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The Effects of Coaching Using a Reflective Framework on Early Childhood Science Teachers’ Depth of Reflection and Change in Practice

by

Debra L. Bloomquist

Submitted to the Graduate Faculty as partial fulfillment of the requirements for the

Doctor of Philosophy Degree in

Curriculum and Instruction

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The University of Toledo
May, 2016
An Abstract of

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This embedded-mixed methods study examined whether the use of a reflective framework with guiding prompts could support early childhood science teachers in improving their reflective practice and subsequently changing their pedagogy. It further investigated whether type of cognitive coaching group, individual or collaborative, impacted teacher depth of reflection and change in practice. Data included teacher reflections that were rated using the Level of Reflection-On-Action Assessment, reflective codes, and inductive themes, as well as videos of participants’ lessons coded using the SCIENCE instrument. Findings demonstrated that through guided reflection, teachers developed reflective thinking skills and, through this reflection, became more critical and began to improve their pedagogical practice. Further findings supported a conclusion that collaborative cognitive coaching may not be the most effective professional development for all teachers; some teachers in the study were found to have difficulty improving their reflectivity and thus their teaching practice. Based on these findings it is recommended that coaches and designers of professional development continue to use reflective frameworks with guiding prompts to support teachers in the
reflective process, but take into consideration that coaching may need to be differentiated for the various reflective levels demonstrated by teachers. Future studies will be needed to establish why some teachers have difficulty with the reflective process and how coaches or designers of professional development can further assist these teachers in becoming more critical reflectors.
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List of Abbreviations

Framework .................The Framework for K-12 Science Education

GFR.........................Guide for Reflection

LORAA ......................Level of Reflection-on-Action Assessment

“MKO”.......................More Knowledgeable Other

MSP .........................Math and Science Partnership

NGSS .........................Next Generation Science Standards

NEF.........................No Evidence Found

NRC.........................National Research Council

NURTURES............ Networking Urban Resources with Teachers and University to
enRich Early Childhood Science

SCIIENCE................ Systematic Characterization of Inquiry Instruction in Early
learnIng Classroom Environments

VSZPD.......................Video Supported Zone of Proximal Development

ZPD.........................Zone of Proximal Development
Chapter 1

Introduction to the Study

Current science reform efforts to increase the use of inquiry-based practices are supported by research as well as publications such as Taking Science to School (National Research Council [NRC], 2007), A Framework for K-12 Science Education (NRC, 2012) and the Next Generation Science Standards (NRC, 2013). Unfortunately, studies show that many teachers, especially early childhood (PreK-3) educators, do not teach using scientific inquiry, (Banilower et al., 2013; Lin, Hong, Yang, & Lee, 2013; Newman et al., 2005) and that they have difficulty changing their practice because they frequently lack science or engineering background knowledge (Trygstad, Smith, Banilower, & Nelson, 2013). This deficiency creates a barrier that stands in the way of in-service science teachers’ ability to transform their current pedagogical views and practices when it comes to science education. Despite national publications and the surplus of research supporting the use of inquiry in the science classroom (Edelson, 2001; Rubin, 1996; Winn, 2002), few studies indicate what actions should be taken to support teachers’ change in practice.

Reflection is one approach that research has deemed effective in moving teachers toward instructing in a different fashion (Cruickshank & Applegate, 1981; DeMulder, Cricchi, & Sockett, 2001; Freiré, 1991). Unfortunately, reflection that encourages analyzing one’s own knowledge, beliefs, and assumptions is not an easy endeavor for many teachers (Schön, 1983); therefore, some type of support or guidance is necessary. This support is especially important when it comes to the implementation of something as difficult as scientific inquiry. Studies demonstrate that many science teachers attempt it, but return to their old way of teaching, finding it too difficult to continue (Lundqvist,
Almqvist, & Ostman, 2012). According to Lin et al. (2013), when teachers are given sufficient time and significant support encouraging reflection on practice, teaching practices can be changed.

Two types of support determined effectual are professional development and coaching. Professional development, when presented effectively, aids teachers in increasing their content knowledge and honing their pedagogical skills. It may also lead to a change in beliefs. Coaching is used to support teachers in their implementation of newly gained knowledge and strategies, as well as to guide them through a process that encourages reflection on their teaching practice.

This chapter will present an overview of reflective practice, as well as discuss the importance of coaching and collaboration on the guidance of reflection to support early childhood science teachers in a transformation of practice. The focus of this dissertation is to compare the depth of reflection acquired by teachers working individually with a coach to those working in a collaborative coaching group. This study will further examine if a change in depth of reflection corresponds with a change in teacher use of inquiry-based teaching practices and whether teaching practice is impacted in individual and collaborative coaching.

**Theories Supporting Reflection**

John Dewey (1933) was a proponent of the concept and ideas behind reflective thinking. Dewey thought of reflection as a form of problem-solving that involved thinking through a problem to arrive at a solution by chaining ideas together in a progressive fashion. Schön (1983), like Dewey, considers the practice of reflection to involve problem-solving, but includes other processes as well. The reflective practitioner,
as Schön deems the person partaking in the reflection, attempts to make sense of a challenging phenomena, identifies areas of practice that need further examination, generates goals for improvement and pursues a course of action (Copeland, Birmingham, De La Cruz, & Lewin, 1993).

Similar to Schön’s stages of the reflective practitioner is Kolb’s cycle of experiential learning (Kolb, Boyatzis, & Mainemelis, 2001). This study used Kolb’s cycle as a foundation for reflection. Kolb’s experiential learning theory accentuates a cyclical relationship among four modes of learning: (a) concrete experience, (b) reflective observation, (c) abstract conceptualization and (c) active experimentation. Concrete experiences are those on which the learner observes and reflects. In this study the concrete experience was a video in which a peer was teaching an inquiry-based science lesson. Participants then reflected on the teaching and lesson observed. Opposite of concrete, abstract conceptualization entails thinking about or analyzing a nontangible object or experience (Kolb et al., 2001). Here, participants were guided toward a more critical reflection of their own teaching. The final stage of the cycle was active experimentation. In this stage, the implications derived from abstract conceptualization were tested and participants implemented their new knowledge and skills into their own inquiry-based science lesson.

Individuals or a group of colleagues could use Kolb’s cycle of experiential learning to help gain a deeper understanding of their teaching practices. When teachers are able to discuss their teaching practice with others more experienced and knowledgeable, like a science coach or other colleagues, they are supported in the reflection on their own teaching and may make changes to their teaching practice. Social
constructivism, specifically Vygotsky’s (1978) Zone of Proximal Development (ZPD) and his “More Knowledgeable Other” (MKO), support the guiding of reflection in this manner. The ZPD is entered when teachers are provided with new information just outside their existing realm of knowledge; therefore, they need to be actively guided through their reflection on the new situation/information by a person or persons more knowledgeable (MKO) than themselves (Vygotsky, 1978). This social interaction helps guide, direct and encourage the teacher’s reflection.

**Supports for Reflection**

As previously discussed, the act of reflection is difficult for many teachers; therefore, they require support and guidance. Many studies examined the types of interventions that may be effective when trying to support teachers through the reflective process. In order to give the teachers in this study a concrete guide through the reflective process, several aspects backed by research and shown to support reflection were included. These supports included (a) the use of a reflective framework embedded in Kolb et al.’s (2001) experiential learning cycle that incorporated prompts to scaffold teacher reflection and (b) collaborative reflection.

**Reflective framework.** As well as being able to observe scientific inquiry being practiced and reflection occurring, teachers need to be guided through the reflection process. Research conducted on teacher reflection has established the importance of having a guided framework to direct and focus teacher thinking and attention to specific practices (Rich & Trip, 2011). When teachers are minimally guided through the reflective process, reflection ends up being superficial (Zhang, Lundeberg, Koehler & Eberhardt, 2011). Thus, reflective practice needs to be scaffolded, structuring the tasks that may
initially be beyond the teachers’ capabilities so they can focus on them without being overwhelmed.

A reflective framework that includes prompts to guide science teachers’ through the reflection process would, therefore, be beneficial. In this study, prompts were given to aid teachers in writing their reflections on both the words and actions of inquiry-based teaching shown in a video provided to them. This encouraged them to reflect on their own pedagogy, leading them toward a change in beliefs and practice. This study used a modified version of the Level of Reflection-on-Action Assessment (LORAA; Padden, 2013) to help scaffold reflection and guide early childhood science teachers (PreK-3) to a deeper, more critical level of reflection.

**Collaborative reflection.** To deepen reflection even further, reflecting with others or in a learning community could aid in the promotion of critical reflection. Teachers engage in critical reflection when they search for the relationships beyond their school and classroom and incorporate the cultural, social, and moral aspects as well (Danielowich, 2007). When professional development participants work together as a learning community through interactive discussions, workshops facilitated by a MKO, observations of each other’s classrooms (live or video), and reflective writings, it is known as collaborative reflection (Lin et al., 2013). These group reflections allow teachers to critique ideas about teaching, evaluate and support one another, present suggestions, and formulate goals.

By joining collaborative groups, teachers can become more mentally and emotionally stimulated by the conversations happening amongst the members. Lieberman (1995) discovered that some teachers even acquire a stronger voice when demonstrating
their opinions and perspectives and become leaders amongst their peers. Lieberman’s (1995) study also indicated that teachers discovered through collaborative groups that their beliefs and practices were not always compatible. The detection of these differences helped to initiate a change in practice.

Statement of Purpose

National organizations have called for the development of teachers who are not only knowledgeable in scientific content but also have the pedagogical skills necessary to lead student-centered, inquiry-based learning (Lebak & Tinsley, 2010). Unfortunately, there are still a multitude of teachers who have yet to embrace this new pedagogical approach, because it is nontraditional and more complex (Fradd & Lee, 1999). Due to the difficulty of this pedagogical approach, professional development for teachers is necessary. However, research has shown that school districts have trouble providing professional development, especially individual coaching, because of the high financial burden.

Research indicated that reflection is a key component in changing teachers’ beliefs and practices, but there are few studies that looked at the impact of reflection on the use of scientific inquiry by early childhood teachers. Even fewer studies focused on the use of collaborative coaching to aid teachers in reflection and changing their pedagogical practice. To date, there is also not a sufficient amount of research that looks at the opportunities and hindrances of collaborative coaching versus individual coaching. This lack of research led to the questions guiding this research: (a) How does collaborative coaching compare to individual coaching in terms of impact on teachers’
depth of reflection? and (b) How does collaborative coaching compare to coaching associated with an improvement in practice?

In this 12-week study, participants were divided into two groups, those who reflected individually and those who reflected in a small group. Videos of peers using scientific inquiry in their classrooms were integrated into Kolb’s experiential learning cycle and used as the concrete experience for the teachers’ reflective observation. This type of video was chosen to help guide teachers into the Video Supported Zone of Proximal Development (VSZPD) by showing them videos of peers incorporating the scientific practices that they are struggling to implement in their own classrooms. This is intended to cause conflict between what they observe in the video and their own memory-based perception of what should occur in the classroom (McCullagh, 2012). Within the VSZPD, video promotes professional development by taking away the anxiety associated with reflection and serving as a tool for the process.

An adapted version of the reflective framework, the LORAA was utilized to code depth of reflections and aid in determining appropriate prompts to use to scaffold teacher’s reflections. Initially, the level of each individual teacher’s reflections was studied and identified. Different prompts were utilized depending on the level of reflection each teacher demonstrated. It was anticipated that this scaffolding would offer teachers the feedback necessary to progress them to higher levels of reflection.

With all teachers in this study receiving the same intervention, collaborative reflection could be explicitly studied. Kolb’s experiential learning cycle and an adapted version of the LORAA were used to identify any possible benefits or hindrances of collaboration on depth of reflection and teacher change of practice. These results are a
first step in informing the educational community of the pros and cons associated with coaching large groups of early childhood science teachers in regard to depth of reflection and change of instructional practices.

**Context of Study**

The focus of this study is a portion of a large scale Mathematics and Science Partnership (MSP) grant funded by the National Science Foundation (Grant No.1102808) entitled NURTURES. NURTURES stands for Networking Urban Resources with Teachers and University to enRich Early Childhood Science and was based at the University of Toledo. The goal of NURTURES was to create a complementary, integrated system of science education for grades PreK-3 by partnering with the University of Toledo, an urban local public school district, local preschools, and community resources (i.e., zoo, botanical gardens, and local science center).

The project was divided into five principle components: (a) A 2-week summer institute for all PreK-3 grade teachers and administrators involved, (b) academic year professional development that included personal learning communities or individual science coaching, (c) family community events with local partners, (d) family take-home science packs, and (e) 1-minute television spots featuring family science activities on the local public service station. This study spotlighted the academic year professional development aspect, specifically focusing on the science coaching provided to aid teachers in the implementation of inquiry-based science in their classrooms.

**Chapter Summary**

Presumably, all science teachers are expected to learn and implement the *Next Generation Science Standards* (NRC, 2013). However, many teachers do not yet know
how to teach science using inquiry-based science practices, or they lack the experience and confidence to do so. A method must be devised that will develop these teachers on a large scale. Guided reflection has proven to be effective in changing teacher practice, but using individual coaching to scaffold teacher reflection may be too large of a financial burden for a school district to undertake. Data collected by Knight (2012) showed that it cost school districts over $2000 per teacher to provide individualized coaching. School districts, as well as large programs that focus on the implementation of the new science standards, want to know which professional development opportunities yield the best results so they can allocate their budgets accordingly (Moche, 2011). The use of a reflective framework along with collaborative coaching may be the answer to developing large numbers of teachers effectively and efficiently. The following chapters examine the literature that supports this study, explain the methodology to be used, the findings from this study, and implications for the future. The results of this study will help to inform educational entities (i.e., school districts and programs such as NURTURES) of a possible way to move large groups of early childhood teachers into reflective practitioners who teach science effectively. This development will be useful in guiding teachers into changing their pedagogical practice to one that embraces the use of inquiry-based science instruction.
Review of the Literature

“In the last decade, numerous reports have been published calling for reform in science education. Each report highlighted the importance of early experiences in science so that students develop problem-solving skills that empower them to participate in an increasingly scientific and technological world” (National Science Teachers Association, 2002). However, research has determined that getting early childhood science teachers to teach using the inquiry-based practices supported by this reform can be a challenge (Colburn, 2000; Lin et al., 2013; Newman et al., 2005).

Over the last decade, national organizations have called for the development of teachers who are not only knowledgeable in scientific content but also have the pedagogical skills necessary to lead student-centered, inquiry-based learning (Lebak & Tinsley, 2010). To help advance teachers toward this goal, state educational organizations must provide their teachers with resources and professional development on research-based practices, such as the use of inquiry in science instruction (Pruitt & Wallace, 2012). When challenging pedagogies such as inquiry are being encouraged, teachers require support and guidance (Crawford, 2007). Unfortunately, research from the National Survey of Science and Mathematics education indicates that only 59% of elementary educators had recently attended a science-focused professional development (Banilower et al., 2013). If attended, professional development programs have been shown to aid teachers in learning content (Suppovitz & Turner, 2000) and transforming their beliefs and practice, but they must be aligned, grounded and implemented based on solid research findings (Marshall & Smart, 2013).
The school administrators whose responsibility it is to allocate the budget for professional development are interested in knowing which types of programs are grounded in research and have been found most effective so expenditures may be targeted fittingly (Moche, 2001). One such program that has been found to be effective in getting teachers to reflect on and analyze their own teaching and, thus, change their practice to include inquiry-based science instruction is cognitive coaching (Ellison & Hayes, 2009).

**A Framework for K-12 Science Education**

Recently in science education, scholars have utilized *A Framework for K-12 Science Education* (Framework; NRC, 2012) and the *Next Generation Science Standards* (NGSS; NRC, 2013) as guides to help educators improve their science teaching practices. A committee composed of scientists, cognitive scientists, science education researchers and experts in science education standards and policy created the Framework to bolster America’s ability to stay competitive in the international arena (NRC, 2012). Americans are currently lagging behind many other nations in their knowledge of science, engineering, and technology. The Framework was also created to give states the opportunity to adopt a common set of science standards, similar to those already being employed in math and language arts. The committee utilized the knowledge gained from the implementation of the NRC’s (1996) science standards to improve K-12 science education (NRC, 2012). Along with the 1996 science standards, the Framework (NRC, 2012) was also informed by several other studies and projects: (a) *Science for All Americans* (Association for the Advancement of Science [AAAS], 1989) 2) *Benchmarks for Science Literacy* (AAAS, 1993),(c). Project 2061
(http://www.aaas.org/program/project2061), and (d) The National Science Teachers Association Anchors Project (2009). All the information obtained was used to determine how students learn science effectively and what science content all K-12 students should know (Achieve, 2013).

The Framework emphasizes the importance of integrating the practices of science with content and is designed to help students link the different domains of science. The Framework consists of three dimensions: scientific and engineering practices, interdisciplinary core ideas, and cross-cutting concepts. The scientific and engineering practices get students investigating the world through science and engineering. Using information gained through the investigations in which they participate, students should recognize that science and engineering contribute to solving many of today’s societal issues, such as generating sufficient energy (NRC, 2012). The practices have students using the behaviors of scientists and engineers as they investigate, build models and theories, analyze and interpret data, construct explanations or design solutions, and argue from evidence. These practices encourage students to investigate and build theories about the natural world, piquing their curiosity about the world around them and motivating them to continue studying science or directing them to science-related careers.

The interdisciplinary core ideas are the science content standards and relate to the interest and life experiences of the students. These core ideas are connected both to societal and personal concerns that involve scientific or technological knowledge. The core ideas also provide a key tool for helping students understand and investigate more complex ideas and solve problems (Achieve, 2013).
The cross-cutting concepts can be applied across all science domains. They help students link the domains of science together and connect knowledge across disciplines, things that have rarely been taught in the past (NRC, 2014). According to the Framework, these concepts need to be made explicit for students, because they provide an organizational schema for connecting knowledge from the many fields of science (Achieve, 2013). The crosscutting concepts aid students in their attainment of acquiring a full understanding of the principles from each separate science field and that theories, laws, and generalizations of science should be understood in relation to their applications (NRC, 2012).

The overarching goal of the Framework is that all students in grades K-12 have (a) some appreciation of science by the end of the 12th grade, (b) enough knowledge of science and engineering that they can participate in a discussion about related issues, (c) knowledge to make informed decisions when it comes to scientific or technological information pertaining to their everyday lives, (d) the ability to learn about science outside of school, and (e) the skills to obtain the career of their choice, including (but not limited to) careers in science, engineering, and technology (NRC, 2012). Many educational institutions are currently using this book as a resource when designing lessons for science classrooms to ensure students are being engaged in scientific practices that allow them to better understand the world around them and make the content knowledge they gain more meaningful (Krajcik, 2013; Robelen, 2013).
Next Generation Science Standards

The NGSS were based on the *Framework* and were developed for K-12 science education so standards would be consistent across all grade levels and disciplines. They were designed as performance expectations for students in grades K-12. States and other stakeholders in science, science education, higher education, and industry composed these standards to prepare US students for college and future careers (Achieve, 2013). The NGSS have 26 states involved and others interested; therefore, they may become the national standards in science education (NRC, 2013).

The NGSS include the same three dimensions as the *Framework*: scientific and engineering practices, disciplinary core ideas, and cross cutting concepts. Most current state curriculums include these three dimensions as separate entities (Achieve, 2013). The NGSS, however, integrates them to show how content and application are connected. These standards focus on a smaller set of concepts than previously used in the US science curriculums. With fewer disciplinary core ideas, students are allotted more time to focus and gain a deeper understanding of the content. The NGSS builds a logical progression of knowledge from grades K-12 (NRC, 2013).

Difficulty of Inquiry for Early Childhood Educators

Although these national standards specifically direct educators to begin teaching science in the early years, science is not a large part of the curriculum in US elementary schools. Schools and districts are encountering increased pressure for accountability in the form of high-stakes testing (Johnson et al., 2001). Since the *No Child Left Behind Act* was issued in 2002, teachers have reported spending substantially more time teaching mathematics and language arts than science (Milner, Sondergeld, Demir, Johnson, &
Czerniak, 2012; Weiss, Banilower, McMahon & Smith, 2001). According to the National Survey of Science and Mathematics Education (Banilower et al., 2013), students in grades K-3 all receive mathematics and language arts instruction on a daily basis, but only 20% of them receive science instruction on most days. Unfortunately, other classes get science instruction only a few days a week or only during some weeks of the year. In 2012, early childhood teachers spent an average of only 19 minutes a day on science, while they spent 89 minutes a day on reading and 54 minutes on mathematics (Banilower et al, 2013). In addition to the lack of time spent on science due to the pressure of high-stakes testing, many early childhood teachers shy away from teaching science due to a lack of confidence and feelings of being unqualified.

Regardless of the push for educators to begin teaching inquiry-based science as suggested by the Framework and NGSS, many early childhood teachers do not feel comfortable teaching science at all, let alone in this manner. According to the National Center for Educational Statistics (1999), there is a tremendous need for early exposure to science in the United States. However, the majority of early childhood teachers lack the preparation in both content knowledge and familiarity with inquiry-based methods to teach science effectively (Bryan & Atwater, 2002: National Center for Educational Statistics, 1999). US statistics show that few early childhood teachers completed majors in science or science education and almost none had any engineering courses whatsoever (Banilower et al, 2013). This lack of content knowledge may influence a teachers’ confidence and, thus, the type of instructional strategies they choose to use when teaching science.
According to Banilower et al. (2013), only 52% of K-3 teachers used any type of hands-on learning when reporting on their most recent science lesson. The more confident teachers are in the subject they are teaching, the more likely they are to engage their students in inquiry-based instruction (de Laat & Watter, 1995). In addition, teachers who do not know how to teach using inquiry-based instruction may not use this pedagogical approach even if they believe it is the most effective way to instruct their students (Dai, Gerbino, & Daley, 2011).

Due to their lack of confidence in science content, many early childhood educators also look to their science books for guidance and support. Unfortunately, as explained by Staer, Goodrum, and Hackling (1998), most textbooks and manuals use more of a direct instruction approach providing teachers with limited ideas for inquiry-based instruction (as cited in Lin, Hong, Yang, & Lee, 2013). It has also been determined that early childhood teachers do not pursue the use of inquiry in their classrooms for reasons such as lack of professional ability, lack of experience, and the pressure put on them by states and administrators due to high stakes testing (Lin et al., 2013).

**Professional Development in Early Childhood Science**

**Problems and participation.** The demands of high-stakes testing and mandated curriculum often lead to districts implementing a one-size-fits-all approach to professional development. This type of professional development leaves teachers uninterested in the topic being addressed due to the developers being positioned as experts who are there to distribute information and knowledge. Unfortunately, not only
does this approach leave teachers disinterested, but also causes many to resist the new pedagogical practice all together (Sparks & Loucks-Horsley, 1990).

Participation in effective professional development allows teachers to increase their content knowledge and skills and may also lead to a change in beliefs; this change can then lead to an improvement in pedagogical practice (Loucks-Horsley, Love, Stiles, Mundry & Hewson, 2003). Early childhood educators need professional development to increase their content knowledge and bolster their confidence in teaching science. This increase in knowledge and confidence may then, in turn, give them the conviction needed to begin using inquiry-based instruction in their classrooms (Supovitz & Turner, 2000).

However, as previously stated, most early childhood educators do not attend science professional development and, if they do, it is not a significant amount. The 2012 National Survey of Science and Mathematics education found that only 12% of early childhood educators participated in 16 hours or more of science professional development in 2012. They also determined that any participation in science professional development is more beneficial than none. However, minuscule amounts such as a few hours over a year or more is not enough to affect teacher’s knowledge or pedagogical practices (Banilower et al., 2013). Several studies suggest that it will take at least 80 hours of professional development is required before a change in teacher practice occurs (Harlen, 2004; Supovitz & Turner, 2000). Unfortunately, many districts provide only a one-time professional development for pedagogical approaches such as inquiry-based science teaching. This type of professional development leaves teachers without sufficient support for the application of the new strategies when they return to the classroom (Garet et al., 1999; Loucks-Horsley et al., 2003; Thompson & Zeuli, 1999).
Additionally, many of the professional development workshops do not focus on how to teach science in spite of research indicating the need for increased knowledge and skills on inquiry-based instructional practices (Badders, 2014).

**Cost of professional development.** School districts spend a significant amount of their budgets trying to find effective types of professional development for their teachers (Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009). The majority of professional development provided to teachers normally consists of a 1-day workshop with little follow-up support, if any at all (Knight, 2012). However, teachers need at least 14 teacher contact hours of professional development per school year to make a positive impact on their students (Yoon, Duncan, Lee, Scarloss, & Shapley, 2007). They are also more likely to use newly learned pedagogical approaches such as inquiry in their classrooms when they actively participate in a mentoring relationship such as coaching or in close collaboration with colleagues (Knight, 2012). Unfortunately, most school districts cannot afford to invest that much money into such intensive and ongoing professional development. Data collected by Knight (2012), indicated that the lowest cost per teacher for individual coaching was $2,298, but when done collaboratively with 23 teachers, the cost decreased to $345 per teacher. This finding indicates that using collaborative coaching could greatly reduce the investment needed by school districts for effective professional development.

**What should effective professional development include?** After the NGSS released two public drafts to educators and stakeholders for feedback, one theme emerged from both of them: the concern for the amount of support that would be needed for the implementation of the new inquiry-based standards (NRC, 2013). Additional professional
development for teachers would be required, but no recommendations were established.
The need for professional development of science teachers is not new. Studies from
Darling-Hammond (2005), Hofstein and Lunetta (2004), and Keys and Bryan (2001) also
indicated the grave need for studies providing methodologies of scientific inquiry
learning opportunities and experiences for in-service teachers. Professional development
in the use of inquiry-based strategies in science is vital for preschool and early childhood
teachers to feel confident enough to incorporate these types of learning experiences into
their lessons. According to the National Science Teachers Association (2013), early
childhood teachers should be provided with professional development that

• engages them in learning science in a way that is hands-on and
interactive, thus permitting them to teach their students the principles of
science in an educated and effective manner.

• is ongoing and science-specific.

• aids them in the comprehension of how children learn scientific and

• advises them of multiple strategies that can be used to teach science
effectively.

• includes the use of mentors/coaches who will provide ongoing support
for teachers in the application of their new learning.

This type of professional development is essential for in-service teachers so that all
early childhood educators are cognizant of the new standards and the Framework, as
well as supported in their application of these into inquiry-based science instruction.
In-service teachers have difficulty adapting to these new methods of teaching without
support and an in-depth understanding of the expectations of the new standards (Lin et al., 2013). As indicated by the recommendation for science professional development from the National Science Teaching Association (2013), coaching is a way to provide in-service teachers with the needed support to aid them in their understanding and implementation of inquiry-based instruction. A study by Bush (1984) found that 10% of teachers who were provided only with a description on new instructional strategies implemented them into their classrooms. This percentage increased by 2%-3% when the training also included modeling, practice, and feedback. However, when coaching was added to the professional development, approximately 95% of teachers employed the new practices in their classrooms. Unfortunately, only 24% of early childhood educators received any feedback on their teaching from a mentor or coach in 2012 (Banilower et al., 2013) and even a smaller percentage of elementary schools even offer coaching.

**Coaching**

In the literature on professional development, coaching is becoming an increasingly popular component, because it provides teachers with the support and guidance they need when implementing new pedagogical practices (Knight, 2009a,b; Loucks-Horsley et al., 2003). Coaching has been defined as “sustained class-based support from a qualified and knowledgeable individual who models research-based strategies and explores with teachers how to increase these practices using the teacher’s own students” (Sailors & Shanklin, 2010, p. 1). School districts across the nation have recently begun using coaching as a professional development model that provides teachers with support and high-quality professional learning experiences (Heineke,
Research indicates that coaching helps teachers change their practice by providing the continuous support they need when faced with learning new teaching strategies, (Cobourn & Woulfin, 2012; Pianta, 2011). Studies by Joyce and Showers (2002) found that teachers are more likely to implement new practices into their teaching when coaching is used to help support their learning.

Although coaching is becoming more prominent in schools and has been shown to be beneficial in helping teachers improve their practice, only one fifth of schools offer coaching in science for elementary teachers (Banilower et al., 2013). This is unfortunate for early childhood educators who already struggle with science content and lack the confidence needed to implement strategies such as inquiry in their science lessons. These teachers require both support when learning new pedagogical practices as well as the strategies modeled for them in the context of their classroom. For teachers to learn to employ new teaching strategies in hopes of meeting the current standards, professional development needs to take place within the context of the classroom and everyday instructional practices (Cohen & Ball, 1999; Johnson, 2010).

Not only does coaching benefit teachers in the learning of new strategies, but it also affords them the time and support they require for reflection, exploration, and discussion of the new practices being implemented into their teaching. According to Mraz, Algozinne, & Kissel (2009), a typical coaching model consists of teachers and coaches engaging in a cycle of demonstration, observation, and reflection. Together, both participants demonstrate, observe, reflect, and consider how such teaching decisions influence students. It has been shown that change in teaching practice occurs when teachers observe their own teaching (Guskey, 1986). These observations allow teachers
to have dialog with their coaches that help them reflect on their beliefs and attitudes. Through these discussions their teaching transforms. This kind of transformation is what coaches hope to nurture with teachers.

Multiple types of coaches are available to teachers: instructional, peer, and cognitive. Each is beneficial in different ways; for example, instructional coaches share proven practices with teachers so they can reach more students (Killion, 2009). Despite the evidence that supports coaching as valuable, not enough research has been conducted that indicates how coaching improves teaching or the duration of coaching that is most effective in changing teacher’s practice (Neumerski, 2012).

**Instructional coaching.** Instructional coaching was developed in the early 1980s to aid teachers who were struggling with meeting the new mandated standards for student learning (Neumerski, 2012). Instructional coaching was established (Cohen & Ball, 1999) when researchers determined that one-time professional development workshops were not effective and that professional development may be better if were embedded within the classroom environment. Instructional coaches’ primary responsibility is to provide differentiated support to teachers so that they are able to implement research-based instructional practices into their classrooms (Knight, 2009a). Instructional coaches are excellent communicators and great at building trusting relationships. These characterizations are important, because coaches need to engage in reflective dialog with teachers, help them realize their goals, and then assist them with creating a plan to reach them.

**Peer coaching.** Developed by Bruce Joyce and Beverly Showers, peer coaching is when teachers coach each other in reciprocal ways (Neumerski, 2012). Multiple studies
support that peer and other types of coaching help teachers implement new teaching strategies (Bush, 1984; Knight, 2009b; Showers & Joyce, 1996). Several studies have found that using peer coaching after training helped teachers apply new practices more effectively than without peer coaching (Bush, 1984; Showers, 1984; Truesdale, 2003). According to Showers (1983), 75% of teachers who received peer coaching after a professional development session implemented the skills learned into their classroom. When teachers are involved in communication with a network of peers, they increase their chances for feedback and have a greater opportunity to enhance their practice. O’Brien (1992), determined that science teachers need to receive feedback on their practice from either their peers or coordinators to aid in the positive development of their instruction.

**Cognitive coaching.** Cognitive coaches not only support teachers in their implementation of new strategies, but also build a rapport with them to guide them into reflecting on the effectiveness of using these practices. According to Ellison and Hayes (2009) cognitive coaching centers on “reflection, complex thinking and transformational learning.” (p. 72). Cognitive coaches engage teachers in dialog and then use questioning and communication skills to lead them into deeply reflecting on their practice (Ellison & Hayes, 2009). The purpose of this type of coaching is not to tell teachers what to do, but to help them reflect upon their teaching through the use of thought-provoking questions, encouragement, and support. Helen Melichar, a teacher involved in a study through the University of Northern Iowa, stated, “It is the questioning that I find most significant to reflection. The questions force a deeper look and keep me from being superficial” (Canning, 1991, p. 20). Research conducted on cognitive coaching demonstrated
significant results in terms of the impact it has on teacher thinking. Cognitive coaching has been shown to benefit teachers professionally and create more collaboration amongst teachers in addition to causing deeper reflection and more complex ways of thinking (Edwards, 2008). It is effective in both guiding teachers to reflect and providing opportunities for teachers to discuss their practice with a more knowledgeable other.

**Reflection**

**The importance of reflection for teachers.** It is extremely important for teachers to reflect in order for their teaching to improve. Reflective thinking addresses practical problems, allowing for doubt and puzzlement before possible solutions are obtained (Hatton & Smith, 1995). For teachers to undergo reflective practice, they must undertake the process of learning through their own experiences to achieve new insights about themselves or their teaching practice (Boud, Keogh & Walker, 1985; Mezirow, 1990; Schön, 1987; Van Manen, 1977). This process includes evaluating their everyday practice as well as the need for the teacher to be self-aware and capable of critically examining their own responses to classroom situations. By doing this, the teacher will gain a new understanding and thus improve future practice (Finlay, 2008). Atkins and Murphy (1993) argued that when people are conscious of uncomfortable feelings, they should critically analyze them along with the experience in which they occurred. If they participate in this analytical process, a change in practice will transpire. According to Ratcliffe and Millar (2009), by providing teachers the necessary time and support to reflect on their pedagogy, teachers’ practices can be changed. Unfortunately, many teachers have a fixed view of teaching, which they develop prior to entering a program and which creates a barrier to reflection. Low self-esteem, childhood experiences, adult
trauma, as well as cultural conditions may be deeply rooted into a teacher’s psyche, deterring them from looking too closely at themselves or their work (Stanley, 1998). Therefore, to help foster effective reflection, teachers need to be offered time and opportunities for the development of metacognitive skills.

Obstructions to teacher reflection. Engaging in reflective thinking and practice is considered to be a core standard and benchmark in the teaching profession (Russell, 1997; Valli, 1993). Developing reflection as a professional perspective is difficult for several reasons, however. First, no shared and clear meaning exists of what reflection is and how it differs from other types of thinking (Rodgers, 2002). The definition of reflection is often inadequate, with the terms being hard to render effective in questionnaires and other research instruments. Collecting and analyzing data to prove reflection has taken place is, thus, challenging for researchers (Hatton & Smith, 1995). The current approaches being used to capture reflective thinking are journals or group discussions following practicum experiences, which are not being directed toward the solution of specific practical problems. These approaches, along with narratives, biographies, and reflective essays are often used as a basis for reflecting on teacher’s underpinning assumptions and how they can provide solutions to teaching dilemmas; however, little research exists showing that reflection is being achieved while completing these tasks (Hatton & Smith, 1995). Second, due to the busy and demanding world of teaching, with the many time constraints and crowded curriculum, it is hard for teachers to find the time to reflect. Many teachers must work countless hours a week to scarcely make a living, leaving little time left for reflection (Stanley, 1998). Last, reflection requires some type of support and structure, because reflection does not come naturally to
many teachers (Loughran, 2002). The practice of reflecting is not commonplace in the teaching profession in the United States. Teachers are primarily concerned with what is currently taking place in the classroom and then delivering an instant, practical action (Hatton & Smith, 1995). Teachers need opportunities and guidance when learning how to reflect effectively. When teachers are minimally guided through the reflective process, reflection becomes superficial (Zhang et al., 2011).

**Collaborative reflection.** Participants working collectively as a community of learners through discussions, classroom observations (live or video), professional development workshops, and reflective writings, is known as collaborative reflection (Lin et al., 2013). When collaboration and reflectivity are integrated with the needs and interests of the individuals involved, professional development becomes effective (Anderson & Olsen, 2006). This effectiveness is demonstrated through the enhancement of teacher focus on instruction that occurs when collaborative reflection is employed. Lin et al. (2013) determined that the practice of participating in multiple interactions with peers combined with clear reflections plays an important role in the development of teachers’ professional skills. Unfortunately, only 32% of elementary schools offer these types of collaborative groups for science education, and only about one third of elementary science teachers are provided with ample opportunity to try out and then discuss what they have learned in professional development workshops with groups of colleagues (Banilower, 2013).

Several studies have shown that establishing a collaborative community with multiple teachers from one building is one of the most important factors in supporting the use of inquiry in the classroom (Butler, Lauscher, Jarvis-Selinger, & Beckingham, 2004;
Jeanpierre, Oberhauser, & Freeman, 2005). Recent consensus on effective professional development advocates for providing teachers the opportunity to work with colleagues in similar situations, facing the same types of challenges, including teachers from the same school who have similar teaching assignments. Teachers implement the new strategies they have learned into their classrooms and discuss the outcomes with the group (Banilower, 2013; Loucks-Horsley et al., 2003; Murphy & Lick, 2001).

Yoon and Kim (2010), suggested that reflection and learning from previous experiences can be facilitated when teachers share teaching situations with others through collaborative discussions. Providing teachers the opportunity to offer suggestions and support, critique ideas, evaluate one another’s teaching, and devise goals assists teachers in the development of reflectivity and, in turn, can elicit a change in practice (Heibert, Gallimore & Stigler, 2002; Lin et al., 2013). Being afforded the time and opportunity to collaborate with other teachers about new pedagogical practices is one factor that is most important in supporting the use of inquiry in the classroom. Teachers learn from others who have implemented a new type of instruction more effectively, thus expanding their beliefs and their use of inquiry in the classroom (Kim, Lavonen, Juuti, Holbrook & Rannikmäe, 2013). Although having colleagues in collaborative groups is important, the inclusion of a facilitator is extremely beneficial. A study by Hatton and Smith (1995) determined that having someone facilitate reflection is important. Teachers in this study found collaboration with peers to be an effective strategy for fostering reflection, but also stated that the staff-supervised peer group discussions were valuable as well. A study by Pugach and Johnson (1990) showed the importance of providing teachers with support during collaborative reflection as well as modeling and coaching through scaffolded
dialog. When knowledgeable facilitators provide teachers with learning experiences, such as group discussions that focus on videos of other’s teaching practice, it affords them needed opportunities to analyze lessons that contain key features of high-quality instruction. These discussions can then lead to further learning opportunities, with teachers being guided into connecting the pedagogy observed in the videos to their own practices (Horizon Research, Inc., 2000). When teachers are only minimally guided, however, their video-based reflections have been shown to focus on trivial features of classroom practice (Calandra, Gurvitch & Lund, 2008).

**Use of video to aid in reflection.** Many teachers have a fixed view of teaching, developed prior to entering a program that creates a barrier to reflection. Therefore, fostering effective reflection requires time and opportunity, especially with a pedagogical approach such as inquiry, which many teachers have never seen implemented effectively. With scientific inquiry being so difficult for some teachers to grasp and put into practice, being able to observe another teacher using it in an effective manner may be beneficial. Having the option to pause or re-watch clips may also be extremely helpful to the depth of reflection achieved. The opportunity to watch and rewatch examples of others’ teaching is an area of great need for difficult types of pedagogy such as inquiry-based science, where multiple activities are often taking place simultaneously. Research shows that teachers learn new instructional strategies and better understand their students’ thinking through viewing videos of the teaching of others’ (Sherin & Han, 2004). Unfortunately, videos emulating high-quality inquiry-based science, especially those practices linked to the NGSS and Framework (NRC, 2012, 2013), are not readily
available, but teachers need to be able to see what an exemplary use of inquiry looks like before they can begin to reflect on their own use of inquiry in the classroom.

Seidel, Sturmer, Blomberg, Kobarg & Schwindt (2011) discovered that teachers reflecting on videos of themselves were less critical and identified fewer alternatives than teachers’ reflections based on videos of others. Watching video of oneself seems to impede critical reflection due to the activation of self-related knowledge and self-defense mechanisms. Many people are also self-conscious and do not want to be videotaped. Through watching video of other science teachers modeling inquiry-based practices, the viewer can see what high quality inquiry looks like and reflect upon it without any feelings of embarrassment or uneasiness. Video of others also presents an authentic way of showing the complex classroom setting, allowing viewers to activate prior knowledge and experience (Seidel et al., 2011).

Teachers need to observe the teaching of others in different situations to learn what types of things to avoid and what exemplars to follow. Research found that teachers learn about effective practice through watching videos from published resources and that the major affordances of these videos is the modeling done in them by the teachers and the comparative reflection that can ensue (Hatch & Grossman, 2009; Zhang, Lundeberg, Koehler, & Eberhardt, 2011). Roth and Chen (2007) determined that when teachers analyzed videotapes of teaching cases it was effectual in promoting learning, because it allowed teachers to notice specific practices and recall evidence. Videos of others also provide stimuli for the modification of ideas by giving the viewer an alternative or better idea that is intelligible, credible and productive, making them more dissatisfied with their present beliefs (McCullagh, 2012). Sherin and Han (2004) determined that teachers learn
new pedagogical practices and have a more comprehensive understanding of their students’ thinking when they view videos of peers. Peer videos have been shown to be a meaningful, unbiased tool that aids teachers in comprehending the context of their own teaching and engaging in comparative reflection (Zhang, 2011).

It is not only important for teachers to be able to observe examples of others using pedagogical practices, such as inquiry to reflect upon, but also for them to be provided with what happened before and after the teaching shown in the videos. According to Copeland et al. (1993), the thought behind the action matters more than the action itself in reflection. More experienced teachers can recall and describe the reflective thought processes going through their heads while particular events are occurring in the classroom (Hatton & Smith, 1995). Witnessing a teacher modeling reflective process may guide viewers to a clearer understanding of reflective practice and enable them to engage in comparative reflection.

The sociocognitive perspective based upon Vygotsky’s ideas of teaching and learning supports the inclusion of observation as a vehicle for promoting teachers’ reflective practice. The social cognitive theory states that adult learners are consciously aware and in charge of their own behavior (Bass, 2012). Thus, they can reflect on their own teaching and make changes to their teaching practice. This change can occur through observing others within the context of social interactions or experiences, specifically those who are more experienced and knowledgeable. Through watching exemplary video examples of peer teaching, a teacher may be drawn into the VSZPDS by the conflict between what they observe in the video and their own memory-based perception of what should occur in the classroom (McCullagh, 2012). Watching video of others has been
found to support reflection and guide teachers in transforming their teaching practices from epistemologically flat to rich, helping teachers reframe their experiences through seeing opportunities for alternative approaches and challenging their old assumptions (Loughran, 2002). Research by Shepherd & Hannafin (2008) showed that teachers’ written reflections in response to video reflection are more focused and accurate than teacher reflections without video. Sherin and van Es (2009) found teachers who used video to write their reflections also improved their ability to use evidence to support their reflection comments.

**Kolb et al.’s experiential learning theory.** Experiential learning is how knowledge is gained from past experiences. For learners to learn from experiences, they must be able to make connections between current and previous experiences, along with seeing potential uses for this knowledge in the future (Bass, 2012). Critical reflection on these experiences is crucial for this type of learning to occur.

The framework that supports Kolb et al.’s (2001) experiential learning theory reflects the stages that Schön (1983) used in his description of the reflective practitioner: framing the problem, factor naming, interpretation, analysis, synthesis, and evaluation. Similarly, Kolb et al. accentuated a cyclical relationship (Figure 1) among four modes of learning: (a) concrete experience, (b) reflective observation, (c) abstract conceptualization and (d) active experimentation (Sparks-Langer, Simmons, Pasch, Colton, & Starko, 1990). The Kolb cycle includes observing a concrete experience, reflecting on the observations made, and implementing what has been learned, providing participants with an experience that will expectantly facilitate deeper levels of pedagogical reflection.
Concrete experiences are those in which the learner observes and reflects. In certain situations, learners will chose to obtain new information through the use of tangible objects or concrete experiences (Kolb et al., 2001). Concrete situations can be viewed from multiple points of view, allowing the observer to use many exemplars to reflect on and learn from the event. These experiences are the foundation for the next step in the cycle, reflective observation.

In contrast to concrete conceptualization, which uses tangible objects or occurrences, abstract conceptualization entails thinking about or analyzing a nontangible object or experience (Kolb et al., 2001). In the third stage of the Learning Cycle, conclusions are drawn and learning occurs due to the reflecting that has previously taken place. The final stage of the cycle is active experimentation. In this final stage, the implications derived from abstract conceptualization can be tested.
Instruments for Measuring Depth of Reflection

For decades, educators and researchers expressed the importance of developing the reflective practitioner in the field of education. They generally believed that successful educators need to reflect on their practice and their actions. However, despite the plethora of literature that postulates reflection in the teaching profession as beneficial, very little of it indicates how to measure its depth, foster meaningful deliberation, or show that reflection has occurred at all. Of the instruments devised to measure or nurture reflection, most were designed for the field of nursing, not education. Also, the few studies that looked at assessing the varying levels of reflection differ in their definitions of these levels, causing further difficulty in determining which instrument is best when it comes to deciphering a teacher’s level of reflectivity. The following sections will review some of the instruments, along with their uses and limitations.

Framework for reflective thinking. Sparks-Langer et al. (1990) developed a coding scheme, entitled a Framework for Reflective Thinking, that included seven levels of reflectivity. Influenced by the works of Van Manen (1977), Kolb (1984), and Schön (1983,1987), along with cognitive psychology, this framework is a coding scheme; researchers used this coding scheme to evaluate students’ ability to reflect on multiple levels. This study was designed to foster reflective pedagogical thinking of third- and fourth-year education majors. These students underwent 10 weeks of field experience that were part of an eight-credit block of three different classes: Curriculum and Methods, Social Aspects of Education, and Measurement and Evaluation. After the completion of the 10-week courses, students taught a mini-unit for a week. Each night of this week, students were asked to complete a guided-reflective journal that included descriptions of
three instructional events that occurred during that day, along with other reflective
comments. These guided journals included prompts allowing students to reflect on
actions or difficulties that occurred during their teaching experience. These reflections,
along with 15-minute reflective interviews of each student, were coded by the researchers
and used to develop the Framework for Reflective Pedagogical Thinking.

This framework was also used in the examination of the reflective thinking of in-
service teachers during the course of a 36-hour staff development program that was
followed by eight peer-coaching sessions. No significant difference in reflection was
found between the pretraining and posttraining; however, a positive change in reflectivity
was found to occur after the coaching sessions. This framework is shown in Table 1 and
discriminates among seven types of thinking and language.

Table 1

Framework for Reflective Pedagogical Thinking

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No descriptive language</td>
</tr>
<tr>
<td>2</td>
<td>Simple, layperson language</td>
</tr>
<tr>
<td>3</td>
<td>Events labeled with appropriate terms</td>
</tr>
<tr>
<td>4</td>
<td>Explanation with tradition of personal preference given as a rationale</td>
</tr>
<tr>
<td>5</td>
<td>Explanation with principle or theory given as rationale</td>
</tr>
<tr>
<td>6</td>
<td>Explanation with principle or theory and consideration of context factors</td>
</tr>
<tr>
<td>7</td>
<td>Explanation with consideration of ethical, moral and political issues</td>
</tr>
</tbody>
</table>
**Sydney University program.** Hatton and Smith (1995) designed a study to investigate the nature of reflection in teaching, define different types of reflection, and evaluate which types of strategies facilitated these types of reflection better in student teachers. This study included peer interviews and written reports, where the students reflected on their thinking and what factors may have influenced it, including their own perceptions and beliefs. Students were responsible for writing two reports, two self-evaluations, two videotapes of their teaching and a 20-minute interview in pairs given by the project’s research assistant. All the data were analyzed, but the written reports were found to provide the most evidence of reflection; therefore, that was the data used as the basis for the research study. From this writing, Hatton and Smith identified four types of writing, three of which were considered reflective: descriptive reflection (reasons are provided based on personal judgment), dialogic reflection (discourse with one’s self to find possible reasons), and critical reflection (reasons for decisions involve historical, social and political perspectives).

Analyses of the written reports demonstrated evidence of reflective thinking occurring in the majority of student teachers, with the largest proportion of these being coded as descriptive reflection. Critical reflection, however, was found only in eight reports of the 60 reports written, and those were determined to be superficial. When analyzing the data, the researchers discovered a pattern that indicated that descriptive reflection often led students into dialogic reflection in their writing. This study led Hatton and Smith to create a hierarchy of reflection (Table 2).
Table 2
Hatton and Smiths (1995) Hierarchy of Reflection

<table>
<thead>
<tr>
<th>Reflection Type</th>
<th>Nature of Reflection</th>
<th>Possible Content</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reflection-in-action</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Schon, 1983, 1987)</td>
<td>5. <strong>Contextualization of multiple viewpoints:</strong> drawing on any of the possibilities 1-4 below applies to situations as they are actually taking place</td>
<td>Dealing with on-the-spot professional problems as they arise (thinking can be recalled and then later shared with others)</td>
</tr>
<tr>
<td>Addressing IMPACT concerns after some experience in the profession</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Reflection-on-action</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Schon, 1983; Smith &amp; Lovat, 1990; Smith &amp; Hatton, 1992, 1993)</td>
<td>4. <strong>Critical</strong> (social reconstructionist) seeing as problematic, according to ethical criteria, the goals are practices of one’s profession</td>
<td>Thinking about the effects upon others of one’s actions, taking account of social, political and/or cultural forces (can be shared)</td>
</tr>
<tr>
<td>Addressing TASK and IMPACT concerns in the later stages of a preservice program</td>
<td>3. <strong>Dialogic</strong> (deliberative, cognitive, narrative) weighing competing claims and viewpoints, and then exploring alternative solutions</td>
<td>Hearing one’s own voice (alone or with another) exploring alternative ways to solve problems in a professional situation</td>
</tr>
<tr>
<td></td>
<td>2. <strong>Descriptive</strong> (social efficiency, developmental personalistic) seeking what is seen as ‘best possible’ practice</td>
<td>Analyzing one’s performance in the professional role (probably alone), giving reasons for actions taken</td>
</tr>
<tr>
<td><strong>Technical rationality</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Schon, 1983; Shulman, 1988, Van Mannen, 1977)</td>
<td>1. <strong>Technical</strong> (decision-making about immediate behaviors or skills) drawn from a given research/theory base, but always interpreted in light of personal worries and previous experience</td>
<td>Beginning to examine (usually with peers) one’s use of essential skills or generic competencies as often applied in controlled, small scale settings</td>
</tr>
<tr>
<td>Addressing SELF and TASK concerns early in a program which prepares individuals for entry into a profession</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This hierarchy included five levels of reflection based on three forms of reflection. The first reflection type is technical rationality (Van Manen, 1977; Schön,
1983), which is concerned with self and tasks. This type includes only one level of reflection (i.e., technical), where the teacher’s decisions are about immediate behaviors or skills. The second form of reflection is reflection-on-action (Schön, 1983). This type incorporates three levels: descriptive, dialogic, and critical. The last type is reflection-in-action (Schön, 1983, 1987), which contains one level, which addresses the reflection that occurs while a teacher is in the act of teaching and requires some experience in the profession. The level is contextualization of multiple viewpoints, which is using any of the four lower levels of reflection as the situation is actually occurring.

**Nolan and Sim reflective evaluation framework.** Nolan and Sim (2011) used Sim’s (2006) adaptation of Boud et al.’s (1985) model of assessing reflection and levels of reflection to measure early childhood preservice teachers’ levels of reflectivity. They chose to use Boud et al.’s reflective framework because it had been successfully used with the training of healthcare professionals. Nolan and Sim’s initially piloted their evaluation framework with six early childhood preservice teachers. These teachers were provided with a manual that guided them through the reflective process while undertaking a series of assignments that motivated them to document past experiences, reflect on their beliefs and values pertaining to teaching, compare their practice to theoretical perspectives, and set goals for the future. Interrater reliability was established between the two researchers through the coding of all six students’ reflective assignments. These researchers determined that reflection could be assessed when using a structured reflective guide to aid teachers in their reflective process in conjunction with a reflective assessment framework. Figure 2 shows an example coding sheet of the Nolan and Sim (2011) Reflective Evaluation Framework.
**Figure 2.** Nolan and Sim’s (2011) reflective evaluation framework.

**Level of written reflection assessment.** This study was designed to develop and test two coding systems for nursing students’ written reflective journals. These coding schemes were based on the ideas of reflection held by Boud et al. (1985) and Mezirow (1990). Five principles of coding were developed during the pilot study to establish rules for coders (e.g., repeated points or arguments were to only be coded once). The first coding system was used to determine if any evidence of Boud et al.’s levels of reflection were found in the written reflections of nursing students. The second coding process assigned students to one of three broader categories that were derived from Mezirow (1990): non-reflector, reflector or critical reflector. Non-reflectors did not show any evidence of Boud et al.’s levels of reflection, while reflectors showed some confirmation of attending to feelings, association, and integration. Critical reflectors showed reflection at various levels, including validation, appropriation, and outcome of reflection.
Wong, Kember, Chung and Yan (1995) determined that student reflective journals could be used as evidence or absence of reflective thinking. They found that assigning students into the three groups of non-reflector, reflector, and critical reflector was reliable and uncomplicated, but refining them to the Boud et al.’s levels of reflection was difficult and less reliable. A coding example of this reflection assessment incorporating Boud et al.’s six levels of reflection is shown in Table 3. It shows the coding results for the five students who were determined to be critical reflectors.

Table 3

Wong, Kember, Chung, and Yan’s (1995) Level of Written Reflection Assessment

<table>
<thead>
<tr>
<th>Subcategories</th>
<th>MCY</th>
<th>OCW</th>
<th>OLK</th>
<th>FLL</th>
<th>OWF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attending to feelings</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Association</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Integration</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Validation</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Appropriation</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Outcome of reflection</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Rating checklist for reflective journals. Plack, Driscoll, Blissett, McKenna, & Plack (2005) used the theories of Boud et al. (1985), Schön (1983) and Mezirow (1990) in the development of their reflective assessment tool. Similar to Wong et al. (1995), these researchers developed a study to test a method of assessing reflection in written journals and a way to establish the level of reflection occurring. Plack et al. (2005) analyzed physical therapy students’ written reflective journals using two levels of coding. Initially, the researchers examined the text (words, sentences, and paragraphs) of the student journals. Here, they looked for evidence indicating any of the nine elements of reflection
they adopted from the works of Boud et al. and Schön. These nine elements listed in Figure 3 were defined as reflection in action, reflection on action, reflection for action, content reflection, process reflection, premise reflection, returns to experience, attends to feelings and evaluation of the experience.

<table>
<thead>
<tr>
<th>Code</th>
<th>Brief Definition</th>
<th>Presence</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Level I Element of Reflection</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td><strong>R-I-A Reflection-in-Action</strong> Occurs while in the midst of an action, on-the-spot decisions</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>R-O-A Reflection-on-Action</strong> Occurs after the action has been completed</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>R-F-A Reflection-for-Action</strong> Occurs before being faced with the situation; begins to plan for the future</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Content</td>
<td><strong>CON Content</strong> Explodes the experience from a number of perspectives (beyond description)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>PROC Process</strong> Describes the strategies used or available</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>PREM Premise</strong> Recognizes and explores own assumptions, values, beliefs, and biases</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stage</td>
<td><strong>RETRN Returns to experience</strong> Describes the experience</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>ATTEND Attends to feelings</strong> Acknowledges and begins to work with feelings</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>RE-EVAL Reevaluates</strong> Reappraises the situation compared to past experiences</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Level II Level of Reflection</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Journal</td>
<td><strong>NR Nonreflection</strong> No evidence of reflection is present</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>R Reflection</strong> Evidence of reflection is present</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>CR Critical reflection</strong> Evidence of critical reflection is present</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Figure 3. Plack et al.’s (2005) Rating Checklist for Reflective Journals*
Second, each journal entry was coded in total and then allocated to one of Mezirow’s (1990) three categories: no evidence of reflection, evidence of reflection, and evidence of critical reflection. Plack et al. (2005) found that this method for assessing written reflection was reliable for the educational purposes of defining a baseline to begin facilitating reflectivity in physical therapy students and determining proficiency in the reflective process.

Level of Reflection-on-Action Assessment. The LORAA (Appendix A) is an instrument developed by Padden (2011) to identify the level of reflection achieved by nursing students in their written reflective journal entries and to increase their assessed level of reflection through prompts provided by the educator. Padden (2011) incorporated the works of Boud et al.’s (1985) and Tanner’s (2006) model of clinical judgment in nursing to devise the theoretical basis for the LORAA. She used Boud et al.’s six hierarchical levels of reflection, along with their recommended feedback suggestions. For each of the six levels of reflection, Boud et al. (1985) provided the teacher with prompts to guide students to deeper levels of reflection. Padden used these prompts to help her students gain a deeper understanding from their experiences so they could implement them in future clinical practices.

Tanner’s (2006) clinical judgment in nursing model incorporates the works of Schön (1983) and Boud et al. (1985). It was designed for experienced nurses to use reflection-on-action and reflection-in-action when facing challenging clinical situations. Using this reflective process would then aid these nurses’ in the development of clinical knowledge and reasoning abilities for future situations. By using the reflective prompts from Boud et al., this model can also be used for nursing students to guide them through
the reflective process. Through this guidance from nurse educators, nursing students learn forms of inquiry that experienced practitioners use when thinking through complex problems (Tanner, 2006).

To assess the effectiveness of the LORAA in assessing students’ reflective levels in their journal entries, Padden (2013) used an adapted version of Nielsen, Stragnell, and Jester’s (2007) Guide for Reflection (GFR), which is based on Tanner’s (2006) clinical judgment in nursing model. The GFR provides nursing students with written instructions to prepare them for reflection, as well as a sequence of questions to guide them through the entire reflective process. These questions are intended to help students learn through reflective journaling.

To establish validity for the LORAA, Padden (2013) enlisted the expertise of three independent raters who were well versed in the art of reflection. Using a Likert scale ranging from 1 = not accurate at all to 4 = very accurate, these experts were asked to rate the degree of accuracy for the criteria described at each level of reflection. Two of the three experts rated each of the six items with a 3 or 4 (quite accurate or very accurate) while the third expert did not provide ratings but indicated that he/she felt the instrument was a “reasonable framework.” Feedback provided by the experts on specific wording and additional questions for feedback to students were included in the final instrument.

To establish interrater reliability, the LORAA was pilot tested using previously written journal entries from recent graduates of a nursing program \(N = 5\) using the adapted version of the GFR. Padden (2013) and two PhD-candidate nurse educators individually read and rated the journal entries using the LORAA. The three ratings for all
journal entries were then compared showing an agreement level from .67% to 100% on four of the five entries. No agreement was achieved for the fifth entry, however. Interrater reliability was determined to be .80 between two of the raters, and the LORAA was said to, therefore, be a reliable instrument for determining the level of reflection.

The LORAA was then again used as part of a larger study in which 112 journal entries were submitted by nursing students who were provided with the adapted version of the GFR for their journal entries. This time, the researcher used the LORAA to rate each journal entry, determining the level of reflection achieved. Padden then used these reflective ratings to provide the appropriate written feedback to each student using the prompts on the LORAA. Then, using the same procedure as the pilot study, Padden and a correter from the pilot study rated 18 of the 112 journal entries, resulting in a .94 reliability score.

**Categories of coding reflection.** Building on Boud et. al’s (1985) levels of reflection, Mezirow (1990) distinguished those participating in the reflective process and divided them into three categories, non-reflector, reflector, and critical reflector. According to Mezirow not all awareness of thoughts or actions are necessarily reflective. Actions such as those that are habitual or thoughtful in nature are considered to be non-reflective. Non-reflectors may review prior learning in their mind or writing, but will not evaluate or reconsider it. They report only what happened. A reflector, however, not only understands a situation but also takes a concept and ponders it in relation to a personal experience (Kember, McKay, Sinclair, & Wong, 2008). To be considered a critical reflector, there must be a transformation of purpose and perspective, challenging the
validity of prior beliefs (Mezirow, 1991). Critical reflectors critically assess themselves and their experiences on a continual basis (Wong et al., 1995).

Chapter Summary

Presently, there is a push for teachers to use inquiry-based practices when teaching science. Research found that many teachers, especially those in early childhood, do not feel comfortable teaching science, let alone using inquiry. This lack of confidence generates obstacles that stand in the way of early childhood science teachers’ ability to change their pedagogical views and practices when it comes to inquiry-based teaching. Participation in effective professional development can help early childhood science teachers increase their content and pedagogical knowledge, giving them the confidence needed to begin using inquiry-based teaching in the classroom. However, many times teachers are not offered support after they return to the classroom, and they have difficulty implementing what was learned. Coaching can provide teachers with this needed support and guidance, aiding them in the implementation of new pedagogical practices. Cognitive coaching not only helps teachers integrate new practices, but also guides them to reflect critically on their implementation. Reflection is a key component in the improvement of teaching. Through daily analysis and examination of teaching practices and situations, teachers can gain a new understanding and improve their practice. Unfortunately, reflection is not an easy process for the majority of teachers, thus they need to be guided through it. In order to do this, a reflective framework is needed.

Various instruments have been designed to assess written reflection and establish levels of reflectivity, but few been designed to aid teachers in achieving a deeper level of reflection. Six different instruments were discussed in this chapter. Two of the studies,
Nolan and Sim (2011) and Wong et al. (1994), both used Boud et al.’s reflective framework to measure levels of reflection, with the later study going one step further by using Mezirow’s (1990) categories of reflectors. Plack et al. (2005) also used the works of Boud et al. (1985) and Mezirow (1990), as well as Schön (1983), to develop an assessment tool that looked for any evidence in written reflections of the nine elements of reflection they adopted from these works. Sparks-Langer et al. (1990) and Hatton and Smith (1995) both used the works of Schön (1983) and Van Manen (1977) to develop coding schemes to rate reflections. Sparks-Langer et al. used the seven levels of reflectivity, while Hatton and Smith developed a hierarchy of five levels based on three forms of reflection. All five of these studies provide different ways to rate reflection.

The LORAA, developed by Padden (2011), however, also provides prompts to guide the reflector into a deeper state of reflection. Padden used Tanner’s (2006) model of clinical judgment and Boud’s et al.’ (1985) six levels of reflection, along with the suggested prompts that accompanied each level. The LORAA was shown to be both valid and reliable. Validity was established by three independent raters who used a Likert scale to rate the accuracy of the criteria for each level of reflection, and interrater reliability (.94) was determined when Padden and two other PhD. candidates individually read and rated a portion of student journal entries. A reflective framework with guiding prompts, like the LORRA, can not only assess reflection but may guide it to a deeper level. This reflection could then be increasingly nurtured if teachers were also given the opportunity to have collaborative discussions with peers, facilitated by a coach.

There are few studies that indicate what actions should be taken to support science teachers in a change of practice, especially inquiry-based instruction. This study
builds on the research in several ways. First, it examines the use of cognitive coaching in both individual and collaborative settings to determine the impact on teachers’ depth of reflection. Second, there is little research on how cognitive coaching improves teaching; this study expanded the research by discovering how coaching collaboratively compares to coaching individually in terms of impact on practice and if an increase in depth of reflection is associated with a change in practice.
Chapter 3

Methodology

With the latest reform in science shifting to the focus on inquiry-based instruction, as defined by the three dimensions of the Framework (NRC, 2011), it is becoming extremely important for teachers to receive support to implement these practices into their teaching. It has been determined that changing from their present pedagogy to one of using inquiry-based practices is an arduous undertaking for teachers (Barrow, 2006; Colburn, 2000; Lin et al., 2013). Reflection is one strategy that has been used to help teachers improve their practice. Additionally, research has shown that reflecting in collaboration with others can lead to an increased reflectivity and may, in turn, elicit a change in practice (Heibert et al., 2002; Lin et al., 2013). As a way to guide teachers through the reflective process, cognitive coaching has recently become a popular strategy to support teachers. However, while these strategies have demonstrated success in other areas, little research has been conducted to determine the impact they have on early childhood science educators.

The following sections describe this study’s use of a reflective framework, an adapted version of the LORAA (Appendix B), to increase participants’ level of reflection and, thus, improve the use of inquiry-based practices in the classroom. Participants received this framework through the use of the Kolb et al.’s (2001) experiential cycle of learning, in either individual or collaborative group settings so depth of reflection achieved could be compared. Strategies incorporated into this coaching intervention were used in professional development in other disciplines and improved participants’ reflective practice. However, no known study evaluated the effectiveness of using this
reflective framework, the LORAA, with early childhood science educators. It was hypothesized that results may demonstrate a greater overall depth of reflection for the collaborative group due to the added support, that this approach will be associated with helping early childhood science teachers incorporate inquiry-based practices into their current pedagogy, and that the implementation of these practices would be observed more in the collaborative group because of their deeper reflectivity.

This study used a sequential embedded mixed methods approach to investigate the impact on depth of reflection and change in practice between teachers who received individual cognitive coaching and those who were involved in a collaborative coaching group. It also explored a possible correlation between depth of reflection and improvement in the use of inquiry-based practices.

**Research Questions**

The research questions guiding this study were as follows:

1. How does collaborative coaching compare to individual coaching in terms of impact on teachers’ depth of reflection?

2. How does collaborative coaching compare to individual coaching in terms of impact on practice?

3. Is an increase in depth of reflection associated with an improvement in practice?

**Participant Selection**

Fifteen teachers were randomly selected from a total of 120 PreK-3 teachers who applied and were accepted to the 2014-15 NURTURES program. Of the 15 selected, 14 completed the study. All of the participants were employed in the same urban public school district and were selected prior to the 2014 summer institute to determine that they
had not been exposed to any part of the NURTURES program or its professional development prior to beginning the study. The use of a random sample of PreK-3 teachers helped to ascertain that this study paralleled a schoolwide coaching experience that incorporated all grade levels together. These 15 teachers were a sample that was similar to the public school system’s demographics in age, gender, years of teaching experience and ethnicity. The public school system’s demographics were as follows:

- Average age: 48
- Race: 90% Caucasian, 8% African American, 1% Hispanic and 1% Asian
- Gender: 307 Females and 8 Males
- Years of teaching experience: 0-38 years; Average years: 18
- Education: 117 bachelor degrees and 198 masters degrees

**NURTURES summer institute.** All participants were required to attend a 2-week summer institute provided by the NURTURES grant. In this institute, participants were involved in inquiry immersion, metacognition sessions, lesson planning, reflection, and other activities that included the Framework (NRC, 2012) and NGSS (NRC, 2013). Inquiry immersion sessions were grade-level specific and engaged teachers in inquiry-focused science lessons within specific content areas: Earth and Space, Chemistry, Physical, and Biology. These sessions were cotaught by a scientist or engineer teamed with an educator. This design was effective in blending challenging content with pedagogy, while also exposing teachers to relevant science content and scientific and engineering practices. The sessions provided teachers with the opportunity to see inquiry teaching in practice and to utilize the scientific and engineering practices themselves before trying to incorporate them into their teaching. Discourse strategies, such as open-
ended and sequenced questions, were also used by the instructors during the inquiry immersion sessions to get teachers thinking at a more critical level about the content being taught, as well as to model the strategies for the participants. An example of an inquiry immersion session can be found in Appendix C.

A university faculty member paired with graduate students or staff taught the metacognition sessions. These sessions were linked back to the inquiry immersion session to make the practices used earlier in the day explicit for teachers and to provide examples to support understanding and the discussion about the various topics covered. For example, a metacognitive session focused on modeling helped participants who earlier made a model of the water cycle further define modeling and experience several other examples of it, such as a model of a water filtration system that emulated the wetlands. Some other topics for metacognition included discourse, math and computational thinking, and asking questions and defining problems.

Participants were also encouraged to reflect on their learning and teaching throughout the summer institute. They were given questionnaires at the end of each day and journal writing activities that encouraged their reflective thinking. Questionnaires included questions such as, “How would you use what was discussed in yesterday’s Next Generation Science Standards session?” and “How will you apply that information?” Inquiry immersion sessions also ended in daily discussions that encouraged participants to reflect on how the three dimensions of the Framework were embedded into the lesson from that day.

Lesson planning sessions were also provided, with teachers having access to scientists and their instructional coaches. Coaches were there to encourage participants to
incorporate the new skills they had learned into their lessons and aid them through the planning process, while the scientist provided teachers with content support. The goal of this session was for teachers to produce two high-quality, inquiry-based science lessons that they could use during the upcoming school year.

**NURTURES academic year professional development.** After attending the 2-week summer institute, teachers were required to participate in six professional learning community (PLC) meetings throughout the school year. These meetings were facilitated by the NURUTRES coaching staff and consisted of varying topics, such as classroom management for inquiry-based science, discourse strategies, and many other pedagogical practices. Some topics were determined by the coaching group to be mandatory, while the teachers involved chose the others.

A small percentage of teachers could opt to be individually coached by one of the NURTURES coaching staff members. This small percentage was limited by the project staff due to the large amount of time it takes to instruct one teacher individually and the limited number of coaching hours available for over 100 teachers. The coach provided individualized support to the teacher throughout the academic year on practices discussed in the summer institute. Teachers sent their coach a lesson plan to be reviewed, and the coach made comments and suggestions. Classroom observations took place on a monthly basis, with post discussions following the lesson. Here, teacher and coach discussed the observations made and any pedagogical practices that the coach or teacher felt may still need extra attention. Goals for the next lesson were also set during this time.

Prior to the institute, all teachers were videotaped teaching what they considered to be a high-quality science lesson. This video served as a comparison for future lessons.
throughout the study, including the final lesson that was videotaped at the end of the school year after all professional development had taken place.

**Overall Procedure**

This study took place in two stages. The first stage was a 4-week pilot study involving four participants, and the second stage was a 12-week study that included the full 14 participants. Participants in both the pilot and full studies were from the same urban public school district.

A reflective framework, the adapted LORAA (Appendix B), was used in scaffolding the participants’ reflections with the goal of leading them to more critical reflectivity. This framework was implemented in both individual and collaborative coaching groups to allow for comparison of depth of reflection achieved. However, there was only a collaborative group in the pilot study, which was used to determine the feasibility of the online discussion group and for validity and reliability purposes.

**Coaching Intervention**

All participants received the same coaching intervention. This intervention used the LORAA and videos of peers imbedded in the Kolb experiential cycle of learning (Kolb et al., 2001). The cycle was 6 weeks long and began with an observation of a video of a peer followed by a written reflection on it. The participants were then rated and prompted on their reflection using the LORAA. After the prompting was complete, participants completed the cycle by writing a lesson, teaching it, and then reflecting on it.

**Kolb experiential learning cycle.** The Kolb experiential learning cycle (Kolbet al., 2001) was used as the foundation for reflection. It, along with the LORAA and videos of peers, was used in both individual and collaborative coaching groups as the complete
coaching intervention for both types of coaching scenarios. Participants began the cycle by observing a peer video and ended it reflecting on an implementation of their own lesson in the classroom. The coaching intervention is shown in Figure 3.

![Coaching Intervention Diagram](image)

**Figure 4.** Coaching intervention cycle.

**Concrete experience.** Videos were used as the concrete experience for reflection in this study. NURTURES peer videos were analyzed to foster participants’ reflection on the use of inquiry-based practices. Teachers often find it difficult to use inquiry practices in their classrooms, and these peer videos offered them a concrete example to reflect upon. The use of video, opposed to direct observation in the classroom, allows teachers the time and opportunity to revisit the example repeatedly to reflect on instruction quality.

**Reflective observation.** This first stage of the reflective cycle allowed the teachers to reflect on instruction and review it multiple times, if necessary. In the initial assignment, teachers were asked to watch the downloaded video and write at least a page reflection on the private online discussion board, double-spaced using 12-point Times New Roman font, in response to what they observed. They were prompted, “Think about what you learned in the summer institute and reflect on the science and engineering
teaching and learning you observe.” Similarly, teachers were asked to write a reflection after the final assignment (i.e., the implementation of their own science lesson in the classroom): “You will now write and implement a science or an engineering lesson in your classroom. Focus on the reflective thinking and discussions we (or the group) had on Facebook when preparing your science lesson. How could you use what you have learned to make your lesson more inquiry-based for your students?” General, rather than specific, reflective prompts were provided to facilitate individualized reflection.

**Abstract conceptualization.** To aid teachers through this important stage of the learning cycle, the coach (who was the researcher in this study), provided prompts to elicit higher level analysis and hypothesis generation. Specific prompts were provided to each teacher to elicit more analytical thinking and generation of hypotheses using questions, such as, “What are your beliefs about the types of questions the teachers used?” and “What was your analysis(es) and interpretation(s) of this situation?” These prompts were taken from the adapted version of the LORAA.

Teachers used what they learned from both their general and critical reflections and implemented their hypotheses in their classrooms, trying out what they had learned throughout the learning cycle. This experience included teachers creating a high-quality science lesson using a given lesson plan template and then implementing that lesson in their classroom. After completing the lesson with their students, participants reflected in writing on their own teaching. The Learning Cycle was repeated with a new peer video being observed and reflected upon.

**Video of others.** In this study videos of others were chosen as the concrete experience for several reasons. First, research found that using video can be motivating
and cognitively stimulating for teachers and, in some cases, promote change in their practices (Seidel et al., 2011). Having the opportunity to observe another teacher’s practice may intrigue observers and cause them to reflect on their own pedagogy, eliciting a change. In this study, teachers were asked to write their reflections after they had viewed the video, allowing them the opportunity to review parts of the video if necessary to guide and support their reflections.

All NURTURES teachers were videotaped two times, one time before the summer professional development and a second time at the end of the school year. In this study, two examples of inquiry-based teaching were chosen from the NURTURES video library. The videos were taken from the NURTURES study because exemplary examples of videos demonstrating inquiry-based practices in the early childhood science classroom are not readily available. Also, it is difficult to find teaching videos that show lessons in their entirety, exempting critical portions of the lesson such as transitions and assessments.

The videos chosen for this study were of two NURTURES teacher leaders. The videos of these teachers were used due to their knowledge and experience of using inquiry-based practices that align with the Framework in their classrooms. In the first year of the program, six teacher leaders were chosen to continue with the grant through its entirety. To apply for this position, the teacher was required to have at least 5 years of teaching experience and to be currently teaching grades PreK-3. Teacher leaders were selected through an application process that included a one-page letter of interest that highlighted previous experiences in creating professional development for their peers and their passion for scientific inquiry, a lesson plan reflecting their method of teaching, and
letters of recommendation from two teachers and their current principal.

Teacher leader videos were coded by master coders from the NURTURES coding team using the SCIIENCE (Systematic Characterization of Inquiry Instruction in Early learNing Classroom Environments) instrument that was developed as part of the NURTURES study. The SCIIENCE identifies inquiry behaviors of classroom teachers that are consistent with the Framework (NRC, 2012). Master coders decide whether or not certain teacher behaviors in elementary science lessons meet the criteria of various codes of the SCIIENCE instrument and which examples are deemed to be exemplary. In order to be a master coder, the individuals were extensively trained and were found to be reliable coders of the gold standard videos with an interrater reliability of greater than .85. The two videos used in this study are considered exemplary examples of inquiry-based science teaching because they contain a range of codes representing inquiry practices aligned with the Framework (NRC, 2012), as well as specific codes that demonstrate quality teaching such as balanced talk and student engagement.

**Video 1.** Video 1 demonstrated a kindergarten inquiry activity focusing on the components of sand and how it is made. This video did not contain any specific disciplinary core ideas, but it was a lesson leading up to the idea of using observations to describe patterns of what plants and animals (including humans) need to survive (K-LS1-1). It included crosscutting concepts such as cause and effect, systems and system models, and stability and change, as well as the scientific and engineering practices of asking questions and defining problems, developing and using models, and obtaining, evaluating and communicating information. Video 1 had several frequency codes that the NURTURES coders determined to be rarely observed or that the NURTURES coaches
had deemed problematic for early childhood teachers. The frequency codes in Video 1 included misconception, move past misconception, open-ended questions, analysis/interpretation, scientific vocabulary, and documentation.

The teacher leader in this video began the lesson eliciting students’ prior knowledge of the beach and sand. She asked the students the question, “What is sand made of?” Students had several misconceptions when answering this question, such as “glitter,” “sugar,” and “coal.” The teacher then asked students if they knew how the sand got on the beach. The students again had varying answers, some containing misconceptions such as humans putting it there and salt water. Students were then sent back to their seats to make observations of sand using magnifying glasses and sifters. They were given a sheet of paper entitled “Examining Sand” that was divided into three sections: sand, rocks, and shells. During their observations, students were asked to look for these three objects and put them in the appropriate place on their paper, thus documenting their findings. After the observation was complete, students were asked to return to the carpet, and their results were discussed. Here, students were moved past their misconceptions of sand being composed of things such as sugar, glitter, and coal.

In the next phase of the lesson, the teacher gave students small buckets of rocks; children were placed into groups of four. The teacher asked students to take turns shaking the bucket rapidly for approximately 1-minute each. The teacher demonstrated this process to students before allowing students to begin. This activity modeled the waves breaking down the rocks at the beach. After the students shook the bucket of rocks, the teacher led a discussion about the children’s observations. This discussion helped the students move past the misconceptions pertaining to how the sand got to the beach. Last,
a summative assessment was given to the students to determine if they understood how sand was made and to share students’ ideas.

**Video 2.** Video 2 demonstrated a first grade engineering activity, which encouraged students to design the tallest structure they could using solid materials such as cardboard, foil, popsicle sticks, and clay. This lesson focused on the properties of the solid materials and included the disciplinary core idea of planning and conducting an investigation to describe and classify different kinds of materials by their observable properties (2-PS1-1). It included the crosscutting concepts of structure and function and scale, proportion and quantity, and engineering practices such as analyzing and interpreting data, constructing explanations and designing solutions, and obtaining, evaluating, and communicating data. The frequency codes included misconception, move past misconception, scientific vocabulary, documentation, open-ended questions, sequenced questions, and analysis/interpretation.

The teacher leader in this video began the lesson by having students sit on the carpet in front of a large poster board with solid items taped to it. She announced to the students that today they would be building the tallest structure they could, using some solid materials. The teacher then asked the students a sequence of open-ended questions to assess their knowledge about the science vocabulary word *properties*, which they had been learning about in the past few lessons. She asked students if they saw any items on the board that they had used in previous lessons and if they remembered the properties they had. Items on the board included a straw, foil, Styrofoam cup, clay, a cardboard square, popsicle stick, rubber band, pipe cleaner, and toothpick. The teacher then followed with a second question asking the students if anyone could tell her a property of
one of the new items on the board. Next, she brought out two new vocabulary words, 
*engineer* and *design*, written on cards and discussed them with the students. The teacher 
explained that today they were going to be engineers designing a tall structure. They were 
asked to keep the question, “How do the properties of an object make it useful?” in mind 
throughout the design process. A discussion about what the word *useful* means then 
followed with students giving their definitions and the teacher explaining it further.

In the second phase of the lesson, students were sent back to their seats and given 
a bag full of the items that were on the large poster board and a planning sheet for 
documentation purposes. The teacher explained that engineers plan before they build 
their designs. The student design process began with students thinking about which of the 
materials in the bag they wanted to use in the building of their tower and then listing them on the planning sheet. They then began sketching the design of their structures on the planning sheet, labeling all the materials used. Four minutes into the design process some students seemed to be struggling, so the teacher stopped them from drawing and began to scaffold their thinking. They then continued drawing their designs and later got to open their bag of materials to begin building.

The teacher moved around the room asking individual students questions about their designs, eliciting their analysis of them. She asked students questions such as,

- “Is that object flexible or rigid?”
- “What part of your tower is helping it be tall?”
- “Do you know why it’s falling down on that side?”
- “What can you do to make it stand up?”
One student had a misconception about the properties of the rubber band she used in the design of her tower. The teacher asked, “Okay, so was the property of it being flexible useful to make it tall or useful to just make it pretty, beautiful?” The student replied, “Both.” The teacher then led her past the misconception that the rubber band made the tower taller through further conversation and questioning. She was also heard telling a student that he may need to redesign his tower because sometimes engineer’s designs do not work.

When students felt they had built the tallest tower they could, they were told to measure it by building a stack of colored cubes next to it the same height. They then counted the cubes to see how many cubes high it was and color that many squares on the class chart that had all the students’ names on it. This chart became a bar graph representing the height of all the students’ towers. Students then cleaned up and returned to the carpet in front of the class graph.

The teacher wrapped up the lesson by discussing the students’ results, if they were accurate measurements, and how they could make sure that they were. She then had a student bring her tower up in front of the class to discuss the materials used and the properties those materials had for making the tower tall. The teacher asked the class the question, “What properties do the toothpick, straw, and the pipe cleaner all have?” Students gave answers such as “tall,” “solid,” and “straight.” She then led students into disagreement by asking the student showing her tower why she did not use the foil to make the tower taller. When the student answered that she did not know, the teacher involved the class by asking, “Who can help her out? Why do you think she used the straw, the pipe cleaner and now I see she put the toothpick up there? Hmmm.” The
teacher concluded the lesson by asking a series of questions to assess students’ understanding of properties and their usefulness.

Not only were these two videos exemplary examples of inquiry-based teaching, but the early childhood teachers in them also demonstrated teaching in classroom demographics similar to those viewing them. This authentic modeling may evoke pedagogical connections for teachers watching the video and may increase the desire to change their practice to emulate what they observed. Teachers learn new instructional strategies more effectively through reflecting on their observations of exemplary models (Roth & Chen, 2007, Seidel et al., 2011, Sherin & Han, 2004), especially if they are in similar classroom settings. Studies indicated that the authenticity of video-based cases positively affects intrinsic motivation and interest in the domain (Deci & Ryan, 1985).

*Added commentary to peer videos.* According to Copeland et al. (1993), it is the thought behind the action that matters, not the action itself that is fundamental to reflection. This is why it is important to provide the viewer with background regarding what happened before and after the video such as the instructional goals set by the teacher, student characteristics, lesson plans, and examples of student work. After these two videos were chosen, the teacher leaders in them were asked by the researcher to watch their own video and write down a commentary of what happened prior to the video recorded lesson, the standards and goals of the lesson in the video and the direction taken after the taped lesson was complete. The researcher then videotaped each of these teacher’s commentaries and spliced them into the appropriate places in the video. This added information gave the participants of this study a broader view of what happened throughout the entire unit and the background knowledge about why the teacher chose
the particular activities completed. This focused the participant’s reflection by allowing them to see the whole picture instead of just a snippet, deterring them from making inferences of what may or may have not happened prior to or after the video lesson.

**LORRA.** The LORAA was chosen for this study for multiple reasons. First, it was shown to be reliable in rating written reflection and determining the level of reflection achieved. As summarized in the literature review chapter, studies that appear to be more successful in the assessment of reflection seem to draw on the work of Boud et al.’s stages of the reflective process (1985), Schön’s (1983) reflection-on-action and reflection-in-action and Mezirow’s (1990) theoretical framework around the components of the reflective process. The LORAA includes both Boud et al. and Schön.

Another reason for choosing the LORAA is that it is specific to Schön’s (1983) reflection-on-action, reflecting on something that has already occurred. Other instruments for assessing reflection include reflection-in-action, which asks the teacher to reflect while in the moment. In this study, participants watched and reflected on videos of peers and their own lessons once they were already implemented in the classroom, therefore, all written reflections were on an action.

Lastly, the purpose of the LORAA is two-fold. While other researchers developed instruments to only measure levels of written reflection, the LORAA provides the educator with not only a way to measure student reflection but a way to scaffold student thinking, guiding them to a deeper level of reflectivity. Reflection is not automatic for most. It is a practice that needs guidance and scaffolding in order to progress to a level where learning can occur (Reiman, 1999). The LORAA allows the educator to identify
students’ starting levels of reflection and assist them in moving beyond that level toward a more critical level of reflection.

In this study, written reflections were rated using the LORAA to allow the researcher to determine the starting level of reflection so appropriate prompts could be chosen to deepen participant reflectivity. The LORAA includes ratings that start at 1, which is a descriptive statement and considered to be non-reflective to a 6, which includes a new perspective gained by the participant and considered to be critically reflective.

**Adaptation of the LORAA for early childhood science education.** Although the purpose of the LORAA is well suited to this study, it was designed with nursing students who were reflecting on their own practice in mind. In order for it to work effectively with early childhood science teachers reflecting on their own teaching and the teaching of others’, some of the verbiage needed to be altered. First, all references to the word student were changed to teacher. Secondly, many of the prompts that were exclusively directed toward the nursing field were either changed or deleted. For example, the prompt that asked, “Were there any environmental factors that influenced your perception of the situation? For example, odors, sounds, lighting effects, space, personnel?” was changed to “Were there any environmental factors that influenced your perception of the situation? For example, announcements, fire drills, students being pulled out of class, organization of classroom, etc.” While the prompt, “What kinds of actions did you take?” was deleted, because the participants in this study were only being prompted when reflecting on the teaching demonstrated in the videos.
Stages of Study

Stage 1. A pilot test was employed to procure interrater reliability and validity for the LORAA, assess its prompts for early childhood educators, and test the feasibility of Facebook for group reflections. For this, four NURTURES’ teachers (N=4) who were currently being coached by the researcher participated in a 6-week study involving one cycle of the coaching intervention. These teachers consented to this study verbally and later signed consent forms. The researcher invited each teacher to a private Facebook group where all reflections and discussions were posted. They were also given the NURTURES’ peer video #1 on DVD along with a schedule of due dates for various assignments they were asked to complete, which correlated to the parts of the Kolb Learning Cycle (Kolb et al., 2001). The researcher asked teachers to watch the first NURTURES’ peer video and write at least a one-page reflection in Word using 12 point, Times New Roman font and return it via email to the researcher. When all four reflections were received, the researcher uploaded them all to the private Facebook page. All participants were then instructed to read all other participants’ reflections and make comments or ask questions about them.

LORAA interrater reliability. After all reflections were posted, the researcher, along with another PhD candidate on the NURTURES grant, independently read and rated teacher reflections using the adapted LORAA. Each individual statement was rated for reliability as well as giving each reflection an overall capsule score. These ratings were compared for consistency, with any discrepancies being settled through discussion. Reliability between the raters on the levels of reflection on all four journal entries were assessed using a percent agreement (Plack et al., 2005), with the percentage agreement of
88% on all reflective statements and 100% agreement on participants’ overall capsule scores. At the end of the study, data were reanalyzed and all outliers were removed. This process allowed the researcher to begin to adapt the LORAA for early childhood science education. The researcher and PhD candidate discussed the verbiage of both reflection levels and prompts to begin the adaptation process.

**LORAA content validity.** To assure validity of the reflective measures of the LORAA, the researcher also used the Level of Reflection section of the Rating Checklist for Reflective Journals designed by Plack et al. (2005) discussed in Chapter 2. Each journal entry submitted during the pilot study was assessed using both the LORAA and Plack et al.’s Level of Reflection rating to determine if the level of reflection indicated by each instrument demonstrated consistent results. These results were compared to establish if the LORAA could be considered a reliable instrument to use to measure written reflection. The results of the pilot indicated that the two instruments showed similar results and thus the LORAA is a valid instrument for assessing depth of reflection.

**LORAA face validity.** To obtain face validity for the use of the LORAA to measure and promote reflection in early childhood educators, the instrument was analyzed by the NURTURES coaching staff. This staff consisted of seven coaches and the grant’s outreach manager who were all asked to read through the LORAA prior to discussing it. A group meeting took place where each level of reflection and corresponding prompt of the instrument was examined thoroughly and a discussion was held to determine if this instrument was suitable for coaching early childhood science teachers. All were in agreement that the LORAA would be appropriate.
Scaffolding. After all written reflections were rated, the researcher used the adapted LORAA prompts to scaffold the participants’ thinking in an attempt to increase their level of reflectivity. This pilot allowed the researcher to determine which prompts were appropriate and/or useful when using them with early childhood educators and which prompts needed to be modified. The researcher also assessed the prompts to determine their practicality when trying to draw the participants’ attention to the frequency codes that occurred in the video. Participants were asked to respond to the prompts given and any other comment or question that was directed toward them by other group members.

Stage 2. The larger study took place over a period of 12 weeks, and the reflective cycle was completed twice within that time period. A schedule of the first cycle is shown below in Table 4. Research determined that teacher change takes time, and effective professional development requires a considerable amount of time that is well-structured, guided, and focused on pedagogy (Birman, Desimone, Porter & Garet, 2000; Guskey & Yoon, 2009). This stage was very similar to the pilot study, but it included 14 new NURTURES teachers who had recently completed the summer institute and had also consented to being part of the research. Seven of the teachers were randomly assigned to the individual coaching group, and the other seven were placed in the collaborative coaching group. Communication among all participants and the researcher took place on a private Facebook group page. The researcher invited each individual coaching participant into a private group that included only the two of them. The collaborative participants had a private Facebook page containing all seven teachers and the researcher.
Table 4

Cycle 1 of Coaching Intervention

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>October 27</td>
<td>All teachers will have received video to watch</td>
</tr>
<tr>
<td>November 7</td>
<td>Video reflection due by this date to researcher’s email</td>
</tr>
<tr>
<td>November 17</td>
<td>Online discussion week (All reflections posted on Facebook by the 16\textsuperscript{th} at the latest so there is enough time to be ready for discussion)</td>
</tr>
<tr>
<td>December 1</td>
<td>Lesson plan due to researcher via email</td>
</tr>
<tr>
<td>December 15</td>
<td>Reflection on lesson due to researcher via email</td>
</tr>
</tbody>
</table>

Once in their designated group, participants began the reflective cycle by watching a NURTURES video on DVD of a peer teaching a science inquiry lesson. They were asked to write a response using 12-point Times New Roman font and double spacing to the following statement: “Think about what you learned in the summer institute and reflect on the science and engineering teaching and learning you observe.” These reflections were sent to the researcher via email. The researcher used the adapted LORAA instrument to rate these written reflections and responded with the appropriate prompts, attempting to increase participants’ levels of reflection and emphasize the frequency codes. Two prompts were initially given for each participant. Prompting and discussion continued asynchronously for 1 week, with the researcher directing participants to check the Facebook page daily to respond to prompts. Participants in the collaborative group were also directed to read all other group members’ reflections, comment on them, and answer any fellow participant’s comments or questions. The
number of prompts received in one coaching cycle varied from four to seven, depending on participants’ participation level. Some initially had trouble with the Facebook platform. Next, participants took what they had learned through the reflection process and applied it to a lesson they created. This lesson was written in a template previously developed by the NURTURES staff and then implemented in the classroom. Once the lesson was complete, participants reflected on their own teaching following this prompt:

You will now write and implement a science or an engineering lesson in your classroom. Focus on the reflective thinking and discussions we (or the group) had on Facebook when preparing your science lesson. How could you use what you have learned to make your lesson more inquiry-based for your students?

This reflection was rated using the adapted LORAA and analyzed for depth of reflection obtained. The second reflective cycle then began with participants watching NURTURES Peer Video 2 on DVD and subsequently writing their reflection on it. This cycle ended with a written reflection on their lesson plan, as well as the lesson being videotaped. This video served as the comparison for the video taken of their teaching prior to the coaching intervention. Both videos were coded using the SCIIENCE instrument to determine if there was any improvement in practice. For reliability maintenance throughout the study, 20% of all written reflections were double-coded by the researcher and a PhD candidate using the percent agreement method. The minimal agreement level, according Graham, Milanowski, and Miller (2012), is 75%. The ratings of the journal entries had agreement levels ranging from 64% to 92% on the individual statements. When an entry was under the 75% acceptability level, raters came to consensus on all statements. Interrater reliability for these statements was determined to
be 80%. The overall capsule ratings ranged in agreement from 88% to 99%, yielding a 96% reliability rating. Therefore, when both reflective scores showing 80% or higher interrater reliability, the adapted LORAA was determined to be reliable for rating early childhood science teachers’ depth of reflection.

**SCIENCE.** The Systematic Characterization of Inquiry Instruction in Early learnIng Classroom Environments (SCIIENCE), was created as part of the MSP NURTURES project. This instrument identifies inquiry behaviors of classroom teachers consistent with the *Framework* (NRC, 2012) and was developed to evaluate the quality of early childhood teachers’ instructional practices. The SCIIENCE instrument is composed of four types of measures: (a) binary codes, (b) frequency codes, (c) category of inquiry, and (d) global ratings. The binary and frequency codes are used to establish if specific teacher behaviors have occurred during a science inquiry lesson. There are nine binary codes in the SCIIENCE instrument, and they were designed to identify behaviors such as using expository text, incorporating appropriate equipment, using technology or testing hypotheses. These behaviors are coded as present or not, because they may continue for longer periods of time. The frequency codes, however, are looked at in 30- second intervals, with the coder looking for the frequency of these specific teacher behaviors throughout the entire lesson. Examples of the 18 frequency codes are eliciting prior knowledge from students, having students make observations about experiments, asking students to analyze and interpret results of experiments, and encouraging students to support their explanations with evidence. The three category codes, scientific investigation, design solution, and test solution, are used to identify the type of activity (scientific inquiry, engineering design, or testing a design) and the six global ratings, (a)
student thinking, (b) balanced talk, (c) student engagement, (d) question quality, (e) inquiry or engineering quality, and (f) discourse techniques, are designed to indicate the overall quality of the various facets of the lesson. Global ratings are assigned values from 1-4, with 1 indicating the lowest possible score. Interrater reliability and validity of the SCIENCE has been established (Kaderavek et al., 2013).

In this study, the researcher selected portions of the SCIENCE to use for coding participant videos. The purpose of this study was to determine if the use of a reflective framework with guiding prompts would increase participants’ level of reflection and, thus, improve the use of inquiry-based practices in the classroom, and any differences existed between the two coaching groups in both aspects. Seven frequency codes and the global ratings were used to determine a change in practice. Binary codes look at the general aspects of a science/engineering lesson and if the behavior is observed or not, not at how many times a specific behavior is observed. Therefore, frequency codes were chosen because they are more indicative of the quality of change in practice, due to the nature of the way they are coded in 30-second intervals. The seven frequency codes used in this study were analysis and interpretation, misconception, move past misconception, documentation, scientific vocabulary, open-ended question, and sequenced questions. These terms are defined by the SCIENCE as follows:

- **Analysis/interpretation** - Teacher leads students to consolidate and interpret the results of their data/observations.
- **Misconception** - The teacher does not declare an inaccurate student response as wrong or tell the right answer.
• Move past misconception - Teacher uses strategies or creates learning situations to help students move past misunderstandings.

• Documentation - Teacher uses a white board, chalk board, paper, or other resources to record the content of class discussions or has students record their own observations/ideas individually.

• Vocabulary - Teacher uses science vocabulary in the context of the lesson, rather than simply stating the definition or asking students for a definition.

• Open-ended questions - Teacher asks questions that encourage students’ own thoughts and ideas.

• Sequence questions - Teacher leads students to a solution through multiple questions, and questions move from general to more specific. The teacher’s next question in a series must rely upon the previous answer.

These seven were chosen because they were inquiry-based practices that were (a) rarely seen by the NURTURES coders or deemed problematic for early childhood teachers by NURTURES coaches, (b) demonstrated in the peer videos, and (c) emphasized by the coach during online discussions. The global ratings were analyzed, as well, to denote if the reflective framework and collaborative coaching affect the overall quality of teaching. Global ratings look at the overarching aspects of the entire lesson (Kaderavek et al., 2013); therefore, minor increases in a number of frequency codes between two consecutive lessons are not considered indicative of change in relation to overall teaching quality. The instrument authors believe significant growth in teaching practice would need to take place for movement in global ratings to be seen.
**Data Collection**

Data were collected at various points throughout the 12-week study to determine the impact of the use of a reflective framework on the depth of reflection and teaching practice in both collaborative and individual coaching groups. It was also used to establish if there was an association between depth of reflection and change in teaching practice.

**Research Question 1.** How does collaborative coaching compare to individual coaching in terms of impact on teachers’ depth of reflection?

To answer Question 1, all of the participants’ reflections throughout the two reflective cycles were rated using the adapted LORAA. The reflections were first rated statement by statement and then were given an overall capsule score. This capsule score served two purposes: (a) it provided the score of each reflection so analysis could be used to determine if participant reflection increased throughout the study, and (b) it gave the researcher a starting point to begin prompting. After the capsule score was calculated, the researcher chose a statement that was representative of that capsule score and began prompting. For example, if a participant received a 1.6 capsule rating, the prompting began at a Level 2. The researcher then looked for statements that were rated a 2 and that had the possibility of leading the participant to reflect on one of the seven frequency codes. Prompts were taken from the adapted LORAA and were used to provide feedback to the participants and guide them to a higher level of reflection. The prompts of the adapted LORAA at a Level 2, were intended to guide the participant to a Level 3 or higher. For 1 week, prompting continued from subsequent statements that were of the same capsule code rating.
A discourse log was used to monitor the amount of time spent prompting and conversing with each individual teacher in both the individual and the collaborative group, as well as the number of prompts given to each participant. The researcher kept track of the time it took to coach each individual participant for two reasons: (a) because time is an important factor in determining the feasibility of scaling up coaching to reach a large number of teachers and (b) to make sure that the time spent on each group was similar and not a variable that may lead to changes in depth of reflection or teaching practice. Participants’ level of commitment to the reflective process was also monitored. This included compliance with previously communicated minimal length of written reflections, length of prompt replies and, for the collaborative group, participation level in the group discussion board.

**Research Question 2.** How does collaborative coaching compare to individual coaching in terms of impact on practice?

**Recorded lessons.** Prior to the start of the intervention study, all teachers were asked to design and implement a high quality science lesson using the NURTURES lesson template located in Appendix D. This lesson was videotaped and coded by the NURTURES coding team using the selected portions of the SCIENCE instrument, the seven focus codes and global ratings. This initial participant video was used as the baseline for teacher practice.

In the second reflective cycle, the researcher videotaped the implementation of the participants’ lessons and coded them using the selected portions of the instrument. The researcher also became a certified SCIENCE coder during this study by taking part in multiple training videos and displaying 85% reliability with the coding team on a test
video. The training protocol included reading through the SCIIENCE coding manual, code definitions, and examples of each code. A series of practice videos followed that focused on a smaller number of codes. These videos were watched and rated as a means to practice coding actual lessons. After the videos were coded, discussions took place about the scores given by the master coders and any discrepancies that existed. Finally, to become a coder, the researcher was required to watch a lesson and score it using the entire instrument, having at least 85% agreement with the master coders to be accepted. To maintain reliability throughout the study, 20% of the videos were double-coded by three master coders. Interrater reliability was calculated for the frequency codes using the prevalence-adjusted bias-adjusted kappa (PABAK) that is used to adjust for bias that sometimes occurs when calculating the kappa score. The adjusted k average was .68. An IRR of .61-.80 is considered substantial according to Dr. Gwet Kilem (2014). The global ratings interrater reliability was calculated using the Cohen’s kappa (k) method with weighting. Cohen’s kappa method is used when there are two or more raters measuring a variable on a categorical scale (Cohen, 1988). Due to the global ratings being assessed using a 4-point ordinal scale, linear weighting was used to allow for 67% more credit than the standard k for scores that differ by 1 (Sim & Wright, 2005). The average IRR for the global ratings was $k = .93$. The SCIIENCE scores of the final participant videos were then analyzed to determine a change in practice when compared to the baseline participant videos’ SCIIENCE scores from the beginning of the study.

*Written lesson plans of high quality science lessons.* After each week of online reflection, participants were asked to write a high-quality science lesson plan. These lesson plans were written using the same template (Appendix D) designed by the
NURTURES’ staff as the pre-intervention lesson. This lesson plan template had teachers include the school district’s content statements that were being covered, as well as the scientific and engineering practices, crosscutting concepts, and disciplinary core ideas from the Framework (NRC, 2012). All lesson plans were submitted to the coach via email. A protocol (Appendix E) was designed by the researcher and used to analyze these lesson plans, indicating any changes that may be occurring in lesson content or quality. The protocol rated sections of the lesson plan using a synthesis rating on a scale of 1 to 4. A total capsule rating was then given for comparison of overall quality. Reliability of this lesson plan protocol was determined by the percent agreement method of interrater reliability, with 20% of the lesson plans being double-coded. These lessons were double-coded by the researcher and another PhD student, with interrater reliability for the capsule scores calculated at 80%.

**Research Question 3.** Is an increase in depth of reflection associated with an improvement in practice?

All the data points collected in research questions 1 and 2 (the LORRA rated reflections, lesson plan scores and SCIIENCE scores) were used for research question 3. To answer this question, the change in scores for each individual on the LORAA were correlated with the change in SCIIENCE scores as well as with the change in lesson plan capsule ratings.

Participants’ reflections were then coded using patterns that were later identified in the study. The researcher examined each reflective statement to determine if the participant was reflecting on one of four aspects of teaching: Teaching, Task, Student, or Content. Only reflective and critically reflective statements were coded, with a reflective
statement being any statement rated a 3 or 4 on the LORAA and a critically reflective statement being rated a 5 or 6. These pattern codes were used to further support the quantitative data in determining if change in depth of reflection correlated with an improvement in pedagogical practice. Table 5 is a summary of all the data that will be collected throughout the study.

Table 5
Summary of Data Collection

<table>
<thead>
<tr>
<th>Cycle</th>
<th>Data Collected</th>
<th>Measurement Tool</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-intervention</td>
<td>Lesson Plan</td>
<td>Lesson Plan Protocol</td>
</tr>
<tr>
<td></td>
<td>Video Lesson</td>
<td>SCIENCE</td>
</tr>
<tr>
<td>Reflective Cycle 1</td>
<td>Video Reflection</td>
<td>LORAA Capsule Score</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reflective Patterns</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Inductive Themes</td>
</tr>
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<td></td>
<td>Lesson Plan Protocol</td>
<td>Lesson Plan Protocol</td>
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<tr>
<td></td>
<td>Lesson Reflection</td>
<td>LORAA Capsule Score</td>
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<td></td>
<td>Online Discussion</td>
<td>Reflective Patterns</td>
</tr>
<tr>
<td>Reflective Cycle 2</td>
<td>Video Reflection</td>
<td>SCIIENCE</td>
</tr>
<tr>
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<td>Lesson Plan</td>
<td>Scientific</td>
</tr>
<tr>
<td></td>
<td>Lesson Reflection</td>
<td>Reflective Patterns</td>
</tr>
<tr>
<td></td>
<td>Online Discussion</td>
<td>Discourse Log</td>
</tr>
</tbody>
</table>

**Data Analysis**

A sequential embedded mixed method approach was employed when collecting data, using qualitative measures to help explain and support the quantitative (Fielding,
2012). This was performed in two phases, with the quantitative data being collected and analyzed first, and the qualitative analysis following. Embedded mixed methods is a popular design used by researchers who are testing an intervention such as the coaching intervention used in this study in a practical setting, like a school (Creswell, 2014).

**Research Question 1.** How does collaborative coaching compare to individual coaching in terms of impact on teachers’ depth of reflection?

**LORAA.** To answer Research Question 1, four reflections from each teacher were collected, rated, and analyzed. Participant’s written reflections on the two NURTURES peer videos and on their two implemented lessons were analyzed through the use of the adapted LORAA. Here, each written statement was rated on a scale of 1-6 according to depth of reflectivity, with 6 being the deepest level. If the statement provided no evidence of reflection, then it was noted, “no evidence found” (NEF). Each reflective thought was individually coded throughout the entire reflection unless two consecutive statements supported each other. When this occurred, the two statements were merged and counted as one reflective statement. For example, “The only change I would make is that instead of using an egg, I might make pancakes instead. I think it would help to see a mixture of ingredients; such as batter, milk, eggs and water, and then watch the chemical change occur when heat was added.” The first statement alone would have been rated a 2, but with the supporting statement following it, together they were rated a 5. A capsule score was then assigned by finding the average of the number of statements at each rating level. The change in reflection was then determined by calculating the difference between the final and initial reflection scores and was used as a data point.
The Mann-Whitney U test was used to compare the change in reflection scores calculated from both participant groups’ reflections to determine any similarities or differences. The Mann-Whitney U is a nonparametric t-test that determines if a significant difference exists between two independent samples (Huck, 2012), such as the individual and collaborative coaching groups. Since reflecting on others is different from reflecting on self, video reflections were calculated separately from self-reflections. Due to failure to complete the study requirements, Teacher 6 was considered an outlier. Therefore, the data for Teacher 6 was not used in any of the statistical analyses in this study.

**Discourse log.** A discourse log was kept to examine the dialog occurring between the coach and participants, looking specifically at the number of prompts used by the coach per group, the amount of time spent in online conversation per groups, and the level of commitment to the reflective process. These logs were analyzed to compare the amount of time spent and prompting required by the coach on each group.

**Research Question 2.** How does collaborative coaching compare to individual coaching in terms of impact on practice?

**Recorded lessons.** Each of the 14 participants’ video lessons (pre and post) were coded using selected portions of the SCIENCE instrument to determine if there was any improvement in practice from the beginning to the end of the intervention study. Each video was coded using a total of seven frequency codes and the global ratings. To analyze these videos, the Mann-Whitney U test, a rank-based nonparametric t-test, was used to determine if there were any differences in change in teaching practice between the individual and collaborative coaching groups. The Mann-Whitney U test can be used to
determine if there are differences between two groups when the dependent variables are either ordinal or continuous (Lehmann, 2006). Two different dependent variables were used when administering the Mann-Whitney test when looking at the teaching videos: frequency codes and global ratings.

**Overall quality of teaching.** Global ratings from the SCIENCE were analyzed to determine any change in participants’ overall teaching quality. Each global rating was analyzed separately for each group using the Mann-Whitney U test to establish if there was any significant change in teaching quality between the two groups. Teacher 3 was removed as an outlier when using the global ratings due to her work in a speech and language impaired preschool classroom. Global ratings focus on classroom discourse strategies and discourse is not relevant in a classroom environment where the students have speech and language impairment.

**Written lesson plans of high quality science lessons.** Each lesson plan was rated with the lesson plan protocol and analyzed separately for each group using the Mann-Whitney U test. This established if there was any significant difference in the change in lesson plan quality between the two groups.

**Research Question 3.** Is an increase in depth of reflection associated with an improvement in practice?

Spearman rank-order correlation is a nonparametric correlation test that measures the association between two variables so that they may be ranked in a two-ordered series (Siegel & Castellan, 1988). Before a Spearman’s rank-order correlation could be administered to determine any correlation between participants’ change in depth of reflection and change in practice, scatterplots were used to establish if there was a
monotonic relationship between the variables. Scatterplots were run for each change in frequency code, global rating and lesson plan capsule rating, with the video change in reflection scores. Video change in reflection scores were used instead of the reflection on self-scores, because participants were prompted on these, thus trying to elicit the deeper reflection. No monotonic relationships were found to exist between the variables, so a Spearman correlation could not be used to analyze the data.

Because there were no monotonic relationships, a post hoc descriptive analysis of the data was conducted. This study used a sequential embedded mixed approach. A qualitative analysis to further explore the relationship between depth of reflection and change in practice was taken to expose underlying themes or patterns not shown by the statistical data (Strauss, 1995). Through using qualitative measures, a holistic view of the relationship between change in depth of reflection and teaching practice could be obtained. When following the procedures for sequential designs, qualitative data are to be analyzed by looking for codes and themes (Creswell & Plano, 2011).

**Groupings.** When examining the data, the first pattern discovered was that all participants could be categorized into three groups based on their change in number of reflective statements made in both the video reflections and self-reflections. Participants who demonstrated an increase in the number of reflective statements from the first to second reflective writing in both video and self were put in a group deemed *progressed.* *Progressed* participants demonstrated an increase in depth of reflection for both types of reflection and were considered to have improved their overall depth of reflection.

Participants in the next group, *progressing,* showed an increase in reflective statements for one type of reflection, but a decrease in the other type of reflection; thus, they were
considered progressing because of the their movement toward an overall increase in depth of reflection. The third group, static, was comprised of participants who remained unchanged in one type of reflection, and slightly regressed in the other. Due to not changing in one type of reflection, and only slightly changing in the other, this group was considered static, or stationary, in their change in depth of reflection.

To ascertain if a change in depth of reflection was associated with a change in teaching practice, these groupings, along with their level of commitment to the reflective process, were compared to the change in four of the seven SCIIENCE frequency codes, all SCIIENCE global rating scores, and the change in lesson plan capsule ratings. The frequency codes of misconceptions and move past misconception were removed from this analysis due to their lack of occurrence during the initial analysis. Not many misconceptions were seen in the participants’ videos; therefore, the researcher could not conclude if participants would have increased in their use of move past misconceptions or not. Scientific vocabulary was also removed from the analysis, because there were discrepancies in the inclusion of science process words as endorsed vocabulary amongst the NURTURES coding team. To reduce the potential for disagreement between coders as to what specific vocabulary was acceptable, the code was changed from a frequency code to a global rating. This added a layer of nuance to the code, because it allowed the variety of the vocabulary words being used in the lesson to be evaluated.

**Reflective patterns.** After groups were analyzed against the change in SCIIENCE and lesson plan ratings, reflective statements were examined, categorized, and then coded using a priori codes. Initially, each statement in the written reflections was categorized into Mezirow’s (1990) three categories of reflectivity: non-reflective, reflective, or
critically reflective. Any statement coded using the LORAA instrument as either reflective (3-4) or critically reflective (5-6) was further coded with the a priori reflective codes: teaching (T), task (TK), students (S) or content (C) or combinations of the four. A priori codes are codes that existed before data analysis and are often a derivative from preexisting frameworks (Johnson & Christiansen, 2012, p. 525). These codes were used to help determine if a change in depth of reflection was associated with a change in teaching practice.

For a statement to receive a T code, the focus of reflection needed to be on the pedagogical practices and strategies used by the teacher. To obtain a TK code, the statement reflected on the task the students were performing or those the participants felt the teacher should have preformed. The S code was awarded if the focus was on how the task or teaching was impacting the students or on the ability levels/needs of the students. The C code was given if the statement focused on the scientific or engineering content in the lesson. Reflective codes were then analyzed to determine what parts of pedagogy teachers reflected on when reflecting on peer videos and themselves and if those codes changed throughout the study. Co-occurring codes occurred often due to participants’ reflecting on more than one aspect of the pedagogical process. Code co-occurrence is when two or more codes are applied to the same segment of text from a single participant (Guest & McLellan, 2003). These co-occurring codes led to the emergence of patterns in the data. The complete analysis of the reflective codes helped determine if a change in depth of reflection impacted teaching practice and led the researcher to further develop inductive themes. Inductive themes are those developed by the researcher during examination of data (Johnson & Christiansen, 2012, p. 525).
**Inductive Themes.** Upon examining the a priori codes, inductive themes and subthemes were identified through thematic analysis. In thematic analysis the researcher sifts through similarly coded data, focusing the analysis on searching for themes and patterns (Glesne, 2011).

It was noticed that when reading reflections in their entirety instead of statement-by-statement, participants’ overall reflective foci could be categorized into 10 overarching themes:

- **Discourse and questioning** - Focus on the discourse happening in the classroom in small or large groups as well as the questioning by the teacher, or missed opportunities for questions within the lesson.
- **Teaching Strategies** - Focus on the way teacher keeps, or fails to keep, students engaged in active learning.
- **Planning** - Focus on the actual planning, or lack there of, to guide student learning.
- **Procedure** - Focus on the step-by-step series of actions taken during a lesson.
- **Cognitive ability** - Focus on the cognitive ability of the student to be successful at a given task or understand a specific concept.
- **Student learning** - Focus on students attainment of knowledge or experiences provided to develop knowledge or skills
- **Student engagement** - Focus on the students remaining attentive and on-task during the lesson.
- **Conceptual understanding** - Focus on student understanding of the content being presented to them and how it connects to previously learned concepts.
- Prior knowledge - Focus on the elicitation of students’ knowledge from previous experiences or missed opportunities.

Some participants showed ineffective reflection in their reflective writing in several different ways. Therefore, the theme of ineffectual reflection was divided into three subthemes: (a) external factors, such as not having your own classroom; (b) repetition of identical reflections; and (3c) using jargon (i.e., metacognition) inappropriately or not in a reflective manner.

**Chapter Summary**

This study had multiple research questions. The first compared individual and collaborative coaching in terms of their impact on depth of reflection. The framework used, an adapted version of the LORAA, provided a way for the researcher to rate teachers’ reflective responses and then provide suitable prompts to scaffold teachers’ thinking to obtain deeper levels of reflection. Participants reflected on both the teaching of others observed in two videos, and their own teaching. The capsules scores of each of the four reflections were compared using the Mann-Whitney U test in each coaching group. Results were then compared. Discourse logs were also analyzed to look at number of prompts given to each group by the researcher, as well as time spent prompting and responding to them.

The second question compared the change in teaching practice achieved by teachers who received collaborative coaching and those who were given individual coaching. This was determined by comparing the change in all participants’ SCIENCE frequency and global rating codes using the Mann-Whitney U test. This helped establish if one group attained a significantly greater change in practice than the other. Lesson plan
protocol ratings were also analyzed using the Mann-Whitney U test to establish if either group significantly improved in lesson plan quality.

Last, this study established if a change in depth of reflection correlated with an improvement in teaching practice. A change in depth of reflection, shown by participant groupings (progressed, progressing, and static), was compared to the change in the SCIENCE scores attained from prestudy to poststudy videos and lesson plan capsule ratings. A priori codes of teaching, task, student, and content, or combination of the four were utilized to further determine the level of reflection obtained by each group. Ten inductive themes and three subthemes were then identified to inform the researcher of other reflective relationships in the data they may exist.
Chapter 4

Results

This study analyzed the differences in depth of reflection and change in teaching practice between individual and collaborative coaching groups and if the two dependent variables were correlated. The goals of the study were to (a) compare collaborative coaching to individual coaching in terms of impact on teachers’ depth of reflection (Research Question 1), (b) compare collaborative coaching to individual coaching in terms of impact on teaching practice (Research Question 2), and (c) determine if there was a correlation between an increase in depth of reflection with an improvement in teaching practice (Research Question 3).

Prior to the study, participants were recorded teaching a science lesson. This was used as a baseline to compare with a final lesson taught. All participants underwent two 6-week coaching cycles, in which they watched a peer video, wrote a reflection on it, were prompted for further reflection, produced and implemented a lesson plan, and then finished by reflecting on their own teaching of the lesson. Participants were divided into two groups, individual and collaborative coaching, to compare change in depth of reflection and in teaching practice.

The LORAA was used both to rate reflections and provide prompts to further the participants’ reflections. The ratings were used to calculate capsule scores for each participant for both video-based reflections and self-reflections. These capsule scores were used in the analysis of change in depth of reflection for Research Questions 1 and 2. For Research Question 3, change in reflection was determined by the change in number of reflective statements from pre- to postreflections. Only statements rated with a 3-6
using the LORAA were analyzed. Pre and post videos and lesson plans were analyzed to
determine change in practice for both groups and to establish if there was a correlation
between change in depth of reflection and change in teacher practice. Last, rated
statements from each participant’s reflections were coded for further analysis.

Coaching Groups’ Impact on Reflection

To test for change in reflection, both on video and on teachers’ own teaching
(self-reflection), the difference between the initial reflection score and the final reflection
score was calculated for each participant. A Mann-Whitney U test was used to compare
the collaborative coaching group to the individual group in regards to their impact on
teachers’ depth of reflection. The average change in both types of reflection, video and
self, are displayed in Table 6.

Table 6

Descriptive Statistics Mann-Whitney U Test

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>ReflectionV</td>
<td>13</td>
<td>.2315</td>
<td>.45125</td>
<td>-.49</td>
<td>.90</td>
</tr>
<tr>
<td>ReflectionS</td>
<td>13</td>
<td>.1308</td>
<td>.42478</td>
<td>-.56</td>
<td>1.20</td>
</tr>
<tr>
<td>Group</td>
<td>13</td>
<td>1.5385</td>
<td>.51887</td>
<td>1.00</td>
<td>2.00</td>
</tr>
</tbody>
</table>

**Video reflection.** A Mann-Whitney U test was run to determine if there were any
differences in change of depth of video reflection between teachers who were
individually coached and those who were in a collaborative coaching group. Distribution
of the reflection scores for individual and collaborative groups were not similar, as
assessed by visual inspection. Change in reflection scores for individual (mean rank 8.33)
and collaborative (mean rank 5.86) were not statistically significantly different, \( U = 13, z = -1.14, p = .295 \), using an exact sampling distribution for \( U \) (Dineen & Blakesley, 1973).

**Self-reflection.** A Mann-Whitney U test was run to determine if there were any differences in change of depth of self-reflection between teachers who were individually coached and those who were in a collaborative coaching group. Distribution of the reflection scores for individual and collaborative groups were not similar, as assessed by visual inspection. Change in reflection scores for individual (mean rank 7.50) and collaborative (mean rank 6.57) were not statistically significantly different, \( U = 18, z = -0.429, p = .731 \), using an exact sampling distribution for \( U \) (Dineen & Blakesley, 1973).

Table 7 shows that the mean ranks for the individual group (8.33 and 7.50) were higher than the collaborative group, which had mean ranks of (5.86 and 6.57).

### Table 7

**Mean Ranks of Reflection**

<table>
<thead>
<tr>
<th>Group</th>
<th>( N )</th>
<th>Mean Rank</th>
<th>Sum of Ranks</th>
</tr>
</thead>
<tbody>
<tr>
<td>ReflectionV</td>
<td>Individual</td>
<td>6</td>
<td>8.33</td>
</tr>
<tr>
<td></td>
<td>Collaborative</td>
<td>7</td>
<td>5.86</td>
</tr>
<tr>
<td>ReflectionS</td>
<td>Individual</td>
<td>6</td>
<td>7.50</td>
</tr>
<tr>
<td></td>
<td>Collaborative</td>
<td>7</td>
<td>6.57</td>
</tr>
<tr>
<td>Total</td>
<td>13</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
However, as mentioned, these mean ranks were not statistically significantly different. Although no statistical significance was found in change in depth of reflection between groups, when the average change in reflection was calculated, the collaborative group was found to have a slightly higher increase in depth of self-reflection. However, the individual group had a higher average when it came to reflection on peer videos. Averages for each group were calculated from the individuals’ capsule scores. The average changes in reflection for both groups are shown below in Table 8.

Table 8

<table>
<thead>
<tr>
<th>Group Change in Reflection</th>
<th>Individual Group</th>
<th>Collaborative Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>VReflection 1 Group Average</td>
<td>1.84</td>
<td>1.86</td>
</tr>
<tr>
<td>VReflection 2 Group Average</td>
<td>2.34</td>
<td>1.93</td>
</tr>
<tr>
<td>Change in Reflection</td>
<td>+.5</td>
<td>+.08</td>
</tr>
<tr>
<td>SReflection 1 Group Average</td>
<td>1.88</td>
<td>1.87</td>
</tr>
<tr>
<td>SReflection 2 Group Average</td>
<td>1.99</td>
<td>2.01</td>
</tr>
<tr>
<td>Change in Reflection</td>
<td>+.11</td>
<td>+.14</td>
</tr>
</tbody>
</table>

Discourse log. A discourse log was kept to determine if one group differed in the number of total coaching minutes, number of prompts given, or level of commitment to the reflective process. Coaching time included reading and rating reflections, reading collaborative group conversations, determining appropriate prompts, providing prompts via Facebook, and giving technological aid and answering questions when necessary. Time was rounded to the nearest 15-second increment. The number of prompts varied due to the amount of time it took for participants to respond to the initial prompts given.
Total time and prompts given for each group are displayed in Table 9.

Table 9

Coaching Time in Minutes

<table>
<thead>
<tr>
<th>Group</th>
<th>Total Coaching Time</th>
<th>Total Prompts Given</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual</td>
<td>561 min.</td>
<td>76</td>
</tr>
<tr>
<td>Collaborative</td>
<td>560.25 min</td>
<td>74</td>
</tr>
</tbody>
</table>

Coaching Groups’ Impact on Teaching Practice

To achieve the statistics for change in teaching practice, the differences between the participants’ initial SCIENCE frequency code scores, global ratings, and lesson plan protocol, and their final scores on each were calculated. Three Mann-Whitney U tests were then used to compare the collaborative coaching group to the individual group in regard to their effect on teacher’s change in practice demonstrated by the three dependent variables.

**Mann-Whitney U for frequency scores.** A Mann-Whitney U test was run to determine if there were any differences between the two groups in the change in seven frequency codes: Misconception, Analysis/Interpretation, Move Past Misconception, Documentation, Scientific Vocabulary, Open-Ended Questions and Sequenced Questions from the pre-intervention video and final video. Table 10 shows the descriptive statistics for all the frequency codes.
Table 10

Frequency Code Descriptive Statistics Mann-Whitney U Test

<table>
<thead>
<tr>
<th>Code</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Misconception</td>
<td>13</td>
<td>.4651</td>
<td>.87706</td>
<td>.00</td>
<td>2.00</td>
</tr>
<tr>
<td>Analysis</td>
<td>13</td>
<td>3.0769</td>
<td>4.38675</td>
<td>.00</td>
<td>12.00</td>
</tr>
<tr>
<td>Movepast</td>
<td>13</td>
<td>1.0000</td>
<td>2.27303</td>
<td>.00</td>
<td>7.00</td>
</tr>
<tr>
<td>Document</td>
<td>13</td>
<td>8.5385</td>
<td>9.16165</td>
<td>-7.0</td>
<td>26.00</td>
</tr>
<tr>
<td>Vocabulary</td>
<td>13</td>
<td>15.6154</td>
<td>7.48931</td>
<td>3.0</td>
<td>25.00</td>
</tr>
<tr>
<td>Openended</td>
<td>13</td>
<td>9.7692</td>
<td>8.77643</td>
<td>-2.0</td>
<td>29.00</td>
</tr>
<tr>
<td>Sequenced</td>
<td>13</td>
<td>4.6154</td>
<td>3.81965</td>
<td>-1.0</td>
<td>9.00</td>
</tr>
<tr>
<td>Group</td>
<td>13</td>
<td>1.5385</td>
<td>.51887</td>
<td>1.0</td>
<td>2.00</td>
</tr>
</tbody>
</table>

**Misconception.** A Mann-Whitney U test was run to determine if there was any difference in the change of Misconception scores between teachers who were individually coached and those who were in a collaborative coaching group. Distribution of the Misconception scores for individual and collaborative groups were similar, as assessed by visual inspection. Median Misconception scores were not statistically significantly different between individual (Mdn = .0000) and collaborative (Mdn. = .0000) coaching groups, U = 17, z = -.781, p = .435.

**Analysis/Interpretation.** A Mann-Whitney U test was run to determine if there was any difference in the change of Analysis/Interpretation scores between teachers who were individually coached and those who were in a collaborative coaching group. Distribution of the Analysis/Interpretation scores for individual and collaborative groups
were not similar, as assessed by visual inspection. Analysis/Interpretation scores for individual (mean rank = 6.83) and collaborative (mean rank = 7.14) coaching groups were not statistically significantly different, U = 20.000, z = -.150, p = .880. Table 11 shows that the mean rank for the individual group (6.83) was lower than the collaborative group, who had mean rank of (7.14). However, mean ranks were not statistically significantly different.

Table 11

Analysis/Interpretation Ranks

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean Rank</th>
<th>Sum of Ranks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual</td>
<td>6</td>
<td>6.83</td>
<td>41.00</td>
</tr>
<tr>
<td>Collaborative</td>
<td>7</td>
<td>7.14</td>
<td>50.00</td>
</tr>
<tr>
<td>Total</td>
<td>13</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Move Past Misconception.** A Mann-Whitney U test was run to determine if there was any difference in the change of Move Past Misconception scores between teachers who were individually coached and those who were in a collaborative coaching group. Distribution of the Move Past Misconception scores for individual and collaborative groups were similar, as assessed by visual inspection. Median Move Past Misconceptions scores were not statistically significantly different between individual (Mdn = .0000) and collaborative (Mdn. = .0000) coaching groups, U = 17, z = -.773, p = .440.

**Documentation.** A Mann-Whitney U test was run to determine if there was any difference in the change of Documentation scores between teachers who were
individually coached and those who were in a collaborative coaching group. Distribution of the Documentation scores for individual and collaborative groups were similar, as assessed by visual inspection. Median Documentation scores were not statistically significantly different between individual ($Mdn = 10.0000$) and collaborative ($Mdn. = 6.0000$) coaching groups, $U = 17.5$, $z = -.501$, $p = .616$.

**Scientific Vocabulary.** A Mann-Whitney U test was run to determine if there was any difference in the change of Scientific Vocabulary scores between teachers who were individually coached and those who were in a collaborative coaching group. Distribution of the Scientific Vocabulary scores for individual and collaborative groups were not similar, as assessed by visual inspection. Scientific Vocabulary scores for individual (mean rank = 7.00) and collaborative (mean rank = 7.00) coaching groups were not statistically significantly different, $U = 21.000$, $z = .000$, $p = 1.000$. Table 12 demonstrates that the mean rank for the individual group (7.00) is equal to the mean rank of the collaborative group (7.00). It was previously determined, however, that these mean ranks were not statistically significantly different.

Table 12

<table>
<thead>
<tr>
<th>Group</th>
<th>$N$</th>
<th>Mean Rank</th>
<th>Sum of Ranks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual</td>
<td>6</td>
<td>7.00</td>
<td>42.00</td>
</tr>
<tr>
<td>Collaborative</td>
<td>7</td>
<td>7.00</td>
<td>49.00</td>
</tr>
<tr>
<td>Total</td>
<td>13</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Open-Ended Questions.** A Mann-Whitney U test was run to determine if there was any difference in the change of Open-Ended Question scores between teachers who were individually coached and those who were in a collaborative coaching group. Distribution of the open-ended questions scores for individual and collaborative groups were similar, as assessed by visual inspection. Median open-ended question scores were not statistically significantly different between individual (\(Mdn. = 9.0000\)) and collaborative (\(Mdn. = 12.0000\)) coaching groups, \(U = 19, z = -.287, p = .774\).

**Sequenced Questions.** A Mann-Whitney U test was run to determine if there was any difference in the change of Sequenced Questions scores between teachers who were individually coached and those who were in a collaborative coaching group. Distribution of the Sequenced Questions scores for individual and collaborative groups were not similar, as assessed by visual inspection. Sequenced Questions scores for individual (mean rank = 5.92) and collaborative (mean rank = 7.93) coaching groups were not statistically significantly different, \(U = 14.500, z = -.944, p = .345\). Table 13 shows the mean rank for the individual group (5.92) is lower than the mean rank for the collaborative group (7.93), although it was previously determined that the mean ranks were not statistically significantly different.

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean Rank</th>
<th>Sum of Ranks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual</td>
<td>6</td>
<td>5.92</td>
<td>35.50</td>
</tr>
<tr>
<td>Collaborative</td>
<td>7</td>
<td>7.93</td>
<td>55.50</td>
</tr>
<tr>
<td>Total</td>
<td>13</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Mann-Whitney U for global ratings.** A Mann-Whitney U test was run to determine if there were any differences between the two groups in the change of global rating scores: Student Thinking, Balanced Talk, Student Engagement, Question Quality, Inquiry/Engineering Quality and Discourse Techniques from the pre-intervention video and final video. Table 14 shows the descriptive statistics for all the global ratings.

Table 14

Global Ratings Descriptive Statistics Mann-Whitney U Test

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1</td>
<td>12</td>
<td>.4167</td>
<td>.87706</td>
<td>.00</td>
<td>2.00</td>
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<tr>
<td>G2</td>
<td>12</td>
<td>.0833</td>
<td>4.38675</td>
<td>.00</td>
<td>12.00</td>
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<tr>
<td>G3</td>
<td>12</td>
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<td>2.27303</td>
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<td>7.00</td>
</tr>
<tr>
<td>G4</td>
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<td>9.16165</td>
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<tr>
<td>G5</td>
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<td>25.00</td>
</tr>
<tr>
<td>G6</td>
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<td>8.77643</td>
<td>-2.0</td>
<td>29.00</td>
</tr>
<tr>
<td>Group</td>
<td>12</td>
<td>1.5833</td>
<td>3.81965</td>
<td>-1.0</td>
<td>9.00</td>
</tr>
</tbody>
</table>

**Global Rating 1.** A Mann-Whitney U test was run to determine if there was any difference in the change of Global Rating 1 scores between teachers who were individually coached and those who were in a collaborative coaching group. Distribution of the Global Rating 1 scores for individual and collaborative groups were not similar, as assessed by visual inspection. Global Rating 1 scores for individual (mean rank = 6.30) and collaborative (mean rank = 6.64) coaching groups were not statistically significantly different, $U = 16.500, z = -.177, p = .860$. Table 15 shows that the mean rank for the
individual group was 6.30, which was lower than the collaborative group who had a mean rank of 6.64. However, these mean ranks were not statistically significantly different.

Table 15

Global Rating 1 Ranks

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean Rank</th>
<th>Sum of Ranks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual</td>
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<td>6.30</td>
<td>31.50</td>
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<tr>
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<td>Total</td>
<td>12</td>
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<td></td>
</tr>
</tbody>
</table>

Global Rating 2. A Mann-Whitney U test was run to determine if there was any difference in the change of Global Rating 2 scores between teachers who were individually coached and those who were in a collaborative coaching group. Distribution of the Global Rating 2 scores for individual and collaborative groups were not similar, as assessed by visual inspection. Global Rating 2 scores for individual (mean rank = 6.90) and collaborative (mean rank = 6.21) coaching groups were not statistically significantly different, $U = 15.500, \ z = -.346, \ p = .729$.

Table 16 shows that the mean rank for the individual group was 6.90, which was higher than the collaborative group who had a mean rank of 6.21. These mean ranks were not statistically significantly different.
Table 16

Global Rating 2 Ranks

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean Rank</th>
<th>Sum of Ranks</th>
</tr>
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<tbody>
<tr>
<td>Individual</td>
<td>5</td>
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<tr>
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<td>Total</td>
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</table>

**Global Rating 3.** A Mann-Whitney U test was run to determine if there was any difference in the change of Global Rating 3 scores between teachers who were individually coached and those who were in a collaborative coaching group. Distribution of the Global Rating 3 scores for individual and collaborative groups were similar, as assessed by visual inspection. Median Global Rating 3 scores were not statistically significantly different between individual (Mdn. = .0000) and collaborative (Mdn. = 1.0000) coaching groups, U = 13.000, z = -.813, p = .416.

**Global Rating 4.** A Mann-Whitney U test was run to determine if there was any difference in the change of Global Rating 4 scores between teachers who were individually coached and those who were in a collaborative coaching group. Distribution of the Global Rating 4 scores for individual and collaborative groups were not similar, as assessed by visual inspection. Global Rating 4 scores for individual (mean rank = 5.70) and collaborative (mean rank = 7.07) coaching groups were not statistically significantly different, U = 13.500, z = -.688, p = .491. Table 17 shows that the mean rank for the individual group was 5.70, which was lower than the collaborative group who had a mean rank of 7.07. However, these mean ranks were not statistically significantly different.
Global Rating 5. A Mann-Whitney U test was run to determine if there was any difference in the change of Global Rating 5 scores between teachers who were individually coached and those who were in a collaborative coaching group. Distribution of the Global Rating 5 scores for individual and collaborative groups were not similar, as assessed by visual inspection. Global Rating 5 scores for individual (mean rank = 5.10) and collaborative (mean rank = 7.50) coaching groups were not statistically significantly different, $U = 10.500$, $z = -1.241$, $p = .215$. Table 18 displays that the mean rank for the individual group (5.10) was lower than the mean rank for the collaborative group (7.50). However, as discussed above, these mean ranks were not statistically significantly different.
Table 18

Global Rating 5 Ranks

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
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<td>12</td>
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</table>

*Global Rating 6.* A Mann-Whitney U test was run to determine if there was any difference in the change of Global Rating 6 scores between teachers who were individually coached and those who were in a collaborative coaching group. Distribution of the Global Rating 6 scores for individual and collaborative groups were not similar, as assessed by visual inspection. Global Rating 6 scores for individual (mean rank = 7.70) and collaborative (mean rank = 5.64) coaching groups were not statistically significantly different, $U = 11.500, z = -1.053, p = .292$.

Table 19 shows that the mean rank for the individual group was 7.70, which was higher than the collaborative group who had a mean rank of 5.64. These mean ranks were not statistically significantly different.

Table 19

Global Rating 6 Ranks

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean Rank</th>
<th>Sum of Ranks</th>
</tr>
</thead>
<tbody>
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<td>Individual</td>
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<td>Collaborative</td>
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<td>Total</td>
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</tbody>
</table>
Mann-Whitney U for Lesson Plan Protocol. The difference was taken in the scores between teachers original lesson and their final lesson plan. A Mann-Whitney U test was run to determine if there was any difference in the change of lesson plan capsule ratings between teachers who were individually coached and those who were in a collaborative coaching group. Distribution of the lesson plan capsule ratings for individual and collaborative groups were similar, as assessed by visual inspection. Median lesson plan capsule ratings were not statistically significantly different between individual (Mdn. = .5000) and collaborative (Mdn. = 1.0000) coaching groups, U = 16.500, z = -.673, p = .501. Table 20 shows the descriptive statistics for the lesson plan protocol capsule ratings (LPCR).

Table 20
LPCS Descriptive Statistics Mann-Whitney U Test

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Minimum</th>
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</table>

Depth of Reflections’ Impact on Teaching Practice

To determine if change in depth of reflection was associated with change in teaching practice, participants were first divided into three groups: progressed, progressing, and static. These groups were determined by the change in the number of reflective statements for both types of reflection. These groupings were compared with the change in SCIENCE frequency code scores, global ratings, and lesson plan capsule ratings. A priori codes of teaching, task, students, content, or a combination of the four
were used to analyze the reflective statements to see if any patterns existed between groups and their change in depth of reflection. Through qualitative analysis, 10 themes then emerged to help further determine if a change in depth of reflection impacted a change in teaching practice.

**Spearman for change in reflection and practice.** Scatterplots were initially run for each frequency code, global rating, and lesson plan capsule rating to determine if the data were monotonic and acceptable to administer a Spearman’s rank-order correlation. A Spearman rank would determine any correlation between participants’ change in depth of reflection and change in practice. The scatter plots demonstrated that no monotonic relationships existed between the variables, so a Spearman correlation could not be administered. Due to the inability to run a correlation, participants were divided into three groups, which were determined by the change in number of reflective statements from pre to post reflections.

**Change in teaching practice by group.** Groups were analyzed to determine how the change in reflective statements compared to the measured change in teaching practice. Change in teaching practice was measured by determining the change in four of the seven originally chosen SCIIENCE frequency codes, global ratings and the change in lesson plan capsule ratings. Student misconceptions, followed by a move past misconception, had to take place in the video to see a change in frequency; therefore, both codes were removed from the analysis. Vocabulary was also removed because of IRR issues that would result from disagreement between two coders on whether a given word counted as vocabulary or not. This was problematic because that disagreement would often be repeated across many 30-second segments, causing a large discrepancy in
the frequency number calculated. Table 21 shows the three groups and how their changes in reflective statements compare to the change in each measure of teaching practice.

Table 21

Change in Teaching Practice by Group

<table>
<thead>
<tr>
<th>Participant</th>
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<th>Document</th>
<th>Open-ended</th>
<th>Sequence</th>
<th>G1</th>
<th>G2</th>
<th>G3</th>
<th>G4</th>
<th>G5</th>
<th>G6</th>
<th>Δ Plan</th>
<th>L of C</th>
<th>Δ VR</th>
<th>Δ SR</th>
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</tbody>
</table>

Note. The following are abbreviated: Global ratings-G; Change in lesson plan ratings- Δ Plan; Level of commitment- L of C where F-fully, P-partially and N-not; Change in video reflection- ΔVR and Change in self-reflection is ΔSR

**Progressed.** Three of the five participants in the progressed group were fully committed to the reflective process, while the other two were only partially committed.

The two participants who were partially committed did not fully comply with written reflection length for their self-reflections and were slow to answer the researcher’s prompts in Reflective Cycle 1, each only answering a total of four prompts. Participant 1 was considered a partial participant because her self-reflections did not meet the required length, and she completed only four prompts during the first round. This lack of response to prompts was due to illness. Her responses to the four prompts, however, were detailed
and reflective. Due to this illness, she may not have been capable of fully reflecting due
to her extenuating circumstances.

When looking at the progressed group’s change in Depth of Reflection, all
participants showed an overall increase. All five participants increased in their reflections
on the teaching in the video as well as their own teaching. When comparing this increase
in Depth of Reflection to actual change in teaching practice, this group demonstrated an
overall improvement in the number of the four frequency codes observed. Analysis/
Interpretation, a higher level pedagogical practice, ranged from an increase of 12
occurrences observed to a score of 0, which indicates no change. Teacher 10, who had the
greatest overall change in Depth of Reflection, demonstrated the greatest change in use of
Analysis/Interpretation. Participant 3, who taught in a speech and language impaired
preschool, exhibited no change in Analysis/Interpretation or Sequenced Questions, but
only a slight increase in Open-Ended Questions. This lack of change in frequency codes
was likely due to her students’ inability to answer open-ended questions or demonstrate
analysis/interpretation. The progressed group had three teachers increase in use of
documentation in their lessons and two decrease. This decrease may have been due to the
type of lesson the teacher was implementing, scientific-inquiry versus engineering. All
teachers in this group showed an improvement in the use of open-ended questions, and all
but two increased their use of sequenced questions. The two participants in the
progressed group, 1 and 3, did not show changes in actual teaching behaviors as
measured by the frequency codes.
In the global ratings, the progressed groups exhibited a range of 1 to -1. For Global Rating 1, student thinking, only one participant showed an increase. Two participants demonstrated an increase in Global Rating 2, balanced talk, while one participant decreased by 1 in Global Rating 3, student engagement. Two participants showed a slight decrease in their question quality, Global Rating 4, two a slight increase and one remained unchanged. For Global Rating 5, inquiry or engineering quality, two participants remained unchanged, two increased and one decreased by one. Last, three participants did not change in their discourse techniques, Global Rating 6, while one participant demonstrated a slight increase and the other a slight decrease.

The progressed group exhibited a range of 0-2 in change in lesson plan capsule ratings. Two participants showed no change in the development of their lesson planning throughout the study. The other three participants demonstrated an improvement in lesson
planning, two increased their overall rating by 1 and the other increased it by 2.

**Progressing.** Four participants (2, 4, 9, 13) demonstrated a full commitment to the study and two were partially committed (12, 14). Participant 14 was considered partially committed because her self-reflections were not the required length, and the last self-reflection was a duplicate of her initial self-reflection with a few minor changes. Participant 12 may have had a hard time being fully committed to the reflective process due to a change of jobs in the middle of the study. She initially had her own classroom and then was transferred to an administrative position with no classroom.

The progressing group was comprised of the participants who increased in one area of reflection but decreased in the other. Of the six teachers in this group, three increased in written reflections of peer teaching observed on the videos while the other three showed improved reflection on their own teaching. This group demonstrated an overall improvement in practice as shown by their frequency code scores. Three participants increased in their use of the Analysis/Interpretation code while the other three remain unchanged. All six went up in their Documentation scores, with increases ranging from 2-22, and five of six increased use of Open-Ended Questioning in their lessons using at least 9 more open-ended questions in their postlesson than in their prelesson. Teacher 9 was the only participant who used less open-ended questions in the postlesson, and this was a slight decrease of 2. All teachers in the progressing group improved in use of Sequenced Questioning with a range of 1-19. Participant 9 showed the least improvement overall in frequency codes and was one of the lowest in the group when it came to an improvement in reflection.
The progressing groups exhibited a range of 2 to -1 when looking at global ratings. For Global Rating 1, three participants showed an increase, two remained unchanged and one decreased by one. The same three participants that demonstrated an increase in Global Rating 1 also increased in Global Rating 2, while two participants decreased by 1 and the other remained the same. For Global Rating 3, three participants showed a slight increase, while the other three showed no change in student engagement in their classrooms. Three teachers improved in their question quality, one declined by 1 and the other two remained unchanged. For Global Rating 5, three participants remained unchanged and the other three increased their scores by 1-2 points. Last, three participants decreased in discourse techniques, Global Rating 6, while two showed no change and one made a slight improvement.
The progressing group produced a range of -1 to 2 in change in lesson plan capsule ratings. Three participants showed an improvement in the development of their lesson planning from their prelesson plan to their post plan. Two demonstrated a slight decrease in their planning, both by -1, while the last participant had no change in the lesson plan rating throughout the study.

**Static.** The static group was comprised of three participants who all showed different levels of commitment. Participant 6 was considered noncommitted due to very short self-reflections, short, non-reflective answers to given prompts, and a lack of response to prompts in Reflective Cycle 1. An example of Participant 6’s response to a given prompt is as follows: “Yes. I thought that after sorting and sifting through the sand the children could have added water to get a different texture.” Participant 5 was partially committed to the process. She was considered a partial participant due to short, non-reflective responses to prompts and a post-self-reflection that did not follow the written requirements. She responded to the prompt of “What were you thinking and/or feeling when she provided the students with paper during this part of the lesson?” with “The children got to write their thoughts down on paper no matter what they said.” Participant 8 demonstrated a full commitment to the reflective process by complying with all written length requirements, responding in a prompt manner to prompts and writing in-depth, reflective responses to prompts. She responded to the prompt, “What were your beliefs about why the teacher had them do this?” by stating,

I believe that the teacher did the following activity to give her students a deeper understanding. It is important to understand how sand is made, in order to understand the concepts of weathering and erosion. It is also important for
children to experience the processes mentioned above in a “hands on” and “developmentally appropriate manner”: “to do Science” and not just to “read about Science”--if we as teacher [sic] want to fully foster the next generation of scientists and follow the new standards in Science.

When examining the static group’s change in depth of reflection, the participants remained unchanged in one type of reflection and slightly decreased in their depth of reflection in the other. One participant showed a decrease in change of video reflective statements while the other two decreased in depth of self-reflection. Decreases ranged from -1 to -3, showing a minor decline. The static group had an overall positive change in frequency codes. Two of the participants remained unchanged in analysis/interpretation, and there were no decreases in any frequency code scores from prelesson to postlesson. Documentation had an increase range of 7-26, with Participant 5 demonstrating a larger increase in documentation than any other participant in the study. All three participants used more open-ended and sequenced questions in their postlesson with the increase in open-ended questions ranging from 2-7 and sequenced questions ranging from 1-9.
Although all three participants showed an overall increase in changes in frequency scores, the global ratings indicated an overall decrease for two of the three teachers. Teacher 6 regressed in all six global ratings, with Global Ratings 2 and 3 decreasing by 2. Teacher 5 showed a -1 decline in Global Ratings 2, 4, and 6, while teacher 8 showed an improvement by 1 in all global ratings except 6, where she remained the same. For the change in lesson plan ratings, the static group varied. Teacher 6 remained unchanged in her planning from the pre- to postlesson plan. Teacher 5 decreased in her overall planning rating by 1, and Teacher 8 improved by 1.

**Reflective Codes.** Reflective codes, a priori codes, were used to analyze differences in teachers’ focus of reflection. All statements rated a 3-6 with the LORAA were coded or cocoded with the reflective codes of T (teaching), TK (task), S (student), or C (content), depending on the focus of reflection. Only six reflective statements were
rated a 6 in the entire study, and they were all coded with a T or TS. Students were
mentioned in multiple reflective statements but not coded with an S. For example, several
statements that mentioned students were coded a T, because the focus was on the
pedagogical practice and not on how it impacted the students. One participant wrote, “I
told the students that I made an error and that we would continue the investigation later.
However, first I had them make their predictions before we ended” (Participant 11).
Another participant stated,

I did not show the students the cover or the title page of the book because I did
not want them to know what the lesson was about until I presented them with the
materials that they would be using. I like an element of surprise. (Participant, 13)

Examples of each type of code and their LORAA rating level are provided in Table 22.

Table 22

Reflective Codes and Examples

<table>
<thead>
<tr>
<th>Reflective Code</th>
<th>Examples</th>
</tr>
</thead>
</table>
| Teaching        | Use of the formative assessment of thumbs up was positive feedback to the teacher. (3)  
More guidance was needed and I had given too much freedom. (4)  
However, I could have included an activity for them to respond in their science journals about their readings. There were a few who were not actually reading. (5)  
I realized in teaching this lesson that teaching science is still not within my comfort zone as with other subject areas. (6) |
| Task            | I wanted the children to have toy animals to look at and interact with each other about how the animals act, but I couldn’t do that so we talked about the animals. (3)  
One change I would make in this lesson is to direct the groups that once the timer rings they are unable to change how they sorted the objects. (4)  
I also did not make the bar graph to connect to the original graph and use the cubes to make a graph. I can still do that as another lesson since the students wrote down the number of cubes tall their towers were. |
| Student         | I was proud to see the other students were able to come up with this conclusion to help explain the misconception. (3)  
I believe this teacher accomplished her goal, and even though the kids were ‘fidgety’ you can clearly see they were absorbing and learning the information. (4)  
No example of level (5) available. |
Content/Student

I could tell through the students’ responses as well as non responses who really understood the prior classroom work and reading (3) Students were able to grasp the concept that objects can be moved and their positions are changed. (4) No example of level (5) available.

Teaching/Student

All students’ responses were respected and recorded and the children were engaged in the questioning and problem-defining step. (3) I think with this type of classroom, much more explanation a modeling was needed. (4) I would even suggest having them work in partner pairs to help each other out. (5) As I said in my beginning paragraph, I don’t know how I would get my students to do all these things in a play-based preschool and still incorporate NURTURES—but I feel (knowing how I have taught science in the past) like I have come a long way, and my students are held to a higher expectation that typically is not seen in a preschool play-based environment. (6)

Task/Student

Being an early childhood education teacher, I just know young children need to build first and maybe learn about the stability and structure through play and discovery of being the engineer. (3) Student predictions on why the given materials were necessary and what their purpose was showed student thinking but then reality happened and I had mud pies! (4) I think it would have been helpful to the students to have a criteria guide posted as to their objective. Students of this age need constant guidance when multiple steps are involved. (5)

Task/Student/Content

They need more opportunities to engage with other materials and objects before the concepts will become more concrete for them. (4)

Teaching/Student/Content

So I thought I would just keep it on a tray…one thing led to another and we soon looked like and smelled like an onion farm. This just led us to so many other directions—food that grow roots, veggies that grow in water, organic vs. non-organic, measuring the foods, etc. (5)

Teaching/Student/Task

The measuring of the water needed a prerequisite lesson prior to using the graduated cylinders, which I hadn’t done. (5)

Teaching/Student/Task/Content

However, since that design part didn’t work, I would use the time to review the properties that the students went over yesterday. (5)

**Progressed.** Participants in the progressed group all began the reflective process with at least three reflective statements in their prevideo reflection. The number of reflective statements written ranged from 3-7, with all participants having one or two of these statements cocoded. Four of the participants’ statements were cocoded teaching/student while the other participant’s was task/student. When looking at the postvideo reflections, reflective statements ranged from 6-13, and the cocoded statements increased from a range of 1-2 to a range of 3-9. Two participants’ reflective focus
remained on the teaching/student relationship, but the three other participants moved to include other relationships such as teaching/task, teaching/task/student and even a reflective statement from participant 10 that included all four foci, teaching/task/student and content. She stated, “However, since that design part didn’t work, I would use the time to review the properties that the students went over yesterday.” (Earlier in the reflection the teacher had stated that the design process was above the students’ ability level).

When looking at the self-reflections of the progressed group, all teachers wrote at least one reflective statement into their prereflection; reflective statements ranged from 1-5. Four of the five participants had cocoded statements focused on either teaching/student or task/student. Participant 1 had a tricoded statement of teaching/task/student. “Talk to talk discourse of the learning conversation using probing wasn’t as strong as I had hoped. Students seemed very dependent on the PowerPoint information about soil rather than just thinking and talking about it” (Participant 1). The post-self-reflections demonstrated an overall group increase in cocoded reflective statements from a range of 1-3 to a range of 1-7. All participants increased in the number of cocoded reflective statements (20 total) written from their pre to post self-reflections, except Participant 1 who remained at 1. Cocoded statements continued to include teaching/student (11) and task/student (1) but also added the cocodes of student/content (4), task/student/content (1), teaching/task/student (2), and teaching/student/content (1). Participant 11 had the greatest increase in cocoded statements moving from three to six, with five statements remaining cocoded at teaching/students and adding a student/content focus; none of her statements were tricoded. Participants 10, 3 and 1 all increased in the number of tricoded reflective
statements made from pre to post self-reflections. For example, Participant 10 moved from a prereflective statement focusing on the relationship between task/student, “Students will still need to continue with this lesson and discuss more reasons why the camouflage works or doesn’t work. So they can improve their designs” to a postreflective statement that included the content as well, “They need more opportunities to engage with materials and objects before the concepts (states of matter) will become concrete for them.” These participants also began to further reflect in their postreflective statements on how they could improve their own teaching. For example, Participant 3 had a cocoded, task/student reflective statement, “As we completed the task, I told myself that next time I will weigh and measure the ice cube before putting it in the microwave…so children can see the difference from solid to liquid…” Participant 10 had a similar tricoded statement of student/task/content and stated, “My students need more opportunities to engage with materials and objects before the concepts will become concrete to them. I will be planning other lessons for that goal.” This, again, would seem to demonstrate that the progressed group was improving their pedagogical practices due to their increase in depth of reflection.

**Progressing.** The range of prevideo reflective statements for the progressing group was 1-11, with five of the six participants having three or more statements cocoded. Two of the participants’ statements were cocoded only teaching/student and task/student, while two other participants included one tricode of teaching/task/student, and the last included teaching/student/content. When looking at the postvideo reflections, reflective statements ranged from 2-14, with three participants increasing in cocoded statements and three decreasing. Participant 4, a participant with an overall decrease in
her change in video reflection, originally had a tricoded statement in her prereflection and only had bicoded statements in her postreflection. Participant 13 with the on tricode during the prereflection had an overall increase of cocoded statements by seven and had two tricoded statements in her postreflection. This participant showed an overall positive change in video reflection. Generally, the reflective focus of the progressing group remained on teaching/student and task/student throughout the video reflective process with few tricoded reflective statements.

The progressing group, as a whole, demonstrated a small increase in both reflective statements and number of cocodes during the self-reflection process. Pre-reflection statements ranged from 1-8, with three of the participants having one of their reflective statements cocoded, Participant 9 having two, Participant 14 having three, with one being tricoded, and Participant 4 having five, with one tricode. The participants with one cocoded statement focused on teaching/student or task/student as they did in the video reflections. The participant with two cocodes changed from her prevideo foci of teaching/student and task/student to teaching/content. Participant 14 had multiple foci of teaching/student, task/student, and teaching/task/student, while Participant 4 had similar foci, except with added foci of teaching/content and teaching/student/content. When looking at the number of postreflective statements, the progressing group ranged from 3-6, with four of the participants remaining unchanged in the number of cocoded statements. Only Participants 2 and 13 increased, going from one cocoded statement to two, with 5 out of 6 being focused on task/student. Participant 4 remained at 5 cocoded statements but increased her number of tricodes from one to three. She kept her original teaching/student/content focus for two of the statements but added a task/student/content.

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She stated, “Dancing rice and ping pong balls should have made them visualize sound energy in action.” While only one member of the progressing group focused on any content in either of the video reflections, three of the six had content as one of their primary foci in the self-reflections.

**Static.** Participants in the static group began the reflective process with two to five reflective statements. Of these reflective statements, all three participants had at least one cocoded statement. Participant 5 had one statement focused on teaching/student and Participants 6 and 8 each had three focused on either teaching/student or task/student. The static group’s video postreflections showed no movement, with a range of two to four reflective statements. Two of the participants (5 and 6) increased by one cocoded statement, while Participant 8 had one less cocoded reflective statement. No tricodes were coded in the static group’s video prereflections.

When looking at the self-reflections of the static group, there was a range of 1-12 reflective statements written. Participant 6 had one with one cocoded statement (task/student), Participant 5 had two and none were cocoded, and Participant 8 had 12 statements with three of them being cocoded (one: teaching/student and two: task/student). The static groups’ overall post-self-reflections demonstrated a minor change in reflective statements going from an original range of 1-12 to a post range of 1-9. Participant 6 had no change in the number of reflective statements from pre- to post-self-reflection or in the number of cocoded statements. Participant 5 showed a slight decrease in reflective statements declining from two to zero. Participant 8 also showed a decrease between pre- and post-self-reflections, with statements falling from 12-9. However, her cocoded statements doubled from three to six; her foci continued to be
teaching/student (two) and task/student (four). As with the video reflections, the static group had no tricoded statements in any of their self-reflections.

**Thematic Analysis**

Ten different themes and three subthemes were established from the qualitative analysis. The thematic analysis of the participants’ written reflections and a priori codes revealed that the teachers had different reflective lenses when watching peer videos or reflecting on their own teaching, while others showed traits of being ineffectual reflectors. These were categorized into 10 themes that included discourse/questioning, classroom management, teaching strategies, planning, procedure, student’s cognitive ability, student learning, student engagement, prior knowledge and ineffectual reflection. The theme of ineffectual reflection was further divided into three subthemes: external factors, repetition, and use of jargon. Table 23 defines and gives examples of each of the 10 themes and three subthemes.

Table 23

**Reflective Codes with Themes**

<table>
<thead>
<tr>
<th>Code</th>
<th>Theme</th>
<th>Sub-themes</th>
<th>Descriptions</th>
<th>Exemplars</th>
<th>Participant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pedagogical practices and strategies used by the teacher</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Teaching</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Discourse/Questioning</strong></td>
<td></td>
<td>All students’ responses were respected…</td>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Many missed opportunities to engage students in discussion…</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Teaching Strategies</strong></td>
<td></td>
<td>I allowed a few students to get away from me…</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>This should also be a good time for modeling the procedures…</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Planning</strong></td>
<td></td>
<td>This is something I would include next time…</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>The measuring of water need a prerequisite lesson prior to using the graduated cylinders</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Task</td>
<td>Task students were performing or participant felt should have been performed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>--------------------------------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| **Procedure** | Prior to the lesson we…I began the lesson…I then… I concluded the lesson by…  
* I noticed many scientific and engineering practices…instead of letting them discover…providing students opportunity to share knowledge based on concrete evidence… |
| **Students** | **How the task or teaching impacted the students or on the ability/needs of the students** |
| **Cognitive Ability** | They need concrete level first before representational 10 |
| **Student Learning** | I promised myself to expose the students to new experiences and materials 3 |
| **Student Engagement** | During the video I observed various students disengaged 14 |
| **Content** | **Focused on scientific or engineering content in lesson** |
| **Prior Knowledge** | This was a missed opportunity to gather information about prior knowledge 12 |
| **Conceptual Understanding** | They could reason why their designs worked and what needed to be changed 2 |
| **Ineffectual Reflection** |  |
| **External Factors** | I was worried about doing this lesson due to the fact I had to sub in another class.  
*It was difficult because the time of year. I typically would have done this lesson during the spring.* 8 |
| **Repetition** | I felt the small group interaction and communication allowed students…(self #1)  
*I felt the small group interaction and communication allowed 3 of 5…(self #2)* 14 |
| **Jargon** | Asking questions and defining problems was evident…there was communication of information… 1 |

These themes and subthemes were looked at across the three groupings to determine if there were any trends amongst the groups, adding to the data to help determine if a change in depth of reflection was associated with a change in practice. Tables 24 and 25 show the participants in each grouping and what their focus was for both video (Table 24) and self (Table 24) pre- and postreflections.
Table 24

Video Reflection Themes by Participants

<table>
<thead>
<tr>
<th>Grouping</th>
<th>Teaching</th>
<th>Task</th>
<th>Student</th>
<th>Content</th>
<th>Ineffectual Reflection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Progressed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>X</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>X</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Progressing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>0</td>
<td>X</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td></td>
<td>X</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>X0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>X</td>
<td></td>
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<td>14</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Static</td>
<td></td>
<td>X0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>5</td>
<td>X</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Note. X- Pre-reflection; 0-Post-reflection

Table 25

Self-Reflection Themes by Participants

<table>
<thead>
<tr>
<th>Grouping</th>
<th>Teaching</th>
<th>Task</th>
<th>Student</th>
<th>Content</th>
<th>Ineffectual Reflection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Progressed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>X0</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>0</td>
<td>X</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>X0</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>X0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>X0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Progressing</td>
<td></td>
<td></td>
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<td>2</td>
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<td>8</td>
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</tbody>
</table>

Note. X- Pre-reflection; 0-Post-reflection
Progressed. All five teachers in this group focused their pre-video reflection heavily on the questioning and classroom discourse that was occurring. Participant 7 wrote, “As I was watching the video, I noticed that the teacher asked the students many open-ended questions, which allows for deeper learning. The teacher also used appropriate wait-time for the students to respond.” Participant 3 compared the teacher in the videos’ lack of a follow-up question to her learning in the summer institute by stating,

Over the summer the professors facilitating the classes, would have asked, “What makes you think that? Or How do you know?” We were asked to push the students and make them think about why or how they came up with the answers and open it up for discussion.

Three of the participants’ post-video reflections focused on the students’ cognitive ability level to complete some of the tasks in the lesson. Participant 10 wrote,

Students planning their designs on paper is too difficult for first graders. Students at this age need the hands on experimentation of the materials and how they work together before they can think about it in their heads and put it on paper.

Participant 1 said, “I think it would have been helpful to the students to have a criteria guide posted as to their objective. Students of this age need constant guidance when multiple steps are involved.” However, Participant 1 also misused jargon throughout her reflection, such as when she stated, “Asking questions and defining problems was evident in the teacher’s opening brainstorming of the background knowledge…” In this particular lesson there was no engineering, so therefore, students did not define any problems. Also, this was the introduction to the lesson in which the teacher was assessing student background knowledge. The students were not yet observing their sand, which is when the asking questions portion of the lesson began. Participant
had a general focus of the procedures taking place in the lesson: “During the experiment/activity process…” “The students began the activity…” “During the metacognition portion of the lesson…” Participant 11 reflected mainly on the procedure of the engineering process happening throughout the lesson.

The pre-self-reflections had multiple focuses. Participants 1 and 11 both focused their reflections on the discourse process, but 11 was again concerned with the procedure of the lesson and telling step-by-step what happened. Participants 1 and 3 were also focused on lesson planning and how it needed to change. Participant 10 focused on the discourse happening in the classroom, while Participant 7 was focused mainly on the procedure she followed in her lesson. Participant 7’s reflective attention remained on the procedure in her post-self-reflection as well. Participant 3, with speech and language impaired students, changed her focus to her teaching strategies and student learning.

I have no idea if my students drew something related to our activity, or if they were drawing to draw—but I could see the squiggly lines being dirt, the green circles being seeds, and just seeing how involved they were—I know they were learning.

Participants 1 and 10 reflected on classroom discourse and student ability levels, while teacher 11 mainly reflected on discourse and the procedure of the lesson.

**Progressing.** Similar to the progressed group, the majority of teachers in this group focused on questioning and classroom discourse in their prevideo reflection. Participant 12, however, seemed to have a general focus on prior knowledge, both the teacher eliciting it and her missed opportunities to gather it. She began her reflection with, “During Carrie’s lesson on sand and how sand forms she did a good job at activating prior knowledge.” Then she later stated, “This was a missed opportunity to gather information about prior knowledge from that student.
She could have visited a beach and searched for shark teeth and found something that looked similar.” Participant 2 focused on the procedure of the scientific process demonstrated by the teacher throughout the video. She wrote statements such as, “She then let them investigate real sand to see what they would find. This is where I thought she led them a little too much by giving them a worksheet with only three choices on it,” and “This is a good scientific practice to use in class, providing students the opportunity to share what they know based on concrete evidence.” Participant 2, similar to Participant 1 in the progressed group, misused some jargon that was specific to what was learned in the NURTURES summer institute, such as the NGSS scientific and engineering practices, cross-cutting concepts, and jargon pertaining to discourse within the classroom. She stated, “The students did not engage in argument about the topic. In fact no arguments at all, they were all behaved and followed directions well.” This is a misuse of the term argumentation, as it is a practice in the NGSS that encourages students to discuss varying points of view supported by evidence and not students being well behaved.

When reviewing the postvideo reflections, progressing participants had mixed foci. Participants 2 and 13 both reflected on teaching strategies that were used, or should have been, by the teacher. Participant 13 wrote, “Stopping the design process at this point was effective so that she was able to explain and model exactly what a sketch of a design is.” Participant 2 also reflected on the ability level of the students, while 13 reflected on the engagement of the students, stating,

The students were not focusing on what she was teaching them at this point because they were not interested in what they were doing at their desks. I would have called the children back over to the carpet to keep them focused on the explanation of the sketch.
The general focus of Participants 14 and 9 was also on student engagement; however, the majority of Participant 9’s statements were nonreflective. Participants 12 and 4 reflected mainly on the questioning and discourse used by the teacher, or opportunities for discourse that they felt she missed. Participant 12 reflected, “Students may have benefitted from looking at pictures of tall towers before or during the lesson to spark a discussion of the properties used to make a building tall.”

The progressing groups’ foci on their self-reflections varied like their video reflections. Two of the six participants (2 and 4) reflected mainly on the conceptual understanding gained by their students, or the opportunities missed to enhance students’ conceptual understanding in their lessons, for both their pre- and postreflections. Participant 4 wrote,

The review of properties of the different states of matter from a previous lesson helped to clarify a possible reason why sound travels faster in a solid rather than a gas as they had predicted. Therefore, the purpose of the lesson helped derive the vocabulary we can use in further investigation, as well as, gave purpose for further investigations about sound and how it relates to energy.

Participant 12, who has special need students, directed both of her reflections to her students’ ability levels. “Based on the current academic and communication needs, the children were not able to answer my questions.” Participant 14 maintained a general focus of planning, or lack thereof, in her self-reflections, stating that due to her experiences from past engineering lessons she should have known that students would have needed more time. However, she used the same reflective outline for both self-reflections, changing a few word here and there on the prereflection to make it fit the postreflection, thus, receiving the code repetition. Lastl, Participant
13 focused her prereflection on the procedure used in her classroom and how the tasks worked or did not, but changed her focus to discourse in her postreflection.

**Static.** The static group all had a focus of questioning in their pre video reflection. Participant 6 also included an added focus of student learning as she reflected, “Reading about how sand is made and trying the experiment to make sand furthered the students’ understanding.” Postvideo reflection focus varied for all three participants. Participant 6’s focus remained on questioning, but Participant 8’s moved to teaching strategies and 5’s changed to student ability.

Each participant maintained pre- and post-self-reflections foci. Participant 5 and 8 were primarily focused on external factors, such as not having one’s own classroom or it being the wrong time of year to teach a particular lesson. These were the only two participants in the study who had an external focus during self-reflections. Participant 6 reflected on the procedure of the lesson, explaining step by step what they did; there were not many reflective statements in her self-reflections.

**Chapter Summary**

The data analysis in this study revealed findings relating to change in depth of reflection, change in teaching practice and if the two were associated with each other. When comparing the two coaching groups, individual and collaborative, on impact of depth of reflection, the data suggested that there was no statistical significance between the two coaching groups. When looking at the average scores of each groups’ capsule ratings from their written reflections, however, the collaborative group did show a slightly higher increase in change of self-reflection than the individual group, while the individual group had a higher increase in change of peer video reflection. Comparing the same two groups for impact on change in teaching practice using SCIENCE frequency codes and global ratings and lesson plan capsule ratings, data also revealed
that there was no statistical significance between groups. The collaborative group had higher mean ranks in the frequency codes of Analysis/Interpretation, Open-Ended and Sequenced questioning, while the individual group demonstrated a higher median score in Documentation. Looking at the data for the global ratings, the collaborative group had slightly higher mean ranks in Global Ratings 4 and 5, while the individual group had a slightly higher mean rank in global Rating 6. The difference in the lesson plan ratings was minor, with the collaborative group having a median of 1 to the individual group’s 0.5.

To determine if an increase in depth of reflection is associated with an improvement in practice, participants were categorized into three groups according to their change in number of reflective statements from pre- to postvideo and self-reflections and compared to the change in frequency scores, global ratings, and lesson plan capsule ratings, which were all indicative of their change in practice. All reflective statements were also coded with a priori codes of teaching, task, student and content or combinations of the four. Ten themes and 3 subthemes were then identified, indicating the main foci of participant’s reflections and/or potential reasons why they may not have been effective at practicing reflection. The main findings from the three groups are described below.

**Progressed.** The progressed group showed an overall increase in their depth of reflection, improving in both video and self-reflections. When looking at the changes in teaching practice as measured by the frequency codes, the majority of this group increased in the number of times they used analysis/Interpretation, Documentation, and Sequenced Questioning, while everyone showed an improvement in use of Open-Ended Questions. No more than two of the five participants in the progressed group ever increased or decreased in any of the six global ratings, and all improved at least by 1 in their lesson plan capsule ratings.
The progressed group showed an increase in both their number of reflective statements written and number of statements that were cocoded from pre- to postvideo reflections. Two of the participants’ foci remained the same between video reflections, but the other three participants’ foci became more dynamic, including tricodes and one statement that intertwined all four reflective codes. The majority of the progressed group increased in the number of cocoded statements for self-reflections, again adding more dimensions to their foci with tricoded statements.

All five teachers in the progressed group focused their prevideo reflection heavily on the questioning and classroom discourse that was occurring throughout Video 1. The majority of the group had a similar focus for the postvideo as well, focusing on the cognitive ability of the students. When looking at the progressed group’s self-reflections, the pre-self-reflections had multiple foci: procedure, lesson planning, discourse and content, as did their post-self-reflections. These focused on content, student learning, discourse, student ability, and the procedure of the lesson.

**Progressing.** The progressing group showed improvement in one of the two types of reflection and a decrease in the other. The entire group demonstrated an increase in documentation and sequenced questions when looking at the frequency codes. Five participants improved in open-ended questions, and three of them increased their use of Analysis/Interpretation. The progressing group was the only group that had any participant increase by 2 in the global ratings. This was demonstrated in Global Ratings 1, 4 and 5, with two participants increasing by 2 for Global Rating 5. Half of the participants in this group increased in lesson plan capsule ratings.
The progressing group had a slight increase in number of reflective statements with equal number of participants increasing and decreasing in cocoded statements between pre- and postvideos. Most participants had the same reflective focus for the pre- and postvideo reflections. There was a small increase in reflective statements and cocodes for self-reflections, with only two participants increasing in cocoded statements. There were few tricoded statements written in any of the reflective writings for this group.

In the prevideo reflections, the majority of the teachers in the progressing group focused on questioning and classroom discourse. The postvideo reflection had mixed foci of modeling, student engagement and discourse. Three of the six participants focused on content for their self-reflections, one participant stayed focused on planning and another one on student ability.

**Static.** Participants in the static group showed no change in one type of reflection and a very small change, either positive or negative, in the other type of reflection. One participant increased in Analysis/Interpretation, while all improved in Documentation, Open-Ended, and Sequenced Questions. One participant decreased in all six global ratings, being the only participant to decrease by 2 in a global rating score, while another participant increased in five out of six global ratings by 1. This same participant was the only one in the static group to increase in her lesson plan capsule scores.

The static group demonstrated no movement in the number of reflective statements for video reflections and had very slight movement in cocodes, with two participants increasing by 1 and one decreasing by 1. There were no video tricoded statements. In self-reflections, there was a minor decrease shown in number of reflective statements with two of three participants only having 1 cocode combined. Participant 8 doubled her cocoded statements, even though she
decreased in the number of reflective statements written. Again, there were no tricoded statements for the self-reflections.

Consistent with the other two groups, the majority of the teachers in the static group focused on questioning and classroom discourse in their prevideo reflection, but their postvideo reflections varied. In their self-reflections, two participants remained focused on external factors while the other participant continually focused on the procedural aspects of her lessons.
Chapter 5
Discussion of Findings

This study examined if cognitive coaching using a reflective framework could increase teachers’ depth of reflection and in-turn improve their pedagogy. In addition, this study also investigated the impact of cognitive coaching groups, specifically individual or collaborative, on the change in reflection and/or teaching practice. When analyzing the data for association between change in reflection and change in pedagogy, three groups of teacher types emerged (progressed, progressing and static). The most interesting aspects of the findings center around these three groups of teachers and the levels of commitment each had to the reflective process. Thus, this discussion is framed around these foci. This chapter also presents implications for the field, makes note of limitations of the study, and proposes areas of future research.

Power of Reflectivity to Foster Change

The findings of this study indicate that the reflective framework was effective in getting teachers to improve their depth of reflection and thus, their teaching practice. This was demonstrated by the progressed participants who were not only willing to practice reflection, but also exhibited the ability to engage in the process by showing an increase in the number of reflective statements for both video and self reflections as well as an increase in number of frequency codes. The progressed group showed the most movement in frequency codes overall, indicating they improved in their practice slightly more than the other groups. This suggests that by deepening their level of reflection and critically analyzing their practice, their pedagogy began to improve. This is in line with Finlay’s (2008) theory that states teachers who critically assess their everyday practice, as well as examine their own pedagogy, are led to a deeper understanding and further development of their practice. Of the four frequency codes used to determine change
in practice, analysis/interpretation is especially telling. For teachers to receive this code, the teacher must use higher-level questioning to lead students to consolidate or interpret the results of their data or observations. This would suggest that progressed participants are more effective, as using higher-level questions to elicit students’ thinking is indicative of effective teaching (Taylor, Pressley & Pearson, 2000).

There were some exceptions to the overall increase in frequency codes for the progressed group, however, such as one participant’s low scores in open-ended questions analysis/interpretation, and sequenced questions due to her speech and language impaired classroom and one participant’s decrease in documentation. This suggests that the SCIIENCE instrument may not be appropriate for assessing speech and language impaired classroom teachers, and that the documentation code can vary with the type of lesson presented. This information led to documentation being removed as a frequency code and changed to a binary code in the SCIIENCE instrument.

The connection between change in reflective practice and change in pedagogy continued to be demonstrated by the upper half of the progressing group who displayed slight improvements in reflection, but seemed to have struggled with getting to a deeper, more critical level, thus impeding their ability to considerably change their practice. They exhibited trends towards improving their practice through an increase in all frequency codes, demonstrating qualities of effective teaching by incorporating strategies, such as open-ended questions and analysis/interpretation, that encouraged higher-level thinking, which is consistent with Taylor et al. (2002), but their overall increase in codes was not as substantial as the progressed participants’ level of increase.
The lower half of the progressing group, along with the static participants, indicated that when the practice of reflection is found to be challenging and teachers have difficulty reflecting on their own teaching or the teaching of others, changing their pedagogical practice might also be problematic; which is consistent with (Ward & McCotter, 2004). The challenge of improving pedagogy was demonstrated by the lower progressing and static participants’ slight increases in three of the frequency codes, as well as negligible movement in analysis/interpretation. This lack of improvement in higher-level practices and change in depth of reflection indicates, as Taylor et al. (2002) found, that these teachers were challenged by reflection and therefore struggled to improve their teaching practice.

**Reflection Focused on Effective Pedagogy**

An important aspect of reflection that appeared to lead to a more critical analysis of pedagogy prompting change in teacher practice was that teachers who progressed tended to focus on students and their connection with teaching or tasks leading to further reflections centered on personal teaching practices. These findings are consistent with research about teacher reflection involving participation in metacognition, during which teachers consider what was successful and unsuccessful in their teaching and become motivated to find ways in which to improve it (Covino & Iwanicki, 1996; Given, 2002). This further suggests that these teachers were not only effective because they focused on student learning (Tsui, 2003), but were analyzing their own pedagogy more critically, thus improving it.

Another example of the focus of reflection being indicative of effective pedagogy was demonstrated by progressed participants’ attention to how they could improve their practice to make their students more successful or how their current practice was encouraging students to engage in active learning and critical thinking. One participant used open-ended questions to
engage students in active learning and elicit higher-leveled thinking from them. She reflected on how her questioning encouraged students to think critically, which Taylor, Peterson, Pearson, & Rodríguez (2002) would suggest was an improvement in practice, as effective teachers are shown to stress higher-level thinking skills and do not simply provide students with facts and knowledge, but rather empower them to actively think, understand and learn for themselves (Ball & Forzani, 2009). Another progressed participant reflected on the teaching strategies she used in her lesson and how they would aid in student learning. This indicates that she valued the reflective process and was using it to improve her students’ learning experiences to make sure they were successful. Using her pedagogical knowledge to ensure their success, she exhibited improvement in her effectiveness as a teacher through critically analyzing her students’ ability levels to determine what struggles they may face, which is consistent with (Herr, 2007).

Other examples of reflections likely to foster change in teacher practice occurred when two progressing participants’ continued to focus on the student/teacher discourse happening in the classroom and how the teacher’s questioning in the video elicited higher-level thinking from the students. This suggests they, like the progressed teachers discussed above, are improving, because when teachers prompt their students to think more critically through questioning they are using an effective teaching strategy (Taylor et al., 2002). Two other progressing participants also focused on how the teaching demonstrated in the video affected student learning. One analyzed the teaching strategies implemented by the teacher in the video and the cognitive ability of the students, while the other changed focus to teaching strategies, but coupled it with student engagement. These two participants showed the greatest overall change in reflection in the progressing group, while also demonstrating an increasing level of reflectivity by expanding their focus to the methods and strategies the teacher used to elicit student engagement and learning.
This suggests that shifting focus to identifying how teaching impacts student learning may be related to an improvement in pedagogical practices (Herr, 2007; Ball et al., 2009; Tsui, 2003). The participant who focused on teaching strategies and student engagement also discussed the teacher’s strategy of modeling to aid in student understanding and gave an alternative approach for when the teacher lost control of her class. This recognition of the usefulness and effectiveness of modeling (Herr, 2007), as well as her critical analysis of a peer’s pedagogy and suggestions for improvement (Hatton & Smith, 1995; Nolan & Sim, 2011), indicates that through her reflection on other’s she was changing her practice to include more qualities of an effective teacher.

In contrast to the instances above, a lack of critical reflection on practice and student learning may inhibit changes in practice. For example, one participant from the progressed group differed slightly from the other teachers. Although she alluded to student learning in her reflections, her reflective focus was on telling, in a procedural manner, what happened throughout her lesson. Her need to discuss exactly what she did step-by-step in her lesson without much reflective analysis may indicate that she is functioning at a lower reflective level and therefore needs additional support (Moche, 2000) beyond the reflective framework provided in this study. Some teachers do not make the essential step toward analyzing their teaching but simply describe the experience (Atkins and Murphy, 1993), thus remaining at a low-level or reflection. Even though her scores revealed an increase in number of reflective statements, overall her expressed thoughts were only marginally reflective.

Several progressing participants demonstrated this same level of reflection when focusing on either their own teaching or the teaching of others. One focused on how the peer in the video proceeded through her lesson about sand. Since this was her first reflection for the study, it makes sense that she would do what many new to reflection do, and just state what she saw happening in
the lesson and how she felt about it (Hatton & Smith, 1995; Stanley, 2013). This description of the incidents taking place indicates a low-level of reflectivity, as shown by the LORAA rating scale. This participant also used jargon, or the repeating of expert discourse most likely from what she remembered from the NURTURES summer institute, which can be seen as a type of ineffectual reflection. This indicates that she may not have reflected on what was happening in the lesson, but instead reproduced what she heard from authorities in the field (Novinger, O’Brien, & Sweigman, 2005). This may suggest that she is not willing to fully participate in the reflective process, or she needs more support to do it effectively. Two participants in the lower part of the group showed very low reflective levels throughout all of their reflections. When examining their overall reflective focus of video-reflections, the reflections were student centered, but the majority of their statements were not reflective; rather they just stated that the students were unengaged, not on task, etc. This suggests that these participants were struggling to critically reflect on the teaching in the video and connecting it to student learning, and instead were just describing the classroom environment, therefore, reducing the possibility that the reflection would lead to an improvement in their practice. This is consistent with research that found when teachers focus on procedural aspects and cannot critically reflect on their practice and how it affects student engagement and learning, low levels of reflection are exhibited, and subsequently change in pedagogy is hindered (Hatton & Smith, 1995; Ward & McCotter, 2004; Nolan & Sim, 2011).

This same reflective focus was also demonstrated in one of these two participant’s self-reflection as she described in detail what happened throughout the lesson without any real reflection. She discussed her didactic talk, followed by the videos she showed and then the explanation of her activity. Again, this suggests that she is having difficulty with reflection, and is therefore, struggling with improving her teaching practice. The root of this disconnect may be her
own belief about science, science teaching or student learning. A teacher, such as the one discussed above, who sees science as a myriad of facts to be memorized or students as unable to engage in the scientific practices, may be hesitant to attempt more inquiry-based approaches (Lotter et al., 2007). Research supports the idea that teachers will resist reflecting on, and changing, their practice if it goes against their conception of teaching (Achinstein & Ogawa, 2006).

The other lower progressing participant focused mainly on the planning of her lesson, reflecting on what went well or needed to be changed in her lesson plans for the future, as well as her feelings of not yet being comfortable with using open-ended questions to prompt student discussion. However, not much growth was seen between the pre and post reflections indicating that she was using a lower level of reflection as a way to solve problems within her lesson plans, but not critically questioning the nature of the problems themselves. This is consistent with research stating that in order to practice reflection one must not just look back at what occurred in practice, but must also think about and assess it in order to grow professionally (Ruth-Sahd, 2003). Her lack of growth may have been due to her using the same reflective outline for both self-reflections (repetition) or to a lack of self-efficacy (discussed later). Her post-reflection was extremely similar to her pre-reflection with some words changed to make it fit the new lesson. This may have occurred because the final reflection was due close to winter break, and she either did not have the time or did not want to put forth the effort to fully reflect on her final lesson.

Other barriers impeded the static participants’ ability to reflect and thus, limited pedagogical change. Two static participants’ self-reflections were continually focused on external factors. The first teacher’s reflection was inhibited by her persistent focus on not having her own classroom; therefore, she could not begin to reflect on her pedagogical practice. The
inconvenience of not having her own room to teach was so distracting for her, she could not reflect on her teaching at all. According to Loughran, (2002), this may have been a way for her to rationalize why she could not teach the lesson like she wanted and avoid the responsibility. The second teacher’s external focus was the time of year. This participant mentioned multiple times that things were difficult because of the time of the year and had a long discussion about going to the zoo. These reasons are consistent with research suggesting it allowed her to disengage from the problem and not accept responsibility for it (Ward & McCotter, 2004).

Teachers, such as these two, who show task concerns are often so preoccupied with these external factors that they are unable to reflect on themselves to identify higher level concerns that they could change in order to improve their practice (Hord, 1987). Until these task concerns have been reduced in intensity, these teachers will not be able to focus on how their teaching impacts student learning. This was apparent in their lack of student focus in any of their self-reflections. As previously discussed, when teachers can critically focus on how their teaching impacts student learning their pedagogy will improve (Hatton & Smith, 1995; Tsui, 2003; Ball et al., 2009; Nolan & Sim, 2011).

**Multidimensional Foci**

When teachers critically analyze their practice and reflect on multiple dimensions of pedagogy improvement in pedagogy transpires. The progressed groups’ improvement in reflection was supported by an increase in the number of reflective statements written and in the number of co-codes given to the reflective statements when analyzing pre versus post reflections. All participants had their pre-video reflective statements co-coded with a connection to students, suggesting that these participants had characteristics of effective teachers because they considered student learning to be most critical in their selection and presentation of activities, which is
consistent with Tsui (2003). When post-video reflective statements were examined, progressed participants continued to reflect on how the students were engaged in the learning experience, with all participants increasing in the number of co-coded statements, and some making deeper connections using three or four codes. This suggests that not only were these participants reflecting at a deeper level, but they were also moving toward an improvement in practice, because teachers are considered effective when they interconnect the tasks they provide with their teaching, students, and content (Ball, Sleep, Boerst & Bass, 2009). The reflective patterns of teachers in the progressed group suggest that when teachers begin to reflect on how all aspects of teaching interrelate, their pedagogy begins to transform and these connections are evident in the classroom. Past research has shown that teachers who demonstrate higher cognitive levels, such as varying their use of instructional strategies, eliciting more conceptual responses from students, and being more committed to student engagement and learning, will improve their teaching performance and produce more successful students (Hunt & Joyce, 1967; Glickman, 1985).

In contrast to multidimensional pedagogical focus on improving teacher practice, when teachers focus on minimal aspects of pedagogy and fail to see how all the facets are related to improving student learning, pedagogical change will be hampered. The progressing participants focused their video reflection co-codes on teacher/student and task/student relationships, showing that these teachers are also considering student learning as the most integral component of the pedagogical process and are, therefore, showing signs of effective teaching, which is consistent with Tsui (2003). However, they had fewer multidimensional connections than the progressed participants, suggesting that these participants have similar reflective qualities to the progressed group, but may not be as far along in the practice of reflection.
This lower level of reflection was also exhibited by the progressing participants’ self-reflections in which half showed an increase in the number of reflective statements, but of those, only one increased in the number of co-coded statements. This suggests that although a teacher may write a greater number of reflective statements, he/she may not be examining teaching more critically. This is consistent with Kaminski (2003) and Nolan & Sim (2011) who posit when a teacher cannot critically analyze his/her experiences and continue to reflect at a lower level, improvement in practice will be hindered. For example, one participant improved her change in self-reflection by four reflective statements. Her original self-reflection included two reflective statements out of 18, and her post self-reflection included six reflective statements out of 19. When reviewing her co-codes, she had one co-coded statement in each of her reflections. This indicates that all of her other reflective statements only examined one aspect of the pedagogical process and were reflective, but not critically reflective. This may conversely affect her ability to improve her pedagogy, because effective teachers are shown to connect all aspects of the classroom (task, teaching, content and student) when planning or implementing a lesson (Ball et al., 2009).

When teachers cannot make these connections and only focus on one aspect of pedagogy, pedagogical change is limited. The static group exhibited this limitation by having few reflective statements and co-codes throughout all four of their reflections, and they had no reflective statements focused on content and no tri-coded statements in any reflections. The one-dimensional nature of the majority of their reflections, paired with the omission of one aspect of the pedagogical process, provides an explanation for the lack of significant visible change in their practice (Ball et al., 2009; Goe & Stickler, 2008; Ward & McCotter, 2004). This indicates that the reflective process was somehow challenging for this group, as it is for many teachers who
struggle with analyzing one’s own knowledge, beliefs and assumptions (Schön, 1983). The practice of reflection is complex, as it is not just a series of steps, but a cyclical process in which one must assess the situation, analyze, interpret and revise (Hatton & Smith, 1995; Zeichner & Liston, 1987).

**Level of Commitment**

Many researchers found that practicing reflection is key when it comes to improving one’s pedagogical skills (Ballard, 2006; Wallace, 2001; & Zeichner, 2007). However, to improve one’s reflection, and therefore make a change in teaching practice, teachers must put forth effort. The need to make a change in behavior is embedded in the practice of reflection (Andrews, 1996).

The majority of the participants in the progressed group appeared completely committed to the coaching process. Their reflections were of the required length, they responded punctually when prompted by the coach, and their prompt responses were lengthy and contained reflective thinking. One can hypothesize, therefore, that the majority of the progressed group increased their reflection because they were willing to put in the time and effort and engaged in the reflective process at a high level. This also may explain the progress made by half of the progressing group that was fully committed to reflection.

In contrast, the static group had one fully committed participant, one partially committed and one who was not committed at all to the coaching process. The participant who was not committed to the process showed no improvement in reflection and a negative trend in improvement in practice, which may suggest that she did not see value in the reflective process and did not want to put in the time or effort that it required (Ruth-Sahd, 2003). Participant 8 was fully committed and had the largest number of total reflective statements in the group, as well as the largest increase (of 3) in co-codes on her self-reflections. This suggests that she is the most
reflective participant in the static group, albeit it a very low-level, and may explain why she showed a slight improvement in all of the frequency codes, especially in analysis/interpretation.

**Self-Efficacy**

As previously discussed, the practice of reflection is difficult for many teachers and does not come naturally to them (Schön, 1983; Loughran, 2002). Many barriers, such as their beliefs about teaching and/or student learning, childhood experiences or cultural conditions may prevent them from being able to critically assess their teaching and how it affects student learning (Stanley, 1998). Due to these circumstances, teachers may focus on external factors rather than their own instruction, use jargon, or repeat or copy previous reflective statements instead of critically assessing individual lessons. Several participants demonstrated these types of ineffectual reflection during their reflective processes.

The lower progressing participant previously discussed who could not critically question the nature of the problems in her lesson plans, demonstrated through her use of repetition, may have had difficulty reflecting on her teaching due to low self-efficacy. A teacher with low self-efficacy may struggle to critically reflect on his or her own teaching and have difficulty changing his/her pedagogical practice (Bandura, 1997; Cantrell et al., 2003; Hatton & Smith, 1995).

Teachers must believe that they can impact their students’ lives in order to be able to critically reflect on their pedagogy (Ashton & Webb, 1986). If teachers do not believe they can change the lives of their students in a positive manner, they will not be motivated to critically assess their own practice (Colton & Sparks-Langer, 1993).

All three static participants struggled with the reflective process and analyzing their pedagogy. Two of the three may have been impeded by their tendency to blame external factors (time of year or not having their own classroom) rather than identifying ways in which they could
improve the situation within their classroom. This may have been a way of avoiding accepting responsibility, or may be that they had low teaching efficacy and believed that there was nothing they could do to improve student learning due to circumstances beyond their control (Cantrell, Young & Moore, 2003).

The other static participant, along with a low progressing teacher, focused on the procedural aspects of their teaching and/or the teaching of others. These teachers may be showing similar qualities to those with ineffectual reflection. As supported by Hatton & Smith (1995) and Taggart & Wilson (1998), these participants demonstrated they were at lower reflective levels because they were just describing the events happening in the lesson and not analyzing the pedagogy they were observing or assessing. They also demonstrated minor changes in practice, which Taylor et al. (2002) suggests indicates they were challenged by reflection and thus, in changing teaching practice. This difficulty with reflection and lack of change in practice may be due to a lack of self-efficacy, because low self-efficacy may negatively influence teacher’s ability to critically reflect on their pedagogy, thus hindering improvement as well (Hatton & Smith, 1995). The static participant was the only non-committed teacher in the study, which further supports a lack of self-efficacy, because teachers with low self-efficacy are found to show a weak commitment to teaching and spend less time in subjects areas in which they feel less confident (Encohs & Riggs, 1990). Teachers with low self-efficacy do not believe in their ability to have a positive impact on student learning (Bandura, 1997; Cantrell et al., 2003), and so they do not put in the time or effort but avoid dealing with the problem (Chwalisz, Altmaier & Russell, 1992).

**Collaborative Versus Individual Coaching**

Despite research suggesting that collaboration is beneficial in helping develop the practice of reflection, the findings of this study suggest that those who are fully committed to the process...
and focus their reflection on student learning can still increase their reflection and, thus, improve their practice without collaboration with others. This is particularly true for those teachers who fell into the progressed and progressing groups. Three of five progressed participants and two of six progressing participants were originally in the individual coaching group, with four of them being completely committed to the process. One participant, who was partially committed, was fully committed when she returned from being ill. This suggests that these participants did not need to collaborate with others to successfully increase in their depth of reflection or to improve their practice because they were fully committed to, and saw value in, the process (Ruth-Sahd, 2003). These participants improved their reflection, thus their teaching practice, by focusing on how their pedagogy affected student learning, and when teachers believe that their pedagogy is effective it can support a change in practice (Lotter, Harwood & Bonner, 2007). Two participants in the progressing group were both in the higher portion of the group. One participant showed the largest increase in depth of reflection and was fully committed to the process. This suggests that, similar to those who were individually coached in the progressed group, she did not need to discuss pedagogy with other teachers in order to deepen her reflection and improve her teaching because she saw value in the process (Lotter et al., 2007). The other participant was partially committed, but substantially improved her practice. This may indicate that she believed changing her pedagogy to one of inquiry-based instruction would be beneficial to her students, so she focused her reflection on student learning, thus improving her practice (Lotter et al., 2007). Her change in reflection was not as substantial as those in the progressed group, which may be due to her lack of effort in following the study’s guidelines.

While several participants’ increased their reflection, research suggests that their reflections may have become even deeper had they participated in the collaborative group (Jao,
This is supported by other findings in this study, including one participant in the progressed group who was a member of the collaborative coaching group. This participant was partially committed to the process, but was the one who increased her depth of reflection the most and demonstrated a substantial improvement in practice. Additionally, the only collaborative participant in the static group showed the most improvement in reflection and practice. This suggests that this improvement was due to her commitment to the reflective process and her ability to talk with others about inquiry-based pedagogy and read their reflections on it. Based on these findings, it seems that discussing pedagogical practices, and/or being able to read and converse about the reflection of others with peers, may have further encouraged the teachers to examine their own pedagogy. This, in-turn, may have elicited a change in teaching practice. This finding is aligned with research showing that collaborative coaching allows for group members to develop a trusting relationship that improves communication, commitment levels, and helps foster knowledge transfer (Brown & Grant, 2010) as well as providing teachers with opportunities to offer suggestions and encouragement, critique ideas, assess one another’s pedagogy, and develop goals, aiding in development of reflection and change in practice (Lieberman, 1995; Heibert, Gallimore & Stigler, 2002 & Lin, Hong, Yang & Lee, 2013).

Despite research indicating collaboration with colleagues is most beneficial for increasing depth of reflection (Lin et al., 2013; Yoon & Kim, 2010) and thus improving practice (Heibert et al., 2002; Lin et al., 2013), it may not provide enough individualized support for those who are ineffectual reflectors. This is supported by the findings from the lower portion of the progressing group and those in the static group. These teachers showed very little improvement in reflection or practice, even though two participants were fully committed. This indicates that collaboration
did not aid them enough in the reflective process and that they may require more support. Since the practice of reflection is difficult for many teachers, with many being resistant to it (Schon, 1983; Zhang et al., 2011), some may need more individualized support to guide them through the reflective process than others. This struggle with reflection may be due to their thoughts about science teaching, low teaching efficacy (Cantrell et al., 2003), low self-efficacy (Bandura, 1997) or a lack of effort or commitment (Tschannen-Moran & Hoy, 2001).

To provide additional support, it may be beneficial to provide teachers with another coaching method or combination of coaching methods that take the social constructivist approach (Vygotsky, 1978) of having a more knowledgeable other. This more knowledgeable other would act as a guide through the reflective process and connect teachers with an expert with which to share ideas about teaching practices. This guidance could encourage their practice of reflection and help transform their pedagogy. The more knowledgeable other may be colleagues, but may also be a coach who is effective in guiding teachers to reflect, affording them opportunities to discuss their practice (Edwards, 2008). When teachers struggle with reflecting because of negative beliefs in their personal ability to impact student learning or in their ability as a teacher to impact students, support is required to change these perceptions. Coaching, along with collaboration, has been shown to provide the support teachers with low teaching efficacy and low self-efficacy need to improve their negative perceptions and increase their implementation of new pedagogical strategies (Darling-Hammond & McLaughlin, 1995; Joyce & Showers, 2002). However, cognitive coaching may not be the best choice for all teachers. Instructional coaching methods may provide teachers with low teaching and self-efficacy more individualized support in their planning and implementation of lessons. Instructional coaching still engages teachers in the reflective process to help them realize their goals, but also assists them with creating a plan to
reach those goals. Instructional coaches may also provide support to teachers through discussions to increase their efficacy, as well as model the desired behaviors in the classroom so that struggling teachers are able to visualize inquiry-based instruction, thereby providing a basis for their reflection. Instructional coaching may also better support the transition of inquiry-based instruction into the classroom. This type of coaching provides differentiated support and can give teachers more confidence knowing someone will help with lesson design and implementation (Knight, 2009a).

**Implications**

The implications of this study will be discussed around three significant topics: professional development, online professional development and pre-service teacher education.

**Professional Development**

The findings of this study suggest that teachers vary in their ability to reflect and may need coaching that is differentiated according to their individual needs. An implication of these data is the suggestion that school districts looking for effective teacher professional development to initiate reform efforts, or those involved in grants that include professional development of teachers to educate them on new pedagogical strategies, should carefully consider all participants’ ability levels and what type of coaching may be most beneficial to each of them. This study demonstrated that some teachers might need more individualized support than others due to their difficulty with the practice of reflection, while others may have benefited more from collaboration. Those seeking professional development may need to consider different types of coaching, such as instructional, for teachers who find reflection difficult and demonstrate some type of resistance to it. Several teachers in the study demonstrated a resistance to reflection, suggesting low self-efficacy or low teaching efficacy and requiring different approaches to
improve their reflectivity, such as those proposed in Bandura’s social cognitive theory (1986).

These suggested approaches (modeling, vicarious experiences, and verbal persuasion), along with instructional coaching, could be used to help teachers who are finding it difficult to reflect for various reasons begin to learn the practice of reflection and subsequently improve their teaching practice. Instructional coaches have the ability to provide intensive, differentiated instruction, to support teachers in their implementation of new strategies, as well as model lessons for teachers to observe (Knight, 2008). Through using exemplary modeling to exhibit inquiry-based instruction, these teachers could begin to see what they should be examining in their own teaching and begin to adopt similar reflective foci. When teachers observe positive results from coach-modeled lessons, they may be more inclined to try similar lessons or strategies, leading to higher standards of performance (Bandura, 1986). However, the more complex theses new strategies are, the more support and encouragement is needed for teachers who demonstrate resistance to them (Bandura, 1986; Hord, 1987). For reform efforts like those suggested by a Framework and the NGSS to be achieved, a great deal of support will be needed to guide the large numbers of in-service teachers who will need assistance along their paths to pedagogical change. Therefore, school districts or universities that are looking to develop teachers’ use of inquiry-based instruction in the science classroom, must consider differentiating their professional development to meet teachers’ varying levels of ability.

**Online Professional Development**

Using the reflective framework, to cognitively coach teachers, within a form of social medial, like Facebook, provided the opportunity for teachers to receive the coaching experience without missing integral class time and afforded them the chance to reflect when it was convenient for them. This demonstrates that online cognitive coaching through social media is
effective and efficient for teachers who may otherwise not be able to participate in the coaching process due to time or travel constraints (Dede, Ketelhut, Whitehouse, Breit, & McCloskey, 2009). As a result of the demanding schedules of teacher, with crowded curriculums and little time, it is difficult for teachers to find time to reflect (Stanley, 1998). This form of cognitive coaching would allow teachers to reflect when it is suitable for them and still have the needed support and guidance to increase their depth of reflection and improve their pedagogical practice. This form of online, cognitive coaching also provides the coach the ability to prompt teachers from anywhere in the country, allowing him/her greater access to teachers throughout the United States (Rossett & Marino, 2005). This would help school districts who may not have access to effective coaches in their area acquire one from anywhere else in the country. School districts are currently spending millions of dollars a year on professional development to improve their teachers’ practice, including teacher coaching and release time as well as travel expenses (Sawchuk, 2010). Online cognitive coaching, using a reflective framework, could improve teachers’ practice while saving districts substantial amounts of money. Although coaching has been shown to be an effective means of developing teachers’ pedagogy, many school districts cannot afford the high cost of supplying each teacher with a coach who is physically present in their classroom (Knight, 2012). Through using social media and a reflective framework, one coach can support multiple teachers simultaneously with no release time needed and no coaching or teacher travel costs. By cutting the number of coaches needed, travel costs and replacement teachers, districts could save up to a thousand dollars per teacher (Knight, 2012).

**Pre-Service Teacher Education**

As with in-service teacher education, the reflective framework with guiding prompts would be beneficial for teacher educators to use with pre-service teachers in guiding them through
the reflective process as they begin to reflect on the teaching practice of others and themselves. The majority of students will enter the program never having been asked to reflect, needing to develop necessary skills to consider how their teaching will affect student learning in the future. By teacher educators promoting reflection in the classroom, they will be preventing their students from settling on some of the existing, traditional pedagogy observed in classrooms today (Korthagen, 2001). The reflective framework used in this study, along with the reflective codes, will give the teacher educator the ability to rate reflective statements, determine the focus of reflection and then prompt the students to a deeper level of reflection, thus guiding them into a more critical analysis of their teaching practice. This will not only teach students how to become critical reflectors, but if done repeatedly, will make it a habitual action, thus they will become teachers who frequently analyze their practice and continually improve it. The ability to do this online through social media, such as Facebook, will also allow this type of pre-service teacher instruction to be effective as either an online component of student-teaching or as part of an online curriculum. Additionally, this could be used to allow students to reflect collaboratively with peers, mentors, or university faculty on their teaching to aid in improving their pedagogy.

This online component could also save universities money by decreasing the cost of instructional facilities. Currently, online learning has become a large part of many universities, reaching students from across the globe at relatively low cost (Saltzman, 2014). According to the chancellor of the University Systems of Maryland, a hybrid approach consisting of both in-person and online components could cut costs by as much as 25% by allowing professors to work with a larger number of students (Perez-Pena, 2012). Providing pre-service teachers with the opportunity to incorporate classroom learning with online cognitive coaching could be a cost effective approach for colleges across the country. Using this method of reflection could also be used to
help address the 2013 Council for the Accreditation of Educator Preparation (CAEP) standards, which require that all candidates are provided with the opportunity to develop deep understandings of pedagogy, content, student learning and the skills necessary to effectively teach students (CAEP, 2015).

**Limitations**

This study had several limitations that may have affected external validity and reliability. Limitations were in the areas of sample size, time and instruments used.

**Sample Size**

Due to the researcher being the only cognitive coach in this study, a small (N=14), purposeful sample was necessary. However, using a small sample size made it difficult to determine statistical significant relationships when looking for the difference between groups and lessened the external validity. Small samples affect the external validity of a study, making it difficult to generalize findings across other populations or across times (Creswell, 2014). Future studies including a larger sample size would ensure a greater chance to find statistical significance between groups and increase the generality of the findings. For example, all teachers in this study had over 10 years of teaching experience and were all women. Broadening the number of study participants may allow for different populations to be included, demonstrating a larger representation of the population.

**Time**

Developing effective reflection takes time (Hatton & Smith, 1995), and the teachers in this study may not have been provided adequate time to foster the practice of reflection. Without being given ample time to nurture the reflective process, desired changes in pedagogy may not transpire. Teachers must be provided with the needed time and support to reflect on their
pedagogy in order for their teaching practices to transform (Ratcliffe & Millar, 2009; Yang & Lee, 2013). The two reflective cycles in this study lasted for a twelve-week period, covering less than half of the school year. This may have not been a sufficient amount of time for all of the teachers to fully engage in the reflective process, and thus begin to change their practice. Research states that teachers need at least 80 hours of professional development, extending for at least one full school year, for transformation of practice to occur (Loucks-Horsley et al., 2003; Supovitz & Turner, 2000). Extending the time of this study to the entire school year, with the addition of at least two more reflective cycles, may allow participants to have more time and support as they practice and develop their reflective practice, providing them further opportunity to improve their pedagogy. Hence, teacher educators, and those who design teacher professional development, need to guarantee that teachers are given adequate amounts of time to develop their reflective practice so they can critically reflect on their teaching and make changes to their teaching practice.

**SCIENCE Instrument**

The SCIIENCE instrument, used to measure change in teacher practice, had several limitations for this study. Several frequency codes were found to be unusable for varied reasons. Firstly, the codes of misconception and move past misconception were removed from the analysis, because it was unfair to assess teacher change in practice if a specific code did not occur. It was discovered for multiple teachers that the code of misconception was not observed in their lessons, therefore, they could neither receive the either code. Secondly, the scientific vocabulary code was removed because there were discrepancies amongst NURTURES coders regarding which science words should be recognized as scientific vocabulary. This led to the code being changed in the coding manual from a frequency code to a global rate, thus reducing the potential for vast difference in inter-rater reliability. Thirdly, although it had minimal affect on any analysis, the documentation code, as a frequency code, may
have had some limitations as well. As previously discussed, documentation could be dependent on the type of lesson being taught. A biology lesson with students continually documenting their observations will receive the code more than an engineering lesson with an initial design followed by the construction of it. Also, the documentation code was dependent on the amount of time it was captured on the edited version. For one participant, documentation was observed in the full video, watched to assess for global ratings, but was not part of the edited version. This participant did not receive any documentation codes for her lesson, even though she actually implemented it. This finding, as with the vocabulary code findings, helped to inform the larger SCIIENCE project.

Documentation has since been changed from a frequency code to a binary on the SCIIENCE instrument. Lastly, global ratings were removed from the analysis of research question 3 because they did not seem to be effective when looking at change over a short period of time. When using pre-post change to determined change in global rating scores, the majority of participants’ global ratings did not change by more than 1 in either direction, this was then considered as no change in the rating. When calculating IRR for global ratings, linear weighting was used to give more credit for scores differing by 1 because they are assessed using a 4-point ordinal scale.

**LORAA**

The LORAA was used to rate teachers’ reflective responses and to provide prompts for the coach to use to foster further reflection. Although, the instrument did provide a systematic rating of reflective statements, at times it was difficult for the rater to distinguish between the differing levels within the LORAA. Also, after rating all statements, the researcher did not fully agree with some statements that were rated at a more critical level than others. For a teacher to receive a 6, a statement was provided stating what was learned from the situation. This, however, does not always indicate critical analysis occurred. One teacher stated that she learned she is still
not comfortable with teaching science. This was rated a 6 because it was a statement of what was learned, but it did not require her to critically analysis her pedagogy. A rating of 2 could have been given, as it more describes her beliefs and feelings. Also, the reflective protocol followed scripted prompts supplied by the LORRA, which may have limited participants’ depth of reflection. If prompts were more individualized, depth of reflection may have been furthered. Lastly, the LORRA did not take into account the overall reflective focus. When reflective themes were analyzed, different types of resistance to reflection were observed as well as participants who were stuck in the descriptive phase of reflection. By rating a reflection statement-by-statement, these important factors are missed.

**Future Research**

Although the findings of this study provide further information to the field of education, questions still remain unanswered. To begin to further understand if collaborative reflection is more effective for all teachers, studies with larger numbers of teachers, from different demographics and varying depths of reflections, will need to be completed. This will further inform the field if all teachers better improve their reflective practice by working in a collaborative coaching experience with peers or if some types will benefit more from one-on-one cognitive coaching. Future research should also explore if teachers at different reflective levels will benefit from different types of coaching, such as instructional. Teachers who are struggling with, or are ineffective in, reflection for reasons such as being focused on task concerns (Hord, 1987) or having a lack of teaching efficacy, may benefit more from beginning the coaching process in an instructional manner or with one that uses multiple types of coaching simultaneously.
For teachers who are finding reflection difficult, further studies need to be completed to determine why they do not demonstrate an improvement in reflection. Many reasons can be assumed such as: they do not see value in the process so they just go through the motions, they do not find the coaching process meaningful, something in their current situation is hindering them from the ability to reflect or they are just not conceptually able. However, studies need to be completed to further define these causes and find ways to guide teachers through them, so reflection is not hindered.

Another potential focus for future research could be further exploring reflective assessment. In the past decade, limited research has been conducting on the assessment of written reflection. Few researchers have looked at assessing written reflections in order to develop reflectivity, but most did not provide information regarding the depth of reflection achieved (Plack et al, 2004). Although this study provided a way to assess teacher’s written reflection through the use of the adapted LORAA, the ratings were not completely telling in terms of depth of reflection. Future research may further explore ways to look at teacher depth of reflection beyond the number of reflective statements written, looking more at pedagogical focus or the overall focus of the reflective piece.

Chapter Summary

Previous research suggested that an increase in depth of reflection is effective in moving teachers toward a change in pedagogy (Cruickshank and Applegate, 1981; DeMulder, Cricchi, & Sackett, 2001; Freiré, 1991) and that using a reflective framework to guide thinking and focus attention to specific practices is beneficial (Rich & Trip, 2011). Previous research also implied that practicing reflection while participating in multiple interactions with peers plays a substantial role in the development of teachers’ professional skills (Lin et al., 2013). The findings of this
study support that the practice of reflection is associated with an improvement in teacher practice, and that the use of a reflective framework increased teachers’ depth of reflection. This study demonstrated that through guided practice of reflection, teachers developed reflective thinking skills that led to deeper reflectivity. As depth of reflection increased amongst participants, pedagogy began to improve, as demonstrated by an increase in higher-level teaching strategies and focus on effective pedagogy and its multiple dimensions. The participants who demonstrated the most substantial growth in depth of reflection also exhibited the greatest changes in their practice. Participants whose reflection remained static throughout the study showed little signs of improving their pedagogy.

Further findings support that teachers may not need collaboration with peers to improve their pedagogy as long as they are committed to the practice of reflection as see value in it. However, the collaborative process may further encourage teachers to examine their teaching practices and elicit a change in pedagogy. Despite these findings and research indicating that collaboration with colleagues is most beneficial for increasing depth of reflection, collaborative cognitive coaching may not be the most effective professional development for teachers who are ineffectual reflectors. Some teachers in the study were found to have difficulty improving their reflectivity, or were ineffective reflectors, and thus struggled to improve their teaching practice.

In consideration of these findings, it is recommended that coaches and designers of professional development continue to guide teachers through the reflective process using a reflective framework, but consider that different types of coaching and approaches may be more beneficial to teachers who are at varying levels of reflection. Further research will be needed to determine why some teachers find the practice of reflection difficult and how coaches or those who design professional development can help in moving them past this barrier.
References


Alger, C., & Kopcha, T.J. (2011). Technology supported cognitive apprenticeship transforms the student teaching field experience: Improving the student teaching field experience for all triad members. *Teachers Educator, 46*(1), 71-88


doi: 10.1177/1525822X03251188


nextGenerationofTeachers.pdf)


Rossett, A., & Marino, G. (2005). If coaching is good, then e-coaching is ... *T+D, 59*(11), 46-49.


doi:10.1086/653467


## Appendix A

### Level of Reflection-On-Action Assessment

#### Level of Reflection-on-Action Assessment (LORAA)

<table>
<thead>
<tr>
<th>Student: __________________ (Code No. if used for research)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Journal No: _________</td>
</tr>
<tr>
<td>Level of Reflection Achieved: _________</td>
</tr>
</tbody>
</table>

Directions: Read the journal entry once to familiarize yourself with the overall content. Reread the journal entry and assess each level of reflection evidenced in the writing, according to the guidelines in the left column below. Briefly cite the student’s written comments that provide evidence of each level of reflection in the middle column. Be aware that the student may not provide evidence for every level of reflection because reflection is not a simple linear process. If no evidence is found for a given level of reflection, document this with the notation “no evidence found” (NEF) and use the guided prompts in the right column to provide written feedback to the student in the reflective journal. In the space above, indicate the highest level of reflection (on a scale of 1 to 6, with 6 being the highest) evidenced in the student’s journal.

Reminder: The purpose of this instrument is to assist faculty in guiding reflective journaling with students. The instrument is intended to be used to identify the level of reflection achieved by students and to provide feedback to guide students to higher levels of reflection. This instrument is not intended, nor is it recommended, to be used to evaluate learning or to grade students’ reflective journal entries.

<table>
<thead>
<tr>
<th>Level of Reflection-on-Action Feedback</th>
<th>Evidence of Reflection Level</th>
<th>Guided Prompts for Reflective Journal</th>
</tr>
</thead>
</table>
| Level 1. Student describes the incident, including what was initially noticed. | • Describe the events as they unfolded as comprehensively as possible.  
• What did you notice about the situation and yourself? In other words, what was your initial grasp of the situation? |
| Level 2. Student describes beliefs and feelings about the incident. | • What were you thinking and feeling at the time the events unfolded?  
• What were your beliefs about what was happening? |
| Level 3. Student relates the incident to similar past encounters, experience, or theoretical knowledge and includes additional data collected and any assistance received with problem solving. | • Did you have any preconceived thoughts or ideas regarding the situation?  
• What were you thinking as you witnessed the events unfolding?  
• Were there any environmental factors that influenced your perception of the situation? For example, odors, sounds, lighting effects, space, personnel?  
• What subsequent thoughts did you have?  
• Without making judgment or analysis of the situation, what images, feelings, or thoughts arose that helped you with interpreting this situation? Jotting your thoughts on paper or by drawing or diagramming may help you to work through this process. |
<table>
<thead>
<tr>
<th>Level 4. Student states the analysis(es) and interpretation(s) of the situation.</th>
<th>Level 5. Student provides information regarding responses to the situation, actions, or interventions taken, or not taken, and why. A statement of statements regarding stressors experienced is included, along with recognition of new perceptions of previously held beliefs and knowledge. Student provides information reporting the response of the patient or other individuals involved in the situation and any subsequent actions taken.</th>
<th>Level 6. Student provides a statement as to what was learned from the situation. Student provides information identifying the need for additional knowledge and skills in handling similar situations in the future, as well as changes in values of feelings as a result of the experience.</th>
</tr>
</thead>
<tbody>
<tr>
<td>• What additional data did you collect and why? • What kind of help (if any) did you receive in working through this problem? Who or what provided this help? • What references did you use to help understand the situation? • Were other persons or personal experiences relevant to the situation?</td>
<td>• What was your analysis(es) and interpretation(s) of this situation? • Did you encounter or develop any alternative interpretations? Did you consider these alternative interpretations? Why or why not? • Putting your thoughts on paper or drawing or diagramming; or using concept maps, flow charts, and Venn diagrams may be helpful in working through your interpretation of this situation.</td>
<td>• What new perspectives have you learned from this situation? What have you learned about yourself? Your client? Your profession? The nursing profession? • What additional skills or knowledge do you need for the future? How will you go about gaining these future skills or knowledge? What will you do with these new skills or knowledge after you have them?</td>
</tr>
</tbody>
</table>

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Appendix B

Adapted Level of Reflection-On-Action Assessment

<table>
<thead>
<tr>
<th>Level of Reflection-on-Action Feedback</th>
<th>Evidence of Reflection Level</th>
<th>Guided Prompts for Reflective Journal</th>
</tr>
</thead>
</table>
| Level 1. Teacher describes the incident, including what was initially noticed. | • Describe the events as they unfolded as comprehensively as possible.  
• What did you notice about the situation or yourself? In other words, what was your initial grasp of the situation? |                                |
| Level 2. Teacher describes beliefs and feelings about the incident. | • What were you thinking and feeling at the time the events unfolded?  
• What were your beliefs about what was happening? |                                |
| Level 3. Teacher relates the incident to similar past encounters, experience, or theoretical knowledge and includes additional data collected and any assistance received with problem solving. | • Did you have any preconceived thoughts or ideas regarding the situation?  
• What were you thinking as you witnessed the events unfolding?  
• Were there any environmental factors that influenced your perception of the situation? For example, announcements, fire drills, students being pulled out of class, organization of classroom, etc.  
• What subsequent thoughts did you have?  
• Without making judgment or analysis of the situation, what images, feelings, or thoughts arose that helped you with interpreting this situation? Jotting your thoughts on paper or by drawing or |                                |

Student: ____________________ (Code No. if used for research)
Journal No: __________
Level of Reflection Achieved: __________

Directions: Read the journal entry once to familiarize yourself with the overall content. Reread the journal entry and assess each level of reflection evidenced in the writing, according to the guidelines in the left column below. Briefly cite the student’s written comments that provide evidence of each level of reflection in the middle column. Be aware that the student may not provide evidence for every level of reflection because reflection is not a simple linear process. If no evidence is found for a given level of reflection, document this with the notation “no evidence found” (NEF) and use the guided prompts in the right column to provide written feedback to the student in the reflective journal. In the space above, indicate the highest level of reflection (on a scale of 1 to 6, with 6 being the highest) evidenced in the student’s journal.

Reminder: The purpose of this instrument is to assist faculty in guiding reflective journaling with students. The instrument is intended to be used to identify the level of reflection achieved by students and to provide feedback to guide students to higher levels of reflection. This instrument is not intended, nor is it recommended, to be used to evaluate learning or to grade students’ reflective journal entries.
| Level 4. Teacher states the analysis(es) and interpretation(s) of the situation. | What was your analysis(es) and interpretation(s) of this situation?  
- Did you encounter or develop any alternative interpretations? Did you consider these alternative interpretations? Why or why not?  
- Putting your thoughts on paper or drawing or diagramming; or using concept maps, flow charts, and Venn diagrams may be helpful in working through your interpretation of this situation. |
| --- | --- |
| Level 5. Teacher provides information regarding responses to the situation, actions, or interventions taken, or not taken, and why. A statement of statements regarding stressors experienced is included, along with recognition of new perceptions of previously held beliefs and knowledge.  
Teacher provides information reporting the response of the student/s involved in the situation and any subsequent actions taken. | Describe any alternative actions that you would consider but the teacher in the video did not take.  
- What would your reasons be for taking, or not taking, these actions?  
- What were you feeling as you witnessed the teacher not taking the actions?  
- How were you previously held beliefs and knowledge challenged?  
- What do you think the outcome of your response to the situation would be?  
- Rehearsing, roleplaying, or visualizing yourself in this situation or similar situations may help to identify actions that may have been used or may be useful in future situations. |
| Level 6. Teacher provides a statement as to what was learned form the situation.  
Teacher provides information identifying the need for additional knowledge and skills in handling similar situations in the future, as well as changes in values of feelings as a result of the experience. | What new perspectives have you learned from this situation? What have you learned about yourself? Your students? The teaching profession?  
- What additional skills or knowledge do you need for the future? How will you go about gaining these future skills or knowledge? What will you do with these new skills or knowledge after you have them? |
Inquiry Immersion Lesson

Appendix C

NURTURES Learning Plan

Lesson Title: Wind and Weather

Inquiry Immersion Lesson

Appendix C
Air is matter, atmosphere is air, wind is moving air.

Connections to Energy & Matter:

Flowing, Evacuating, and Communicating Information

Engaging in Argument from Evidence

Obtaining, Evaluating, and Communicating Information

Planning and Carrying Out Investigations


Planning and carrying out investigations to answer questions or test solutions to problems in K–2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions.

Engaging in Argument from Evidence in K–2 builds on prior experiences and uses observations and evidence to compare ideas and representations about the natural and designed world(s). Construct an argument with evidence to support a claim.

Obtain, evaluate, and communicate information in K–2 builds on prior experiences and uses observations and texts to communicate new information. Communicate solutions with others in oral and/or written forms using models and/or drawings that provide detail about scientific ideas.

Scale, Proportion, and Quantity

Objects may break into smaller pieces and be put together into larger pieces. Simple tests can be designed to gather evidence to support or challenge student ideas about change.

Energy, Force, and Motion

Sunlight warms Earth's surface. Weather and changes in weather affect the lives of organisms, including humans. Simple tests can be designed to gather evidence to support or challenge student ideas about change and cause and effect.

Energy Transfer

Sunlight warms Earth's surface. Weather and changes in weather affect the lives of organisms, including humans. Simple tests can be designed to gather evidence to support or challenge student ideas about change and cause and effect.
Enduring Understanding(s) taught using appropriate inquiry practices:

- Weather changes daily and throughout the seasons
- Wind is moving air
- Wind can be measured by direction and speed
- Wind is moving air seasons
- Weather changes daily and throughout the seasons

Student Learning Targets:

- Students should be able to describe how weather changes daily and throughout the seasons.
- Students should be able to describe that wind is moving air seasons.
- Students should be able to design, test, and redesign a tool that measures wind direction and speed.
- Students should be able to observe and graph wind direction and speed.

Student Learning Targets:

- Students should be able to describe how weather changes daily and throughout the seasons.
- Students should be able to design, test, and redesign a tool that measures wind direction and speed.
- Students should be able to observe and graph wind direction and speed.

Scientific and Engineering Practices (Codes) To Look For During Lesson:

- 3A, 3D, 4A, 6C, 7A, 7B, 8F, 8G

Assessment(s):

- Pre-assessment: Students will be asked what they know about wind, what wind is, and if there are ways in which we can measure the direction and speed of the wind.
- Summative Assessment: Students will redesign their wind measurement devices to make it a practical, effective tool for measuring wind direction and speed. They will present their design, build, and test their instrument to measure wind direction and speed. They will collaborate with peers to discover the pros and cons of their design.
- Formative Assessment: Students will be asked what they know about wind, what wind is, and if there are ways in which we can measure the direction and speed of the wind.
- Peer Assessment: Students will redesign their wind measurement devices to make it a practical, effective tool for measuring wind direction and speed. They will present their design, build, and test their instrument to measure wind direction and speed. They will collaborate with peers to discover the pros and cons of their design.

Discussion Plan:

- How will you foster the learning conversations throughout the lesson to ensure that there is a balance of teacher/student talk and student/student talk? Students will share out redesigns and why they choose to make those revisions. Students will redesign their wind measurement devices to make it a practical, effective tool for measuring wind direction and speed. They will present their design, build, and test their instrument to measure wind direction and speed. They will collaborate with peers to discover the pros and cons of their design.

Student-Student:

- Students will then collaborate with a partner and another pair of participants in the design, testing, and redesigning of wind measurement device.

Teacher-Teacher:

- Lesson will begin with didactic talk on wind and how wind direction and speed influence different aspects of weather.

Teacher-Student:

- Lesson will begin with didactic talk on wind and how wind direction and speed influence different aspects of weather.

Student-Student:

- Students are discussing the topic of the lesson with each other.
<table>
<thead>
<tr>
<th>Description</th>
<th>Teacher Questions</th>
<th>Possible Student Responses</th>
<th>Vocabulary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-assessment of background knowledge on wind</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10:15 - 10:30</td>
<td><strong>Dr. Molitor</strong> talk about what causes wind - pressure difference causes fluid flow</td>
<td>Discuss the example of water running out of hose. Explain how pressure difference affects wind.</td>
<td>Dr. Molitor</td>
</tr>
<tr>
<td>11:00 - 11:15</td>
<td><strong>Dr. Spongberg</strong> - talk about effects of moving air - Tornadoes</td>
<td>Demonstrate with chilled balloon how air moves around.</td>
<td>Dr. Spongberg</td>
</tr>
<tr>
<td>11:30 - 11:45</td>
<td><strong>Dr. Molitor</strong> talk about what causes wind</td>
<td>Wind blows from areas of high pressure to areas of low pressure.</td>
<td>Dr. Molitor</td>
</tr>
<tr>
<td>11:45 - 11:55</td>
<td></td>
<td>The energy in wind comes from the sun.</td>
<td></td>
</tr>
<tr>
<td>11:55 - 12:10</td>
<td></td>
<td>Wind moves because of a change in pressure.</td>
<td></td>
</tr>
<tr>
<td>12:10 - 12:20</td>
<td></td>
<td>Air moves around the ground.</td>
<td></td>
</tr>
<tr>
<td>12:20 - 12:30</td>
<td></td>
<td>Why does air move about wind?</td>
<td></td>
</tr>
<tr>
<td>12:30 - 12:45</td>
<td></td>
<td>What else can you tell me about wind?</td>
<td></td>
</tr>
<tr>
<td>12:45 - 12:55</td>
<td></td>
<td>How can you tell if it is windy?</td>
<td></td>
</tr>
<tr>
<td>12:55 - 13:10</td>
<td></td>
<td>Description of wind: something to do is wind.</td>
<td></td>
</tr>
<tr>
<td>13:10 - 13:20</td>
<td></td>
<td>Can someone add something to my description of wind?</td>
<td></td>
</tr>
<tr>
<td>13:20 - 13:30</td>
<td></td>
<td>Wind is strong.</td>
<td></td>
</tr>
<tr>
<td>13:30 - 13:45</td>
<td></td>
<td>You can feel the wind.</td>
<td></td>
</tr>
<tr>
<td>13:55 - 14:10</td>
<td></td>
<td>Explain how pressure difference affects wind.</td>
<td></td>
</tr>
<tr>
<td>14:10 - 14:20</td>
<td></td>
<td>Pressures of high pressure areas.</td>
<td></td>
</tr>
<tr>
<td>14:20 - 14:30</td>
<td></td>
<td>Air moves from high pressure areas to low pressure areas.</td>
<td></td>
</tr>
<tr>
<td>14:30 - 14:45</td>
<td></td>
<td>The energy in wind comes from the sun.</td>
<td></td>
</tr>
<tr>
<td>14:45 - 14:55</td>
<td></td>
<td>Wind moves because of a change in pressure.</td>
<td></td>
</tr>
<tr>
<td>14:55 - 15:10</td>
<td></td>
<td>Air moves around the ground.</td>
<td></td>
</tr>
<tr>
<td>15:10 - 15:20</td>
<td></td>
<td>Why does air move about wind?</td>
<td></td>
</tr>
<tr>
<td>15:20 - 15:30</td>
<td></td>
<td>What else can you tell me about wind?</td>
<td></td>
</tr>
<tr>
<td>15:30 - 15:45</td>
<td></td>
<td>How can you tell if it is windy?</td>
<td></td>
</tr>
<tr>
<td>15:45 - 15:55</td>
<td></td>
<td>Description of wind: something to do is wind.</td>
<td></td>
</tr>
<tr>
<td>15:55 - 16:10</td>
<td></td>
<td>Can someone add something to my description of wind?</td>
<td></td>
</tr>
<tr>
<td>16:10 - 16:20</td>
<td></td>
<td>Wind is strong.</td>
<td></td>
</tr>
<tr>
<td>16:20 - 16:30</td>
<td></td>
<td>You can feel the wind.</td>
<td></td>
</tr>
<tr>
<td>16:30 - 16:40</td>
<td></td>
<td>Air moves.</td>
<td></td>
</tr>
<tr>
<td>16:40 - 16:50</td>
<td></td>
<td>Explain how pressure difference affects wind.</td>
<td></td>
</tr>
<tr>
<td>16:50 - 17:00</td>
<td></td>
<td>Pressures of high pressure areas.</td>
<td></td>
</tr>
<tr>
<td>17:00 - 17:10</td>
<td></td>
<td>Air moves from high pressure areas to low pressure areas.</td>
<td></td>
</tr>
</tbody>
</table>

**Materials:**
- Ice chest
- Balloon-several

**Vocabulary:**
- Air
- Pressure
- Energy
- Jet Stream
- Strong Wind
- Wind
- Breeze
- Tornado
- Hurricane
- Atmosphere
- Pressure
- Temperature
- Leaf
- Branch

**Possible Questions for Students:**
- How can you tell if it is windy?
- What else can you tell me about wind?
- What causes wind to move?
- How does air move around the ground?
- How can you tell if it is windy?
<table>
<thead>
<tr>
<th>Time</th>
<th>Activity Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:30 - 9:45</td>
<td><strong>Expository Text</strong> by Arthur Dorras. <strong>Feel the Wind</strong>. Read expository text. <strong>Questions from story:</strong></td>
</tr>
<tr>
<td>9:45 - 10:00</td>
<td><strong>Can you design an instrument that can measure wind speed and direction?</strong> Remember design process from day 2 and consider specs from weather station design. Design in pairs on paper or whiteboard app. Explain the importance of a good design in order to construct the design.</td>
</tr>
<tr>
<td>10:15 - 11:00</td>
<td>Participants finish up design process and then hand their design off to another group to construct from the design. When instruments are constructed, they will be tested.</td>
</tr>
<tr>
<td>9:45 - 10:00</td>
<td><strong>Materials</strong> to build wind measurement devices: paper, markers, plastic film, sticks, plastic bags, cloth, fans, air cannons. <strong>MATERIALS TO BUILD</strong> wind measurement devices (plastic film, sticks, pins, cloth).</td>
</tr>
<tr>
<td></td>
<td><strong>Questions:</strong> What types of weather instruments can we design to measure wind speed and direction? What can we be sure that will work? How can we design an instrument to measure wind speed and direction?</td>
</tr>
<tr>
<td></td>
<td><strong>Responses:</strong> paper, markers, plastic film, sticks, plastic bags, cloth. <strong>Design:</strong> wind measurement devices (plastic film, sticks, pins, cloth).  <strong>Types of weather instruments:</strong> wind direction, wind speed.</td>
</tr>
</tbody>
</table>

**Exploration/Data Collection:**

- **Materials to build wind measurement devices (plastic, flag material, cloth, sticks, pin wheel type material, etc), air cannon or fan for testing**
- **Questions:** what is working well or not so well? How can we make it better? What is working well or not so well? Would your design off to another group to design in order to construct the design.
<table>
<thead>
<tr>
<th><strong>Discussion/Share</strong></th>
<th>15 minutes</th>
<th>11:00 - 11:15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constructing participants will then share with the designers how effective the instrument is and how easy/difficult it was to construct from the design plan.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Wrap-up</strong></th>
<th>15 minutes</th>
<th>11:15 - 11:30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recap of practices and cross-cutting concepts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Construct from the design plan and how easy/difficult it was to then share with the designers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constructing participants will</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Important Questions to Keep in Mind While Creating Your Learning Plan**

*****DOES YOUR LEARNING PLAN COVER THESE? CHECK ALL THAT APPLY!*****

**Scientific Investigation Plan**

- What is the question for the investigation? (This should encourage students to predict or form a hypothesis.)
- What investigation will the students be engaged in?
- What data will students be collecting?
- How will the students analyze the data?
- What are the specifications or the characteristics of the solution that your design should address?
- What is the problem you are trying to solve?

**Engineering Design Process Plan**

- What is the problem you are trying to solve?
- What are the specifications or the characteristics of the solution that your design should address?
- How will you structure the design process?
- What data will the students be collecting?
- How will the students analyze this data?
- How will you structure the re-design process?
- What will students be collecting? (This should encourage students to predict or form a hypothesis.)
- What is the question for the investigation? (This should encourage students to predict or form a hypothesis.)

---

**Any safety notes?**

- **Yes**
- **No**

---

**Remember to bring closure to the lesson! Time for student meaning-making**
Lesson Title:

Content Statement(s):

Teacher Name(s):

Date:

Lesson Summary:

Student Learning Objectives/Performance Expectation(s):
Students should be able to or students that demonstrate an understanding can (see description/example below):

Description and Example of Student Learning Targets/Performance Expectation(s):

• What students should be able to do at the conclusion of a lesson(s). These statement(s) take into account the Science and Engineering Practices.

Disciplinary Core Ideas and Crosscutting Concepts:

Living things have physical traits and behaviors, which influence their survival.

| Grade Level: | 
| Teacher Name(s): |

NURTURES Lesson Plan Template

Appendix D
Assessment(s):
How will you know learning is occurring or has occurred?

Pre-assessment:
Formative assessment:
Summative assessment:
Discourse Plan: How will you foster the learning conversations throughout the lesson to ensure that there is a balance of teacher/student talk and students are discussing the topic of the lesson with each other?

Student-Student:
Teacher-Student:
180

Student-Teacher:

**I have addressed the following questions in my learning plan. Check all that apply:**

- Scientific Investigation Plan
  - What is the question for the investigation? (This should encourage students to predict or form a hypothesis.)
  - What investigation will the students be engaged in?
  - What data will students be collecting?
  - How will the students analyze the data?
  - How will you foster the development of explanations? (Revisit student hypotheses.)
  - How will you foster student discussion of their explanations?

- Engineering Design Process Plan
  - What is the problem you are trying to solve?
  - What are the specifications or the characteristics of the solution?
  - How will you structure the design process?
  - What data will the students be collecting?
  - How will the students analyze this data?
  - How will you structure the design process?
  - What data will the students collect from their prototypes?
  - How will you foster the articulation of the solution?
  - How will you foster student discussion of their solutions?

**Remember to bring closure to the lesson (time for student meaning-making):**

- How will you bring closure to the learning activity?
  - How did the students learn or should have learned? (Discuss and summarize)
  - What did the students learn about or should have learned about future investigations?

**References:**


## Practice 1: Asking Questions and Defining Problems

### 1.1 Prior Knowledge

- **Checkboxes:** Yes, No, N/A

**Brief Description:**
Teacher indicates or indirectly implies in plan that students will be asked to recall previous knowledge from outside the current classroom and how this knowledge will be connected to the lesson.

**Performance Expectations:**

**DCI:**

**Lesson Topic:**

**Grade:**

**Teacher:**

---

Practitioner indicates in plan either directly or through types of questions that student misconceptions will be addressed. These misconceptions should not be immediately corrected, instead of emphasizing right from outside the current classroom and how this knowledge will be connected to the lesson. Instead of emphasizing right.

---

Directions: Mark **Yes** if the practice is included in plan and you feel it would not appropriately fit into the lesson. Mark **No** if the practice is not included in plan and you feel it would be beneficial if it were. Mark **N/A** if the practice is not included in plan and you feel it would not appropriately fit into the lesson.

Practitioner indicates in plan either directly or through types of questions that student misconceptions will be addressed. These misconceptions should not be immediately corrected, instead of emphasizing right.
<table>
<thead>
<tr>
<th>Practice 3: Planning and Carrying Out Investigations</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1 Test Hypotheses</td>
</tr>
<tr>
<td>Teacher indicates in plan that students will design or carry out activities in which previously generated hypotheses are tested. The data obtained during the investigation will be used to support or reject the hypotheses.</td>
</tr>
<tr>
<td>☐ Yes ☐ No ☐ N/A</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Practice 2: Developing and Using Models</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1 Student Model</td>
</tr>
<tr>
<td>Teacher indicates in plan that students will create models to represent scientific concepts or processes. Models can be two-dimensional (e.g., drawings) or three-dimensional (e.g., constructed from physical materials).</td>
</tr>
<tr>
<td>☐ Yes ☐ No ☐ N/A</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Practice 2: Developing and Using Models</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.2 Model Discourse</td>
</tr>
<tr>
<td>Teacher indicates in plan that students will be engaged in discourse about an existing model. This discourse may include interpreting the model, explaining the scientific concepts demonstrated within the model, or using the model to make predictions or draw conclusions.</td>
</tr>
<tr>
<td>☐ Yes ☐ No ☐ N/A</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
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<td>3.2 Test Hypotheses</td>
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<td>Teacher indicates in plan that students will be engaged in discourse about an existing model.</td>
</tr>
<tr>
<td>☐ Yes ☐ No ☐ N/A</td>
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</tbody>
</table>

<table>
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<tr>
<td>3.3 Test Hypotheses</td>
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<tr>
<td>Teacher indicates in plan that students will be engaged in discourse about an existing model.</td>
</tr>
<tr>
<td>☐ Yes ☐ No ☐ N/A</td>
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</tbody>
</table>

<table>
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<tr>
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</thead>
<tbody>
<tr>
<td>2.3 Model Discourse</td>
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<tr>
<td>Teacher indicates in plan that students will be engaged in discourse about an existing model.</td>
</tr>
<tr>
<td>☐ Yes ☐ No ☐ N/A</td>
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</tbody>
</table>

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>3.4 Test Hypotheses</td>
</tr>
<tr>
<td>Teacher indicates in plan that students will be engaged in discourse about an existing model.</td>
</tr>
<tr>
<td>☐ Yes ☐ No ☐ N/A</td>
</tr>
</tbody>
</table>
Practice 4: Analyzing and Interpreting Data

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

Teacher indicates in plan that students will consolidate their own explanations for phenomena and/or be asked to support statements with evidence, prior knowledge or logical reasoning. These are likely to be "how" or "why" questions.

6.1 Explanation

Teacher indicates in plan that students will generate their own explanations for phenomena and/or be asked to support statements with evidence, prior knowledge or logical reasoning. These are likely to be "how" or "why" questions.

Practice 6: Constructing Explanations and Designing Solutions

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

Teacher indicates in plan that students will generate their own explanations for phenomena and/or be asked to support statements with evidence, prior knowledge or logical reasoning. These are likely to be "how" or "why" questions.

Practice 5: Using Mathematics and Computational Thinking

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

Teacher indicates in plan that he/she or students will obtain numerical data and consolidate, organize, and/or analyze this data. This can also include statistical analyses of the data, such as computing an average.

5.2 Graphical Summaries of Data

Teacher indicates in plan that he/she or students will create a graph of data collected for interpretation and/or analysis. This includes bar graphs, pie charts, scatter plots, etc.

5.3 Quantitative Analysis

Teacher indicates in plan that he/she will guide students to draw conclusions from numerical or graphical summaries of data.

5.1 Numerical Summary

Teacher indicates in plan that he/she or students will obtain numerical data and consolidate, organize, and/or analyze this data. This can also include statistical analyses of the data, such as computing an average.

5.4 Graphical Summaries of Data

Teacher indicates in plan that he/she or students will create a graph of data collected for interpretation and/or analysis. This includes bar graphs, pie charts, scatter plots, etc.

Practice 7: Using Mathematics and Computational Thinking

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

Teacher indicates in plan that students will recognize their mistakes and resolve them.

4.3 Move Past Misconceptions

Teacher indicates in plan that students will move past their misconceptions. Discussions of results of experiments are used to support a hypothesis.

Practice 4: Analyzing and Interpreting Data

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

Teacher indicates in plan that students will consolidate and interpret the results of their investigations. This includes recognizing patterns, comparing and contrasting objects, and determining whether data supports a hypothesis.

Teacher indicates in plan that students will move past their misconceptions. Discussions of results of experiments are used to support a hypothesis.
### Practice 7: Engaging in Argument From Evidence

**7.1 Disagreement**

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
<th>N/A</th>
</tr>
</thead>
</table>

**Teacher indicates in plan that he/she will encourage and accept multiple conflicting answers.**

### Practice 8: Obtaining, Evaluating, and Communicating Information

**8.3 Formative Assessment**

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
<th>N/A</th>
</tr>
</thead>
</table>

**Teacher indicates in plan that formative assessments will be integrated into the lesson to evaluate student understanding.**

### Synthesis Score for Scientific and Engineering Practices

<table>
<thead>
<tr>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
</table>

**Design of the lesson is highly effective in incorporating and using sufficient scientific and engineering practices throughout the lesson.**

### Cross-Cutting Concepts

**Directions:**

- **Mark Yes** if Cross-Cutting Concepts is included in plan.
- **Mark No** if Cross-Cutting Concepts is not included in plan.
- **Mark N/A** if you feel it would not appropriately fit into the lesson.

**Comments:**

- Teacher indicates in plan that he/she will use appropriate science vocabulary in context throughout the lesson.
- Teacher indicates in plan that he/she will use formative assessments to inform instruction.
- Teacher indicates in plan that formative assessments will be integrated into the lesson to evaluate student understanding.

---

**Practice 7: Engaging in Argument From Evidence**

**7.1 Disagreement**

- Teacher indicates in plan that he/she will encourage and accept multiple conflicting answers.

---

**Practice 8: Obtaining, Evaluating, and Communicating Information**

**8.3 Formative Assessment**

- Teacher indicates in plan that formative assessments will be integrated into the lesson to evaluate student understanding.
1. Patterns

Teacher indicates in their lesson that students will observe patterns in current lesson or that current lesson is preparing students to use this concept in a future lesson.

Students will observe that the shape and stability of natural and designed objects are related to their function (K-2).

Students will observe that objects and objects in the natural world have different structures which can sometimes be simple or complex (K-2).

Students will learn that different materials have different structures which can sometimes be simple or complex (K-2).

Teacher indicates that students will learn that different materials have different structures which can sometimes be simple or complex (K-2).

2. Cause and Effect

Teacher indicates in their lesson that students will observe patterns in current lesson or that current lesson is preparing students to use this concept in a future lesson.

Students will learn that objects and objects in the natural world have different structures which can sometimes be simple or complex (K-2).

Students will learn that different materials have different structures which can sometimes be simple or complex (K-2).

Teacher indicates that students will learn that different materials have different structures which can sometimes be simple or complex (K-2).

3. Scale, Proportion and Quantity

Teacher indicates in their lesson that students will use scale, proportion and quantity in current lesson or that current lesson is preparing students to use this concept in a future lesson.

Students will use relative scales (e.g., bigger and smaller; hotter and colder; faster and slower) to describe objects. They may use standard units to measure length (K-A2).

Students will recognize natural objects and observable phenomena exist from the very small to the immensely large. They will use standard units to measure and describe physical quantities such as weight, time, temperature, and volume (3).

Teacher indicates in their lesson that students will use scale, proportion and quantity in current lesson or that current lesson is preparing students to use this concept in a future lesson.

4. Systems and System Models

Teacher indicates in their lesson that students will learn about the structure and function of objects.

Students will observe that the shape and stability of structures of natural and designed objects are related to their function(s) (K-A2).

Students will learn that different materials have different substructures, which can sometimes be observed; and substructures have shapes and parts that serve functions (3).

Teacher indicates in their lesson that students will learn about the structure and function of objects.

5. Energy and Matter

Teacher indicates in their lesson that students will observe or measure stability and change in current lesson or that current lesson is preparing students to use this concept in a future lesson.

Students will observe that objects may break into smaller pieces, be put together into larger pieces, or change shapes (K-A2).

Students will learn that matter is made of particles and energy can be transferred in various ways and form different types of energy (3).

Teacher indicates in their lesson that students will observe or measure stability and change in current lesson or that current lesson is preparing students to use this concept in a future lesson.

6. Structure and Function

Teacher indicates in their lesson that students will observe or measure stability and change in current lesson or that current lesson is preparing students to use this concept in a future lesson.

Students will observe that the shape and stability of structures of natural and designed objects are related to their function (K-2).

Students will learn that different materials have different substructures, which can sometimes be observed; and substructures have shapes and parts that serve functions (3).

Teacher indicates in their lesson that students will observe or measure stability and change in current lesson or that current lesson is preparing students to use this concept in a future lesson.

7. Stairility and Change

Teacher indicates in their lesson that students will observe or measure stability and change in current lesson or that current lesson is preparing students to use this concept in a future lesson.

Student will observe that objects and objects in the natural world have different structures which can sometimes be simple or complex (K-2).

Students will learn that different materials have different structures which can sometimes be simple or complex (K-2).

Teacher indicates in their lesson that students will observe or measure stability and change in current lesson or that current lesson is preparing students to use this concept in a future lesson.

8. Structure and Function

Teacher indicates in their lesson that students will observe or measure stability and change in current lesson or that current lesson is preparing students to use this concept in a future lesson.

Students will observe that the shape and stability of structures of natural and designed objects are related to their function (K-2).

Students will learn that different materials have different substructures, which can sometimes be observed; and substructures have shapes and parts that serve functions (3).

Teacher indicates in their lesson that students will observe or measure stability and change in current lesson or that current lesson is preparing students to use this concept in a future lesson.
Students will observe some things stay the same while other things change, and things may change slowly or rapidly (K-2).

Students will measure change in terms of differences over time, and observe that change may occur slowly or rapidly (K-2).

Synthesis Score for Cross Cutting Concepts

| 6.2 New Situation | ☐ | 4.2 Overarching Relationships | ☐ | 3.4 Observation | ☐ | 3.3 Teacher Demonstration | ☐ | 3.2 Equipment | ☐ |

Directions: Mark any of the following that were indicated in the plan.

Other Teaching Practices and Resources

Comments:

Synthesis Score for Cross Cutting Concepts

| 4 | 3 | 2 | 1 |

Design of the lesson is highly effective in incorporating appropriate cutting concepts (4).

Design of the lesson shows effective use of cutting concepts (3).

Design of the lesson does not effectively incorporate or show future use of cutting concepts (2).

They will eventually change (3).

Students will learn some systems appear stable, but over long periods of time, students will learn that change may occur (K-2).
6.3 Evaluate Understanding

Teachers may ask students to evaluate their own understanding of a concept. Students may ask to evaluate how well they understood a concept or recognize misconceptions or gaps in their understanding or judge their level of success or failure in an activity.

6.4 Documentation

Teachers plan to record information or have students record information generated during the lesson on paper, a chalkboard, or some other medium. Relevant information must be student-generated, such as students' ideas or discussions, or data obtained from an experiment, such as measurements or observations. This information can be in the form of written work, numerical data, or drawings. Teachers plan to ask questions that encourage students to think and discuss in more than one way. Questions that ask students to choose from a set of predetermined options are not open-ended.

6.5 Sequenced Questions

Teachers plan to use multiple questions on a particular topic to lead students to higher levels of thinking or to move from general to specific concepts. There must be a student response between questions, and teachers plan to ask follow-up questions that encourage students to think and discuss further. Questions that ask students to choose from a set of predetermined options are not open-ended.

8.1 Expository Text

Expository text is used in the science lesson plan. The expository text may be part of an electronic or paper format, or a set of instructions or a discussion. Expository text may ask students how well they understood a concept or recognize misconceptions or gaps in their understanding or judge their level of success or failure in an activity.

8.2 Technology

Teachers plan for students to use electronic devices, such as computers or iPads, during the science lesson or the teacher plans to use the technology with student involvement.

8.4 Documentation

Teachers plan to record information or have students record information generated during the lesson on paper, a chalkboard, or some other medium. Relevant information must be student-generated, such as students' ideas or discussions, or data obtained from an experiment, such as measurements or observations. This information can be in the form of written work, numerical data, or drawings.

8.6 Open-ended Questions

Teachers plan to ask questions that encourage students' own thoughts and ideas. Questions that ask students to choose from a set of predetermined options are not open-ended.
Scientific Investigation: Students are engaged in a hands-on activity that explores a scientific concept. In an investigation, students either gather new scientific information or confirm previous information through direct observation.

Confirmation Activity: Students are engaged in an activity that explores a scientific concept in advance.

Structured Inquiry: Students are engaged in an activity in which they generate potential solutions to a proposed problem. This could be a hypothetical discussion or as a prelude to an activity in which students will test their solutions.

Guided Inquiry: Students are provided with a question and method to test question supported by evidence they have collected.

Open Inquiry: Students derive their own question, design and carry out own methods and communicate their results.

Test Solution: Plan indicates that students will be engaged in an activity in which they will test their solutions.

Design Solution: Plan indicates that students will be engaged in an engineering design activity in which they will be responsible for generating potential solutions to a proposed problem.

Other: Plan indicates that some other form of activity was chosen other than a scientific investigation or engineering activity.
**Capsule Rating for Overall Lesson Plan:**

When deciding overall capsule score for the lesson consider scores and comments from all of the three previous sections along with how well the performance expectations and disciplinary core idea correspond with the lesson activities.

<table>
<thead>
<tr>
<th>Level 1: Ineffective Lesson Plan</th>
<th>Level 2: Unlikely Lesson Plan</th>
<th>Level 3: Likely Lesson Plan</th>
<th>Level 4: Exemplary Lesson Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highly unlikely that plan will impact the science concepts intended to be achieved. Activities in plan demonstrate little or no attempt to use any scientific/engineering practices or cross cutting concepts to engage students in active learning and critical thinking.</td>
<td>Unlikely that plan will impact the science concepts intended to be achieved. Activities in plan demonstrate purposeful use of scientific/engineering practices and cross cutting concepts to engage students in active learning and critical thinking but are inappropriately aligned.</td>
<td>Likely that plan will impact the science concepts intended to be achieved. Activities in plan demonstrate purposeful use of scientific/engineering practices and cross cutting concepts to engage students in active learning and critical thinking.</td>
<td>Highly likely that plan will impact the science concepts intended to be achieved. Activities in plan demonstrate purposeful and highly selective use of scientific/engineering practices and cross cutting concepts to engage students in active learning and critical thinking.</td>
</tr>
</tbody>
</table>

**Comments:**