their weekly lessons as part of an emergent curriculum focused on the interests and abilities of the children. Outcomes included the capacity to scaffold the development of children's scientific skills and to create learning experiences relevant to toddlers' interests. They deepened and refined their understanding with data to drive their pedagogical practices.

In correlation with my Arizona context, reflective, job-embedded professional development helped the EHS teachers in my project address many of the skills from the *AECWKC*. *AECWKC* is a statewide document which identifies "basic knowledge, skills, and abilities needed for early childhood professionals" serving children birth to age five (FTF, 2015, p. 7). Skills are leveled 1 through 5 and indicate an increased ability to move through developing an awareness, articulating, applying knowledge, analyzing and creating, and judging and advocating (FTF, 2015). I share a few connections between teacher research skills developed in my project and *AECWKC*. The level 3 goal to "develop plans and procedures for ongoing assessment of individual children" was achieved because the teachers designed action plans and updated their lessons based on the toddlers' interests and developmental levels (FTF, 2015, p. 47). A level 5 in Child

Observation and Assessment is the ability to “analyze, evaluate, articulate, and apply current theory [and] research…on developmentally appropriate, authentic assessments” (FTF, 2015, p. 48). The EHS teachers in my project analyzed and evaluated their observations of toddlers in reference to current research on toddler science development through the appropriate use of studying documentation. The EHS teachers exhibited level 5 effective interactions for concept development, a CLASS® indicator and *AECWKC* skill, when they analyzed and applied practices that “inform[ed] understanding of effective questioning and instructional interactions and…promote[d] students’ higher-order thinking skills” (FTF, 2015, p. 60). Through the intentional selection of materials, the EHS teachers strategically facilitated “curiosity, exploration, play”, a level 5 competence (FTF, 2015, p. 27). Their philosophy of early childhood practice was developed and articulated through their refined understanding of the capabilities of themselves and the toddlers as scientific learners (FTF, 2015, p. 112). As evidenced, my project connected the EHS teachers’ teacher research skills with statewide-adopted skills necessary to provide quality early learning experiences in Arizona.

I designed a project that addressed my problem of practice. I was able to offer science-related professional development in my local context in a way that developed effective teacher research skills. Moreover, the job-embedded factor of studying documentation of children in their own classrooms supported participants’ roles as EHS teachers. Thus, I met my goal of developing teachers’ teaching and learning. My action research project was successful in this EHS context in Arizona. My future research plans are to examine how job-embedded PLD and data-driven instruction connect, the impact to teacher pedagogy in other classroom contexts, and how reflective job-embedded PLD promotes teachers to increase their teaching skills according to the *AECWKC*.

Implications for Future Research: The Impacts of Job-Embedded PLD

The impacts of job-embedded action research on professional learning should be considered for future research. Job-embedded action research promoted professional growth because it provided a "practical and relevant" continuous learning cycle for the teachers to develop "critical reflection" of their professional practices (Mertler, 2014, pp. 3-4; NAEYC, 2010; NAEYC, n.d.). It was collaborative because they engaged in conversation with each other during the CPRM. It was participatory since the educators were "integral members" that led the conversations (Mertler, 2014, p. 13). Effective PLD emphasizes continuous reflection and inquiry (Marsh & Gonzalez, 2018b; Martin et. al, forthcoming; NAEYC, 2010). Reflective practice was proven instrumental as a key component to improving effective teaching practices (Epstein & Willhite, 2015; Maddux & Donnett, 2015; Marsh & Gonzalez, 2018b; Schaffer & Thomas-Brown, 2015). Based on the outcomes and the literature, I concluded that my job-embedded action research project was a form of effective professional development for the EHS teachers.

Studying the toddlers in their EHS classroom context helped the teachers to develop a better understanding of the interests of the toddlers. It improved their data-driven pedagogical approaches to teaching and learning science. Additional research should focus on how the process of studying documentation impacts teachers in other Arizonan contexts such as Quality First-enrolled providers (the state's early childhood quality improvement and rating system) and/or Arizona Department of Economic Security-contracted providers (childcare programs contracted to serve low-income families using federally-funded child care subsidies). Future research might pose several questions: How does job-embedded, reflective PLD impact educator learning in a Quality First [or other Arizona context] program? How does job-embedded, reflective PLD impact educator learning in a Head Start classroom serving children ages three to five? In what ways does job-embedded, reflective PLD support the statewide early childhood system?

This type of PLD does not happen on its own. Early childhood programs must design and provide early childhood science PLD that integrates the approach of teachers as researchers of children's learning. PLD must relate to teachers' job-embedded contexts to develop deeper and more relevant understanding of the children they serve. To be meaningful to the context, PLD must include critical reflection around science in the study of documentation of children's behaviors through photographs, video and other evidence of their learning. This is a paradigm shift from traditional PLD. My innovation offered a transformative type of professional learning designed to improve teachers' ability to reflect on effective instructional strategies to support young children through developmentally appropriate science experiences. My action research project aimed to support reflective and relevant early childhood science PLD and to explore the impact of a job-embedded professional development model.

Conclusion

In conclusion, my problem of practice was addressed because my innovation afforded a unique learning opportunity to fill the need for science-related toddler PLD. Teachers increased their understanding of toddler science and of their own professional practices through use of their teacher as researcher skills. Their reflective experience of actively focusing on toddler science increased their comfort level with science. This translated into a refined scientific lens. I discovered that the study of documentation mirrored action research. When teachers studied documentation of toddlers' learning, they practiced and implemented key action research and inquiry skills that enhanced their professional learning. Additionally, I reflected on my research processes and learned that the teachers experienced professional development as a helix; they ended up with a deeper, refined understanding through reflective, job-embedded PLD. Future research should consider job-embedded professional development as an important approach to supporting data-driven instructional practices and reflection of children's capabilities and competencies.

To close, the EHS teachers in my project perceived themselves as researchers who solved problems and improved professional practices as they, together with toddlers, investigated, uncovered new understandings, constructed theories, and explored science (Bucher & Hernández, 2016; Edwards & Gandini, 2015). My innovation supported teachers to engage in collaborative and reflective inquiry (Edwards & Gandini, 2015) to impact curriculum planning and implementation. They studied their work with children, connected practice to theory, and benefited their science knowledge base (Sela & Harel, 2012). By collecting, analyzing, and discussing documentation, the EHS teachers were action researchers, conducting child-centered research in their classrooms (Edwards & Gandini, 2015; Johnson, 1993; Mertler, 2014). From the results, additional provocations to study reflective, job-embedded PLD, toddler science, and teacher research presented themselves. The participants exemplified their inquiry skills and capacities as teacher researchers through reflections about what they learned about themselves and about the toddlers they supported. They epitomized the work of an early childhood teacher:

We observe. We reflect. We research.

REFERENCES

Abramson, S. (2012). Co-inquiry: Documentation, communication, action. In G. Perry, B. Henderson, & D.R. Meier (Eds.) *Our inquiry*, *our practice: Undertaking, supporting, and learning from early childhood teacher research(ers)* (108-116). Washington, D.C.: NAEYC.

Arizona 8 PBS. (2018). *Arizona early childhood workforce registry: Find a training*. Retrieved from https://www.azregistry.org/index.cfm?module=trainingSearch&navID=nav27.

Arizona Department of Education. (2018). *Arizona's early learning standards, 4th edition*. Phoenix, AZ: Arizona Department of Education.

Arizona Department of Education. (2014). *Arizona's infant and toddler developmental guidelines, 1st edition.* Phoenix, AZ: Arizona Department of Education.

Arizona State University. (2018). *2018-2019 major map: Early childhood and early childhood special education*. Retrieved from https://webapp4.asu.edu/programs/t5/roadmaps/ASU00/TEECSEBAE/null/ALL/2018.

Böhm, A. (2004). Theoretical coding: Text analysis in grounded theory. In U. Flick, E. Kardoff, & I. Steinke (Eds.), *A companion to qualitative research.* London, England: Sage Publications.

Broderick, J.T. & Hong, S.B. (2011). Introducing the cycle of inquiry system: A reflective inquiry practice for early childhood teacher development. *Early Childhood Research & Practice, 13*(2). Retrieved from http://ecrp.uiuc.edu/v13n2/broderick.html.

Brown-Easton, L. (2008). From professional development to professional learning. *Phi Delta Kappa International, 89*(10). https://doi.org/10.1177/003172170808901014.

Brown, L. S., & Melear, T. C. (2006). Investigation of secondary science teachers' beliefs and practices after authentic inquiry-based experiences. *Journal of research in science teaching, 43*(9), 938–962. Retrieved from http://dx.doi.org/10.1002/tea.20110

Brydon-Miller, M., Greenwood, D., & Maguire, P. (2003). Why action research? *Action research, 1*(1), 9-28. Retrieved from https://www.civitas.edu.pl/pub/nasza_uczelnia/projekty_badawcze/Taylor/Brydon-Miller.pdf.

Bucher, E. & Hernández, M. (2016). Beyond bouncing the ball: Toddlers and teachers investigate physics. *Young Children, 71*(3). Retrieved from http://www.naeyc.org/yc/files/yc/Beyond%20the%20bouncing%20ball.pdf.

Bulawa, P. (2014). Adapting grounded theory in qualitative research: Reflections from personal experience. *International Research in Education, 2*(1), 145-168. DOI:10.5296/ire.v2i1.4921.

Can, S. & Kaymaker, G. (2016). Pre-service science teachers' perception of the principles of scientific research. *Journal of Education and Training Studies, 4*(10). 168–173. Retrieved from https://files.eric.ed.gov/fulltext/EJ1113847.pdf.

Chalufour, I. (2010). Learning to teach science: Strategies that support teacher practice. *Early Childhood Research & Practice*. Retrieved from http://ecrp.uiuc.edu/beyond/seed/chalufour.html.

Charmaz, K. (2014). *Constructing grounded theory, 2nd edition.* Thousand Oaks, CA: Sage Publications.

Cheeseman, S. & Sumsion, J. (2016). Narratives of infants' encounters with curriculum: The benediction as invitation to participate. *Contemporary Issues in Early Childhood*, *17*(3), 275-288. Retrieved from http://journals.sagepub.com/doi/abs/10.1177/1463949116660951.

Chow, S.L. (2010). Experimenter expectancy effect. In *Sage reference encyclopedia of research design.* http://dx.doi.org/10.4135/9781412961288.n142.

Connolly, M. R., & Seymour, E. (2015). *Why theories of change matter* (Wisconsin Center for Education Research Working Paper No. 2015-2). Madison, WI: University of Wisconsin. Retrieved from: http://www.wcer.wisc.edu/publications/workingPapers/papers.php.

Copley, J.V. & Padron, Y. (1998). Preparing teachers of young learners: Professional development of early childhood teachers in mathematics and science. *Forum on Early Childhood Science, Mathematics, and Technology Education*. Retrieved from https://files.eric.ed.gov/fulltext/ED416992.pdf.

Crawford, A. B. (2007). Learning to teach science as inquiry in the rough and tumble of practice. *Journal of Research in Science Teaching*, *44*(4), 613–642. Retrieved from http://dx.doi.org/10.1002/tea.20157.

Croft, A., Coggshall, J.G., Dolan, M., Powers, E., & Killion, J. (2010). Job-embedded professional development: What it is, who is responsible, and how to get it done well (Issue Brief). Retrieved from https://learningforward.org/wp-content/uploads/2017/08/job-embedded-professional-development.pdf.

Dana, N.F. (2013). *A teacher inquirer's field guide: Digging deeper into action research*. Thousand Oaks, CA: Corwin.

Dewey, J. (1910). *How we think.* Boston, MA: D.C. Health & Company.

Dewey, J. (1933). *How we think: A restatement of the relation of reflective thinking to the educative process.* Chicago, IL: Henry Regnery.

Dewey, J. (1938). *Logic: The theory of inquiry.* Oxford, England: Holt.

Dunst, C.J., Bruder, M.B., & Hamby, D.W. (2015). Metasynthesis of in-service professional development research: Features associated with positive educator and student outcomes. *Educational Research and Reviews, 10*(12), 16-29. Retrieved from https://eric.ed.gov/?id=EJ1067213.

Edwards, C.P. & Gandini, L. (2015). Teacher research in Reggio Emilia: Essence of a dynamic, evolving role. *Voices of Practitioners.* Retrieved from https://digitalcommons.unl.edu/cgi/viewcontent.cgi?referer=https://www.google.com/&httpsredir=1&article=1108&context=famconfacpub.

Edwards, C.P., Gandini, L., & Forman, G.E. (2012). *The hundred languages of children: The Reggio Emilia experience in transformation, 3rd edition.* Santa Barbara, CA: Praeger.

Epstein, A. & Willhite, G.L. (2015). Teacher efficacy in an early childhood professional development school. *International Electronic Journal of Elementary Education, 7*(2), 189-198. Retrieved from http://eric.ed.gov/?q=early+childhood+professional+development&ft=on&id=EJ1057861

First Things First. (2013). *Arizona's unknown education issue: Early learning workforce trends*. Retrieved from https://www.azftf.gov/WhoWeAre/Board/Documents/FTF-CCReport.pdf

First Things First. (2015). *Arizona early childhood workforce knowledge and competencies, 1st edition.* Phoenix, AZ: First Things First. Retrieved from http://azearlychildhood.org/flipbook/462017/?page=142.

Flavell, J. H. (1992). Cognitive development: Past, present, and future. *Developmental Psychology, 28*(6), 998-1005. Retrieved from http://psycnet.apa.org/record/1993-09141-001.

Fullan, M. (2006). *Change theory: A force for school improvement*. Victoria, Australia: Centre for Strategic Education.

Galdas, P. (2017). Revisiting bias in qualitative research: Reflections on its relationship with funding and impact. *International Journal of Qualitative Methods, 16*(1). https://doi.org/10.1177/1609406917748992

Gambetti, A. & Gandini, L. (2014). Reflections on the little ones of silent movies: Make-believe with children and fish at the infant-toddler center. *Innovations in Early Education: The International Reggio Emilia Exchange, 21*(2). Roswell, GA: North American Reggio Emilia Alliance.

Glaser, B.G. & Holton, J. (2004). Remodeling grounded theory. *Forum: Qualitative Social Research, 5*(2). Retrieved from http://www.qualitative-research.net/index.php/fqs/article/view/607/1315.

Glaser, B.G. & Strauss, A.L. (2006). *The discovery of grounded theory: Strategies for qualitative research*. New Brunswick, NJ: Transactions Publications.

Gerde, H.K., Pierce, S.J., Lee, K. & Van Egeren, L.A. (2017). Early childhood educators' self-efficacy in science, math, and literacy instruction and science practice in the classroom. *Early Education and Development, 29*(1), 70-90. Retrieved from https://www.tandfonline.com/doi/full/10.1080/10409289.2017.1360127.

Goodrum, D., Hackling, M. & Rennie, L. (2001). *The status and quality of teaching and learning of science in Australian schools: A research report.* Canberra, Australia: Department of Education, Training and Youth Affairs.

Gordon-Finlayson, A. (2010). QM2: Grounded theory. In M.A. Forrester (Ed.) *Doing qualitative research in psychology* (154-76). London, England: Sage Publications.

Gordon, S.P. (2016). Expanding our horizons: Alternative approaches to practitioner research. *Journal of Practitioner Research, 1*(1). http://doi.org/10.5038/2379-9951.1.1.1030.

Hamre, B., Hatfield, B., Pianta, R., & Jamil, F. (2014). Evidence for general and domain-specific elements of teacher–child interactions: associations with preschool children's development. *Child Development, 85*(3), 1257-1274.

Hargreaves, A. & Fullan, M. (2012). *Professional capital: Transforming teaching in every school.* New York, NY: Teachers College Press.

Harvard Center on the Developing Child. (2007). *The Science of early childhood development* (In Brief). Retrieved from https://developingchild.harvard.edu/resources/inbrief-science-of-ecd/.

Harvard Graduate School of Education: Project Zero. (2015). *I used to think…now I think…* Retrieved from http://www.pz.harvard.edu/resources/i-used-to-think-now-i-think-vt.

Hatch, A., Greer, T., & Bailey, K. (2006). Student-produced action research in early childhood education. *Journal of Early Childhood Education, 27*(2), 205-12. https://doi.org/10.1080/10901020600675182.

Henderson, B., Meier, D.R., Perry, G., & Stremmel, A.J. (2012). The nature of teacher research. *Voices of Practitioners.* Retrieved from https://www.naeyc.org/sites/default/files/globally-shared/downloads/PDFs/resources/pubs/Nature%20of%20Teacher%20Research.pdf.

Herr, K., & Anderson, G.L. (2015). *The action research dissertation: A guide for students and faculty, 2nd edition*. Thousand Oaks, CA: Sage

Holmes Group. (1990). *Tomorrow's schools: Principles for design of professional development schools.* East Lansing, MI: Holmes Group, Inc.

Hong, S.Y., Torquati, J., & Molfese, V.J. (2013). Theory guided professional development in early childhood science education. *Faculty Publications from CYFS, 29*(17), 1-32. Retrieved from http://digitalcommons.unl.edu/cyfsfacpub/29.

Ivankova, N.V. (2014). *Mixed methods applications in action research: From methods to community action*. Los Angeles, CA: Sage Publications.

Johnson, B. (1993). Teacher as researcher. *ERIC Digest.* Retrieved from https://eric.ed.gov/?id=ED355205.

Jones, M. M. (2008). Collaborative partnerships: A model for science teacher education and professional development. *Australian Journal of Teacher Education, 33*(3). Retrieved from http://files.eric.ed.gov/fulltext/EJ1069642.pdf.

Katsampoxaki-Hodgetts, K. Fouskaki, M., Siakavara, K., Moschochoritou, R. & Chaniotakis, N. (2015). Student and teacher perceptions of inquiry-based science education in secondary education in Greece. *American Journal of Educational Research, 3*(8). Retrieved from http://pubs.sciepub.com/education/3/8/4/.

Kozulin, A., Gindis, B., Ageyev, V.S., & Miller, S.M. (2003). *Vygotsky's educational theory in cultural context.* Cambridge, England: Cambridge University Press.

Lally, R. & Mangione, P. (2017). Caring relationships: The heart of early brain development. *Young Children, 72*(2). Washington, D.C.: National Association for the Education of Young Children.

La Paro, K.M., Hamre, B.K., & Pianta, R.C. (2007). *Classroom assessment scoring system manual: Toddler*. Baltimore, MD: Brookes Publishing.

Lee, O.V.D. (2004). Professional development in inquiry-based science for elementary teachers of diverse student groups. *Journal of research in science teaching*, *41*(10), 1021–1043. http://dx.doi.org/10.1002/tea.20037

Lewis, L., Parsad, B., Carey, N., Bartfai, N., Farris, E., Smerdon, B., & Greene, B. (1999). Teacher quality: A report on the preparation and qualifications of public school teachers. Washington, D.C.: United State Department of Education. Retrieved from https://nces.ed.gov/pubs99/1999080.pdf.

Maddux, H.C. & Donnett, D. (2015). John Dewey's pragmatism: Implications for reflection in service-learning. *Michigan Journal of Community Service Learning*, 64-73. Retrieved from https://files.eric.ed.gov/fulltext/EJ1116448.pdf.

Maricopa Community Colleges. (2018). *Early childhood degree/programs*. Retrieved from https://asa.maricopa.edu/departments/center-for-curriculum-transfer-articulation/programs-degrees?combine=early%20childhood.

Marsh, J.P. & Gonzalez, D. (2018a). Exploring identity through literacy practice and practitioner research. *Journal of Adolescent and Adult Literacy, 62*(4). https://doi.org/10.1002/jaal.917.

Marsh, J.P. & Gonzalez, D. (2018b). Practitioner research: Inquiry that impacts adolescent and adult literacy learning and teaching. *Journal of Adolescent and Adult Literacy, 62*(2). https://doi.org/10.1002/jaal.878.

Martin, L.W., Ash D., & Tran, L.U. (forthcoming). *The reflective practitioner: Expanding practice in museums.* London, England: Routledge.

McClure, E. R., Guernsey, L., Clements, D. H., Bales, S. N., Nichols, J., Kendall-Taylor, N., & Levine, M. H. (2017). *STEM starts early: Grounding science, technology, engineering, and math education in early childhood.* New York, NY: The Joan Ganz Cooney Center at Sesame Workshop.

McCormick, T. M, Eick, C.J., & Womack, J. S. (2013). Culturally responsive teaching: Awareness and professional growth through a school-university collaboration. *School University Partnerships, 6(*1), 6-14. Retrieved from https://eric.ed.gov/?id=EJ1008672.

McKeown, T.R., Abrams, L.M., Slattum, P.W., & Kirk, S.V. (2016). Enhancing teacher beliefs through an inquiry-based professional development program. *Journal of Education in Science, Environment and Health, 2*(1), 85- 97. Retrieved from http://files.eric.ed.gov/fulltext/EJ1105353.pdf.

McMillan, J.H. & Wergin, J.F. (2010). *Understanding and evaluating action research, 4th edition.* London, England: Pearson Publications.

Mertler, C.A. (2014). *Action research: Improving schools and empowering educators, 4th edition.* Thousand Oaks, CA: Sage Publications.

Mitchell, T.D., Richard, F.D., Battistoni, R.M., Rost-Banik, C., Netz, R., & Zakoske, C. (2015). Reflective practice that persists: Connections between reflection in service-learning programs and in current life. *Michigan Journal of Community Service Learning*, 49-63. Retrieved from https://files.eric.ed.gov/fulltext/EJ1116316.pdf.

Murphey, D. (2013). A sense of knowing: Teacher research with community college preservice teachers. *Voices of Practitioners*, *8*(2), 1-14. Retrieved from https://search.proquest.com/openview/9cbbbfeb4c345d81b8248d681a8d912c/1?pq-origsite=gscholar&cbl=2027469.

National Association for the Education of Young Children. (2004). Creating the environment for movement. *Beyond the Journal*. Retrieved from https://www.naeyc.org/files/naeyc/Creating_the_Environment_for_Movement.pdf

National Association for the Education of Young Children. (2009). *Developmentally appropriate practice in early childhood programs serving children birth to age 8* [White paper]. Retrieved April 22, 2018 from National Association for the Education of Young Children: https://www.naeyc.org/sites/default/files/globally-shared/downloads/PDFs/resources/position-statements/PSDAP.pdf.

National Association for the Education of Young Children. (2010). What is professional development in early childhood education? *NAEYC online.* Retrieved from https://www.naeyc.org/files/naeyc/What%20Is%20Professional%20Development%20in%20Early%20Childhood%20Education.pdf

National Association for the Education of Young Children. (n.d.). What is professional development in early childhood education? Retrieved from https://www.naeyc.org/files/naeyc/What%20Is%20Professional%20Development%20in%20Early%20Childhood%20Education.pdf

National Research Council. (1996). *National science education standards*. Washington, DC: National Academy Press.

National Research Council. (2000). *How people learn: Brain, mind, experience, and school: Expanded edition.* Washington, DC: The National Academies Press. https://doi.org/10.17226/9853.

National Scientific Council on the Developing Child. (2011). *Building the brain's "air traffic control" system: How early experiences shape the development of executive function*. Cambridge, MA: Center on the Developing Child at Harvard University. Retrieved from https://46y5eh11fhgw3ve3ytpwxt9r-wpengine.netdna-ssl.com/wp-content/uploads/2011/05/How-Early-Experiences-Shape-the-Development-of-Executive-Function.pdf.

New, R. (2007). Reggio Emilia as cultural activity theory in practice. *Theory into Practice*, *46*(1), 5-13. Retrieved from https://eric.ed.gov/?id=EJ756000.

Newman, L. & Woodrow, C. (Eds.). (2015). *Practitioner research in early childhood: International issues and perspectives*. Thousand Oaks, CA: Sage Publications.

Next Generation Science Standards Lead States. (2013). *Next generation science standards: For states, by states*. Washington, D.C.: The National Academies Press. Retrieved from https://www.nextgenscience.org/standards/standards.

Next Generation Science Standards Lead States. (2018). *Conceptual shifts in the Next Generation Science Standards*. Retrieved from https://www.nextgenscience.org/sites/default/files/resource/files/Appendix%20A%20-%204.11.13%20Conceptual%20Shifts%20in%20the%20Next%20Generation%20Science%20Standards.pdf.

Noble, H. & Smith, J. (2015). Issues of validity and reliability in qualitative research. *Evidence Based Nursing, 18*(2). doi: 10.1136/eb-2015-102054.

Oakes, J. (1990). *Multiplying inequalities: The effects of race, social class, and tracking on opportunities to learn mathematics and science*. Santa Monica, CA: Rand.

Patton, M.Q. (2015). *Qualitative research & evaluation methods integrating theory and practice, 4th edition.* St. Paul, MN: Sage Publications.

Pelo, A. (2006). Growing a culture of inquiry: Observation as professional development. *Exchange*, 50-35. Retrieved from http://ececompsat.org/docs/as-cultureofinquiry.pdf.

Piaget, J. (1964). Cognitive development in children: Development and learning. *Journal of Research in Science Teaching, 2*, 176-86. http://dx.doi.org/10.1002/tea.3660020306.

Piasta, S.B., Logan, J.A.R., Yeager Pelatti, C. & Capps, J.L. (2015). Professional development for early childhood educators: Efforts to improve math and science learning opportunities in early childhood classrooms. *Journal of Educational Psychology, 107*(2), 407-422. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4527174/.

Protheroe, N. (2008). Teacher efficacy: What is it and does it matter. *Principal*. Retrieved from https://www.naesp.org/sites/default/files/resources/1/Pdfs/Teacher_Efficacy_What_is_it_and_Does_it_Matter.pdf.

The Public School Forum of North Carolina. (1995). *A profession in jeopardy: Why teachers leave and what we can do about it and keeping talented teachers*. Raleigh, NC: North Carolina Professional Practices Committee. Retrieved from https://www.ncforum.org/wp-content/uploads/2016/10/A-Profession-in-Jeopardy-Why-Teachers-Leave-and-What-We-Can-Do-About-It-Fall-1996.pdf.

Reason, P., & Bradbury, H. (Eds.). (2001). *Handbook of action research: Participative inquiry and practice*. London, England: Sage Publications.

Reggio Children. (2016). *The hundred languages in ministories: Told by teachers and children from Reggio Emilia*. Worchester, MA: Davis Publications.

Rinaldi, C. (2003). The teacher as researcher. *Innovations in Early Education: The International Reggio Exchange, 10*(2). Retrieved from https://www.reggioalliance.org/downloads/researcher:rinaldi.pdf.

Roth, A.C.V. & Månsson, A. (2011). Individual development plans from a critical didactic perspective: Focusing on Montessori- and Reggio Emilia profiled preschools in Sweden. *Journal of Early Childhood Research, 9*(3), 247-261. Retrieved from http://journals.sagepub.com/doi/pdf/10.1177/1476718X10389148.

Saldaña, J. (2016). *The coding manual for qualitative researchers*. Thousand Oaks, CA: Sage Publications.

Schaffer, L. & Thomas-Brown, K. (2015). Enhancing teacher competency through co-teaching and embedded professional development. *Journal of Education and Training Studies, 3*(3), 117-123. Retrieved from http://files.eric.ed.gov/fulltext/EJ1060818.pdf.

Schcolnik, M., Kol, S., Abarbanel, J. (2006). Constructivism in theory and in practice. *English Teaching Forum, 44*(4), 12-20. Retrieved from http://files.eric.ed.gov/fulltext/EJ1107896.pdf.

Scheinfeld, D.R., Haigh, K.M., & Scheinfeld, S.J.P. (2008). *We are all explorers: Learning and teaching with Reggio principles in urban settings*. New York, NY: Teachers College Press.

Schön, D.A. (1983). *The reflective practitioner: How professionals think in action.* New York: Basic Books.

Schroeder Yu, G. (2012). Professional development through the study of children's interests: The use of collaborative inquiry and documentation protocol among early childhood teachers. *Research Gate*. Retrieved from https://www.researchgate.net/publication/305346510_PROFESSIONAL_DEVELOPMENT_THROUGH_THE_STUDY_OF_CHILDREN%27S_INTERESTS_THE_USE_OF_COLLABORATIVE_INQUIRY_AND_DOCUMENTATION_PROTOCOL_AMONG_EARLY_CHILDHOOD_TEACHERS.

Sela, O. & Harel, M. (2012). The role of teacher education in introducing action research into the education system: A case study of an education college. *Current Issues in Education, 15*(2). Retrieved from https://www.researchgate.net/publication/289049508_The_role_of_teacher_education_in_introducing_action_research_into_the_education_system_A_case_study_of_an_education_college.

State of Victoria Department of Education and Early Childhood Development. (2012). *Early years learning and development framework: Practice principle guide, volume 8: Reflective practice*. Melbourne, Victoria: State of Victoria. Retrieved from http://www.imagineeducation.com.au/files/CHCPRP003/Victorian_Early_Years_Learning_and_Development_Framework.PDF.

Stremmel, A.J. (2012) Reshaping the landscape of early childhood teaching through teacher research. In G. Perry, B. Henderson, & D.R. Meier (Eds.) *Our inquiry, our practice: Undertaking, supporting, and learning from early childhood teacher research(ers)* (108-116). Washington, D.C.: NAEYC.

Stribling, S.M. (2013). A view of quality and ethics of teacher research in public schools. *Voices of practitioners, 8*(1). Retrieved from https://www.naeyc.org/files/naeyc/file/Voices/Voices_Stribling_V8N1.pdf.

Taylor, S. J. & Bogdan, R. (1998). *Introduction to qualitative research methods: A guidebook and resource, 3rd edition*. Hoboken, NJ: John Wiley & Sons.

Teaching Strategies. (2018). *Introducing my teaching strategies*. Retrieved from https://teachingstrategies.com/myteachingstrategies/.

Thomason, A.C., & La Paro, K.M. (2009). Measuring the quality of teacher–child interactions in toddler child care. *Early Education & Development, 20*(2), 285–304. https://doi.org/10.1080/10409280902773351

Trent, J. (2010). Teacher education as identity construction: Insights from action research. *Journal of Education for Teaching, 36*(2). 153-68. https://doi.org/10.1080/02607471003651672.

United States Department of Education. (2015). What are preschool development grants? Retrieved from https://www2.ed.gov/programs/preschooldevelopmentgrants/pdgfactsheet81115.pdf.

United States Department of Health and Human Services. (2015). *Head start early learning outcomes framework*. Washington, D.C.: Administration for Children and Families.

United States Department of Health and Human Services. (2016). *Head start program performance standards.* Washington, D.C.: Administration for Children and Families.

United States Department of Health and Human Services. (2018, January 1). *Office of head start*. Retrieved from https://www.acf.hhs.gov/ohs.

Vecchi, V. (2010). *Art and creativity in Reggio Emilia: Exploring the role and potential of ateliers in early childhood education.* New York, NY: Routledge.

Vygotsky, L. (1978). Interaction between learning and development. In M. Gauvain, & M. Cole (Eds.), *Readings on the development of children* (pp. 29-36). New York, NY: W.H. Freeman and Company.

Wei, R. C., Darling-Hammond, L., Andree, A., Richardson, N., & Orphanos, S. (2009). Professional learning in the learning profession: A status report on teacher development in the United States and abroad (Technical Report). Dallas, TX: National Staff Development Council.

Wein, C.A., Guyevskey, V., & Berdoussis, N. (2011). Learning to document in Reggio-inspired education. *Early Childhood Research & Practice, 13*(2). Retrieved from http://ecrp.uiuc.edu/v13n2/wien.html.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity.* New York, NY: Cambridge University Press.

Weston, C., Gandell, T., Beauchamp, J., McAlpine, L., Wiseman, C., & Beauchamp, C. (2001). Analyzing interview data: The development and evolution of a coding system. *Qualitative Sociology*, *24*(3), 381-400. Retrieved from https://link.springer.com/article/10.1023/A:1010690908200.

Willig, C. (2008). *Introducing qualitative research in psychology*. London, England: McGraw Hill Education. Retrieved from http://www.mheducation.co.uk/openup/chapters/9780335244492.pdf

Worth, K. (2010). Science in early childhood classrooms: Content and process. *Early Childhood Research & Practice: Beyond this Issue*. Retrieved from http://ecrp.illinois.edu/beyond/seed/worth.html.

APPENDIX A

COLLABORATIVE PLANNING AND REFLECTING MEETING NOTETAKING GUIDE

Collaborative Planning and Reflecting Meeting (CPRM) Notetaking Guide	
Toddler Classroom: EHS Teachers: Date:	
Reflect from last CPRM *Facilitator guides a reflective conversation about the last CPRM, such as asking questions about what has transpired with children and science since the last meeting.* What did you notice when implementing your plan from the last meeting?	
Describe and share documentation of children's learning *Co-teachers present while facilitator records notes and questions for a facilitated conversation.*	
Clarify with questions *Facilitator asks questions to clarify the event or activity. Team shares their responses.*	
Probe and Brainstorm *Co-teachers and facilitator collaboratively discuss their observations related to the scientific thinking skills being observed in the documentation. Facilitator might probe the teams to share what questions they might be having about themselves or about the children and to share their ideas and experiences to co-construct knowledge.* What do you think the child was thinking? What questions do you think the child might be trying to answer? What do you think the child was interested in during this study? How does this behavior relate to our group topic of study?	
Engage in Conversation *Co-teachers, with input from facilitator, fabricate a plan for offering materials and experiences to children to scaffold scientific thinking.* What did you learn about toddlers? What did you learn about yourself? What do you want to pursue next regarding scientific thinking, based on this evidence?	
Plan Decisions for Provocation *Co-teachers finalize the logistics of their future activity or provocation: hypothesis for what might happen, what materials and set-up are necessary, and the date and time*	**What materials and set-up will you plan?** **What do you think will happen when you offer this experience? What might the children do?**

	On what date/time will you offer this experience?
	How will you document (e.g., video, photo, anecdotal notes)?

Adapted from Schroeder-Yu, G. (2012). Professional development through the study of children's interests: The use of collaborative inquiry and documentation protocol among early childhood teachers. *Research Gate*.

APPENDIX B

RECRUITMENT LETTER

Dear Early Head Start Teacher:

My name is Eric Bucher. I am a doctoral candidate in the Mary Lou Fulton Teachers College (MLFTC) at Arizona State University (ASU). I am working under the direction of Dr. Josephine Marsh, faculty member in MLFTC. I am conducting a research study on infant and toddler science professional learning and development. I would like to extend an invitation to you to participate in this project!

The purpose is to understand how reflective, job-embedded science professional development impacts your learning of science and your attitude towards integrating science teaching into the infant and toddler curriculum. You may use your preparation and planning time or professional development dates to participate in this project.

Your participation in this study is voluntary. If you choose not to participate or withdraw from the study at any time, there will be no penalty whatsoever. Your choice to participate or not participate will not affect your standing or your employee performance evaluation in any way. You must be 18 years of age or older to participate. The possible benefit to participation is the opportunity for you to reflect on and think deeply about how your experiences in early childhood science might lend to your professional learning and development over time. Another benefit to your participation is the potential to develop your skills in reviewing and analyzing Teaching Strategies GOLD data to inform your practices and understand science teaching and learning with infants and toddlers. You may also consider using your participation in this research project and any results in your professional development plan or performance evaluation.

I ask for your help, which will involve your participation in the below components:

- **A pre-project interview** (October 2018). Approximately 20 minutes. I would like to audio record this interview. I will ask you at the beginning of the interview if you consent to have it audio recorded for transcribing purposes. The interview will not be recorded without your verbal permission. Please let me know if you do not want the interview to be recorded; you also can change your mind after the interview starts, just let me know.
- **Initial Early Childhood Science Workshop** (October 2018). Approximately 90 minutes. You will be introduced to research project. I will facilitate the conversation and provide science-related resources as well as technical assistance around the use of Teaching Strategies GOLD and Google Drive.
- **Collaborative Planning and Reflection Meetings** (every other week, October 2018-February 2019). Approximately 60 minutes. We will review and discuss Teaching Strategies GOLD observations and share reflections and ideas related to infant's and toddler's science learning.
- **Electronic Feedback/Correspondence** (September 2018-February 2019). Approximately 3 hours virtually per month. I will upload our reflections, photographs, and collaborative planning meeting notes into Google Drive, which provides us opportunity to provide feedback in real time. You can review and respond to each other's comments.
- **Closing ECE Science Workshop** and **Post-Project Interview** (February 2019). Approximately 90 minutes. I would like to audio record this interview. I will ask you at the beginning of the interview if you consent to have it audio recorded for transcribing purposes. The interview will not be recorded without your verbal permission. Please let me know if you do not want the interview to be recorded; you also can change your mind after the interview starts, just let me know.
- I may also review your Toddler CLASS scores at the beginning and at the completion of this project to determine any growth in your professional skills from participating in this research project. All data collected from this project will be made available to you upon written request.

There are no foreseeable risks or discomforts to your participation. Any responses that you give during interviews or meetings will be confidential. During the research project, you will be assigned a participant number between 1-8. This number will be used on all data collected in the study. The master list of participant numbers will be stored in a password-protected computer. Your participation will remain confidential. Additionally, your participation in this project and any data or results from participation will not be shared with your Supervisor. Though, you may choose to share your participation as you see fit.

Results from this study may be used in outside reports, presentations, or publications. In publication, a pseudonym will be assigned to your name for confidentiality. Child-level data will be confidential and will be either aggregated or assigned pseudonyms for publications. If you have any questions concerning the research study, please contact the research team – Dr. Josephine Marsh at josephine.marsh@asu.edu.

Thank you,

Eric Bucher

Please let us know if you wish to be part of the study by completing the form below. You will be provided with a copy of this invitation letter and your completed form.

If you have any questions about your rights as a participant in this research, or if you feel you have been placed at rick, you can contact us at 480-727-4453 or the Chair of Human Subjects Institutional Review Board through the ASU Office of Research Integrity and Assurance at (480) 965-6788.

____ ____

Your printed legal name **Name of the site you work at**

____ ____________________________

Signature consenting permission to participate in this **Date**

research project (you can choose to withdraw at any time)

APPENDIX C

EARLY CHILDHOOD SCIENCE WORKSHOP AGENDAS

Initial Early Childhood Science Workshop Agenda – 90 minutes			
Time	**Agenda Item**	**Information Provided & Questions to Pose/Prompt**	**Notes**
15 minutes	Introduction to Innovation	Ask participants to introduce their names, sites, and roles; provide an overview of the innovation methods and timeframe listed in Chapter 3 Do you have any questions about the innovation?	Will start to build a shared enterprise; will provide a synopsis of the timeframe and plan commitment
45 minutes	Early Childhood Science	Ask participants to chart: What do you think of when you hear ECE science?; review the *ELOF* and *AzELS* Science Standards; present on the research about children as scientists from Chapter 1	Will provide a baseline of knowledge of their understanding of ECE science; will provide a collaborative discussion opportunity
30 minutes	Technical Assistance: My Teaching Strategies Google Drive	Provide a walk-through on both the My Teaching Strategies and Google Drive websites; show how to pull reports with documentation from My Teaching Strategies; show how to access Google Drive then upload document files; show how to review and post comments in Google Drive	Will provide a baseline of knowledge about where participants are in their performance with digital tools; will provide a base of knowledge so that participants know how to use the digital tools incorporated into my innovation

Closing Early Childhood Science Workshop Agenda – 90 minutes			
Time	**Agenda Item**	**Information Provided & Questions to Pose/Prompt**	**Notes**
5 minutes	Welcome and Check In about Google Drive Documentation	There were no posts from participants to download from Google Drive; Ask: were there any barriers to using Google Drive? Tell me about your experience with our electronic communication.	Will clarify responses from participants; will provide additional qualitative data to lend to the analysis process
60 minutes	Collaborative Planning and Reflection Meeting	Conduct a reflective meeting using the CPRM notetaking guide; I will share documentation of children engaging in a science activity and the participants will facilitate and ask questions	Will provide qualitative data related to scientific behaviors like asking questions that were listed in the CPRM
20 minutes	Early Childhood Science Post-Project Interview and *I Used to Think/Now I Think* handout	Conduct the post-innovation interview with the whole group; Record responses	Will provide insight into how the participants perceive their learning after the project

APPENDIX D

I USED TO THINK/NOW I THINK HANDOUT

I USED TO THINK…, BUT NOW I THINK…

A routine for reflecting on how and why our thinking has changed

Name: ____

Age: ___________ Highest Degree/Certificate: ______________________________

When we began this study of ECE science, you had some initial ideas about it and what it was about. In a few sentences, write what it is that you ***used to think*** about ECE science starting with: "I used to think…"

Then, think about ***how your ideas about ECE science have changed*** as a result of what we've been doing. In a few sentences write down "But now, I think…" about ECE Science.

Adapted from Harvard Graduate School of Education: Project Zero. (2015). *Visible Thinking*. Harvard Graduate School of Education.

APPENDIX E

EXAMPLE OF DATA ANALYSIS PROCESS (CODE TO THEME)

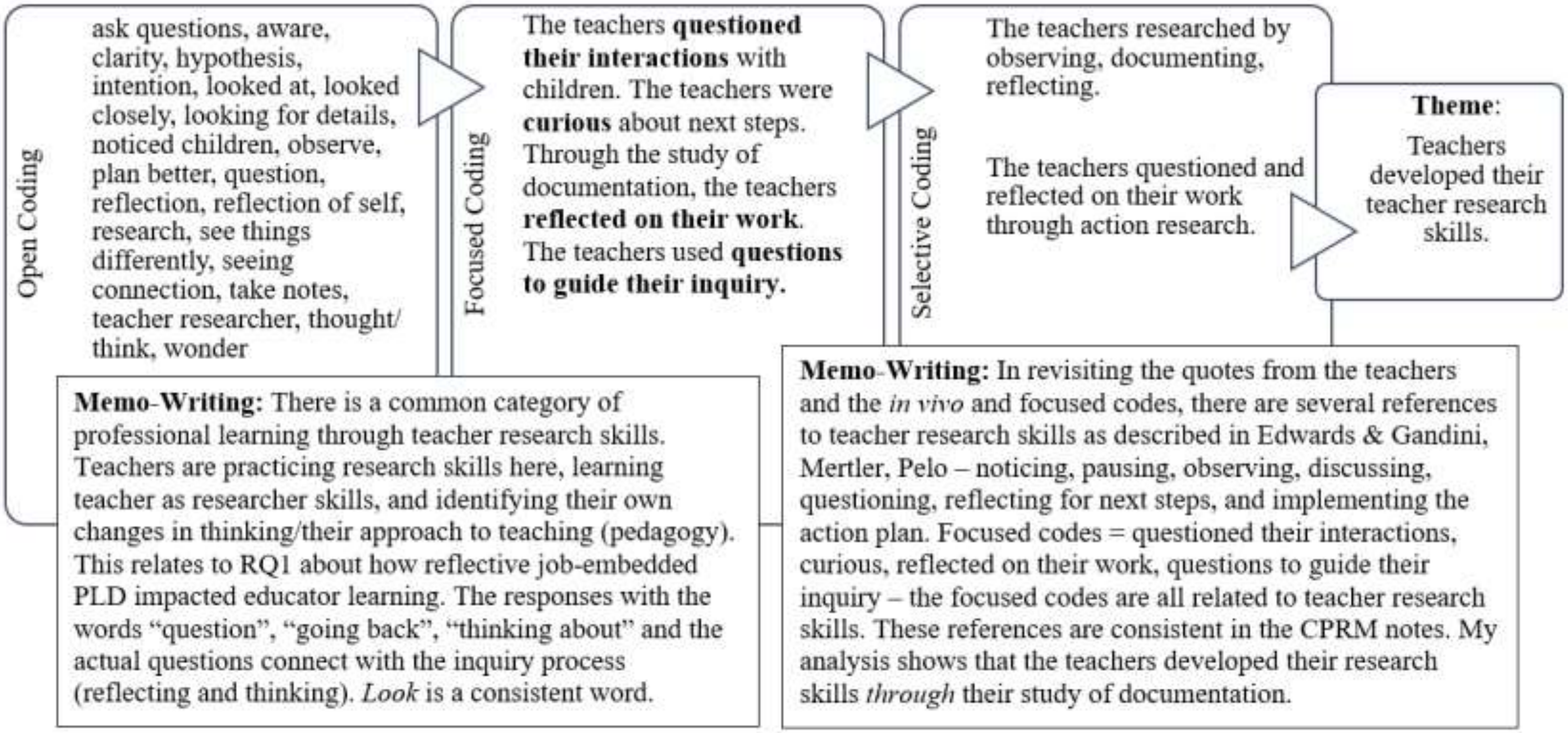

Figure 3: Through the analysis process, I moved from highlighting verbatim responses (open coding) to finding recurring categories. Then, I refined the categories into subcategories by saturating the data (focused coding), subsequently finding the deepest level of core patterns and relationships (selective coding). I constructed the theme-related findings based on what I discovered through grounded theory analysis with the three cycles of coding. This figure shows the process of analysis for one theme from code to theme with examples of how my memo-writing helped me move through the coding process.