ABSTRACT

LEWIS, LINDSAY KRISTIN. The Impact of Teacher Beliefs on Elementary Teachers' Use of Scaffolding in a Technology-rich, Inquiry-focused Classroom. (Under the direction of Dr. Eric N. Wiebe)

This mixed-methods study, conducted with five elementary teachers, explored the relationship between teacher beliefs and classroom practice. Three theoretical frameworks -- Technological, Pedagogical, and Content Knowledge (TPACK), Teacher Beliefs, and Scaffolding -- were used for creating the data collection tools and for analyzing the data. Teachers were interviewed and observed in an effort to relate their beliefs about using technology and writing to teach science to their classroom practice when implementing Electronic Science Notebooks (ESNs) to teach elementary science.

The data collected suggested that while teachers with greater technological knowledge also had more positive beliefs concerning self-efficacy when teaching science, a greater degree of technological understanding did not necessarily mean that the scaffolding role was shared equally between the ESN and the teacher. Likewise, a higher pedagogical understanding did not mean that the scaffolding role was shared equally between the ESN and the teacher. Concerning the use of writing to teach science, writing was not scaffolded by teachers with the most content knowledge. Finally, teachers with prior experience with ESNs provided more scaffolding for the writing and inquiry process, and they were more likely to engage students in whole class discussion.

Although the results of this work cannot be generalized beyond this sample, understanding these teachers' beliefs and classroom practice provided potential insight into how professional development programs could be designed to better support teachers as they plan to incorporate writing into their science instruction or implement ESNs in their

classroom. As an example, when there was discrepancy between a teacher's intended use of technology and the actual use behavior, the teacher discussed the barriers that prevented the best strategies from putting into practice. Strategically planned professional development can provide these teachers with a greater understanding of the factors that shape their beliefs and the impact that those beliefs have on their practice.

The Impact of Teacher Beliefs on Elementary Teachers' Use of Scaffolding in a Technology-rich, Inquiry-focused Classroom

by
Lindsay Kristin Lewis

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APPROVED BY:

_____	_____
Eric N. Wiebe, PhD Committee Chair	M. Gail Jones, PhD
_____	_____
Sarah Carrier, PhD	Jane Lubischer, PhD

DEDICATION

To my brother, Caleb, you are the best gift my parents ever gave me. There is no *buddy* better than you, brother; to my parents, thank you for teaching me the value of kindness, gratitude, perseverance, and listening before speaking.

BIOGRAPHY

Lindsay Kristin Lewis attended Appalachian State University from August 2001 to June 2005. She attended North Carolina State University from August 2009 to December 2015.

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In addition to the faculty, I could not have completed graduate school without the support of my fellow graduate students. I respect you for your intellect; I admire you for your tenacity; and I am grateful for your friendship.

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INTRODUCTION

On the national level there are policies in place that advocate for greater accountability and endorse higher standards across many subject areas in K-12 education. Particular to science education, the National Research Council (NRC) recently released the *Next Generation Science Standards* (NGSS) framework, which outlines goals for science curriculum taught in the K-12 setting (NRC, 2011). This was done in response to: (1) the continued need to push for higher quality in science education, (2) the desire to increase scientific literacy for all, and (3) the understood benefit of emphasizing science in elementary school. This is evident in the statement given in a press release by Helen Quinn, chair of the NRC, concerning the NGSS. She stated, "Currently, science education in the U.S. lacks a common vision of what students should know and be able to do by the end of high school, curricula too often emphasize breadth over depth, and students are rarely given the opportunity to experience how science is actually done" (NRC, 2011, p. 1). The continued need to push for higher quality is reiterated by the Trends in International Mathematics and Science Study (TIMSS) report released in 2003. While there is skepticism concerning the policy decisions made as a result of the TIMSS data (Carnoy & Rothstein, 2013), taken as a general statement, the data shows that the state of education in the US has improved since the 1999 report, yet US students continue to lag behind many other countries in math and science performance (NCES, 1999; NCES, 2003). Another example of the efforts made to improve education is the National Governors Association (NGA) release of the *Common Core Standards* (NGA, 2012) which span across curricula. Collectively, these educational mandates from the NGA and NRC call for students to formulate ideas and support them with

reason, information, facts, and details, as well as receive help from adults and technology as they learn to write in order to present their point of view to others. Furthermore, this push for technology-use is seen in a report released by the President's Council of Advisors on Science and Technology (PCAST, 2010). The PCAST report recognizes that technology can be a vehicle for meeting the above-mentioned standards, regardless of field of study.

The standards in place around science education, although rich in content, recognize that science is more than content knowledge. Over a century ago, Dewey stated, "the future of our civilization depends upon the widening spread and deepening hold of the scientific habit of mind" (Dewey, 1910. P.126). These "habits of the mind" (Çalik & Coll, 2012; Dewey, 1910) align with science practices and include carrying out scientific investigations, engaging in argumentation based on evidence derived from empirical data, and communicating (i.e., written and spoken word) hypotheses and findings to others. To this end, writing can be a valuable tool when learning science through inquiry, as it promotes critical thinking. Additionally, writing calls upon students to use reasoning (Baker et al., 2008).

The push for science education to promote these "habits of the mind" is evident in the NGSS, where the NRC (2011) called for a long-term plan to gradually deepen the understanding of students by having them practice science in addition to learning the concepts. They emphasize

> [f]rom the very start of their education, students should be asked to engage in the communication of science… students should write accounts of their work, using

> journals to record observations, thoughts, ideas, and models. They should be encouraged to create diagrams and to represent data and observations with plots and tables, as well as with written text, in these journals. They should also begin to produce reports or posters that present their work to others. (NRC, 2011, pp. 3 – 21)

In order to comply with the mandate for "From the very start of their education," states have intensified the focus on science taught at the elementary level (Milner, Sondergeld, Demir, Johnson, & Czerniak, 2012). Also, in order for gradual progress to be measured, there are new testing mandates for elementary science (Milner et al., 2012). The increased emphasis on testing at the elementary level is one example of the heightened scrutiny on elementary science. As multiple sources reiterate the need for improving science education beyond basic understanding of content (Eshach, 2006; Zoller, 2011), this increases the demands placed on elementary teachers, and those demands may affect the pedagogical decisions a teacher makes.

Those pedagogical decisions in the science classroom are heavily influenced by how a teacher believes science should be taught (Enoch & Riggs, 1999). As this is a broad topic with multiple schools of thought, the area is rich in research. To narrow the focus for this research, there are two pedagogical strategies for teaching science that will receive further attention: (1) the use of writing (Nam, Choi, & Hand, 2010; Syh-Jong, 2007) and argumentation to teach science (Naylor, Keogh, & Downing, 2007) and (2) integrating technology when teaching science (Graham, Borup, & Smith, 2012).

Writing to Learn Science

There is a difference between writing *in* science and writing *to learn* science. The distinction is based on what is asked of the students (Abell, 2006**)**. Writing *in* science class can be broad and include things such as: short answer responses to questions, journaling, and detailed note-taking. These types of writings don't necessarily call on students to illustrate a deep understanding about the process of learning science (Rivard & Straw, 2000). Conversely, by giving students the opportunity to use writing as a method *to learn* science, it places the responsibility on the students to show what they comprehend, as opposed to the teacher drawing conclusions about the students' understanding. Examples of more sophisticated uses for writing in science include: (1) science notebooks that require students to record predictions and compare those predictions to empirical results (Leonardo Project, 2011), (2) lab reports that allow learners the opportunity to practice writing in the discipline (Carter, Ferzli, & Wiebe, 2007) or (3) recording in journals in a way that provides examples of true conceptual change over time (Dianovsky and Wink, 2012). These types of assignments are beneficial to students because writing to learn can have a positive impact on a student's conceptual understanding (Abell, 2006; Bangert-Drowns, Hurley, & Wilkinson, 2004).

Writing to learn asks students to be purposeful in their writing and to engage in metacognition (Harris, Graham, & Brindle, 2007; Sitko, 1998), wherein they not only write about what they believe to be true, but they are also expected to provide explanation for why they think the way they think (Hacker, Keener, & Kircher, 2009). Although this requires more feedback (i.e. time-intensive grading) from the teacher, the benefits are worth it; as

writing has been shown to strengthen student understanding by fostering these metacognitive processes (Dianovsky & Wink, 2012). In addition to this, writing facilitates formative assessment by allowing students to better articulate what they do and do not understand when they are obligated to be more cognitively aware of their learning and thought processes (Chen, Hand, McDowell, 2013).

Although writing is beneficial to learning, it is under-utilized in the science classroom**.** A study by Milner et al. (2012) revealed that only 36% of teachers associated learning science with writing. Also, when teachers attempt to implement writing, they often encounter strategic and logistical challenges such as time management around planning and providing feedback to students (Baker et al., 2008). Despite these setbacks, writing is central to the NGSS, which calls for students to develop habits and ways of thinking through writing that are prevalent in the scientific community (NRC, 2011). An example of one such practice, which is usually incorporated along with writing, is scientific argumentation.

Both writing and argumentation are found in the NGSS, which call for students to participate in the language-intensive activity of argumentation when learning and practicing science (NRC, 2011). Argumentation through writing and speaking is valuable in the science classroom; however, like writing, there has historically been a struggle in encouraging students to engage in either oral or written argumentation (Ruiz-Primo, Li, Tsai, and Schneider, 2010). While scientific argumentation can take place verbally, the focus here is the practice associated with writing because its use may be a solution for how to better incorporate writing in elementary science.

The solution to increasing writing in elementary science is likely multifaceted. For that reason, looking into teacher beliefs and technology integration, collectively, may offer insight into what takes place in a classroom where writing is being used for students to learn science. It is widely accepted that gaining a better understanding of teacher beliefs is an effective way to initiate change in a classroom (Milner, et al., 2012; Ng, 2011). There is emerging evidence that technology can facilitate the process of using writing as a learning tool (Lowther, Ross, & Morrison, 2003; MacArthur, 2009).

Integration of Instructional Technologies

Current policies push for an increase in the integration of technology across curricula. The President's Council Advisors on Science and Technology (PCAST) released a report calling specifically for increased efforts in science and technology education. PCAST's rationale was that STEM education in K-12 would be decisive when it came to the success of this nation (PCAST, 2010). The following discussion offers insight into how the proper use of technology in the classroom can improve instruction.

Just as writing implementation varies from classroom to classroom, there is also a range in the extent to which technology is effectively utilized in the classroom. For example, a typical low-impact (i.e., non-transformative) approach to using technology is using word-processing to do tasks previously done with a paper science notebook. In this case, using the computer to simply type out a document is intellectually no more challenging or rewarding that hand-writing a paper. A more sophisticated use of technology requires students to use the tool more purposefully in ways that support more sophisticated ways of thinking. This is desirable for the sake of developing 21st century skills (Robin, 2008; Bellanca, 2010).

Students and teachers should be using technology as a tool to actively engage in the learning process. (Ng, 2012)

This push to integrate technology comes at a time when there is increasingly ubiquitous use of technology in American schools and homes (Drayton, Falk, Stroud, Hobbs, & Hammerman, 2010); however, teachers are not always using technology effectively. There are three important issues that interfere with achieving the potential for technology to strongly impact student learning. The first issue is that, historically, too few courses at the undergraduate level have been designed to address uncertainties that future teachers may have about technology-use (Capobianco, 2007). Many institutions have made steps to address these uncertainties in the last decade, but there are still many newly practicing teachers who lack the desired skills to implement technology successfully. Another major deterrent to effective technology-use is that it is mostly used in schools for administrative tasks (Gray, Thomas, & Lewis, 2010), which is not maximizing the potential of technology. Lastly, there has been a breakdown in the way technology is implemented. Using it without having the content knowledge is not a successful way to teach the material (Harris & Hofer, 2011). These issues reveal a need in the teacher education system, whether it is based on how to use technology tools themselves or how to best utilize technology in conjunction with the content.

Specific to science education, technology can be a valuable tool for students to use as a means to engage in inquiry. As previously mentioned, low impact technology use, such as having students take notes on a computing device, doesn't drastically change the learning environment. There are slightly more advanced utilizations (e.g., using the internet as a

search tool), but for technology to be a vehicle for learning, there needs to be more input on the part of the teachers and the learners. For example, at an even higher level, there are targeted programs or software that act in conjunction with the instructor and require planning and forethought on behalf of the teacher. This changes the way that lessons are planned and implemented, and it affects how learning is assessed (Mulder, Swaak, & Kessels, 2002). Examples of these more sophisticated uses for technology specific to science classrooms include: (1) virtual labs that allow for authentic exploration of science concepts such as molecular structure (e.g., the University of Colorado's Physics Education Technology [https://phet.colorado.edu]), (2) dynamic software that allows learners to manipulate data and see immediate change (e.g., Hollebrands, 2007) or allows students to maneuver graphical representations (e.g., Anderson and Slough, 2012), or (3) electronic science notebooks (ESNs), which guide the students through the inquiry cycle of making predictions and comparing those predictions to results from empirical data (Leonardo Project, 2011). These more sophisticated uses of technology often provide embedded scaffolding, which provides a positive impact on the learning outcomes for science students (Oliver, Herrington, &Vick, 2003).

There continues to be a need for more effective use of technology in schools specifically geared towards achieving an instructional goal (Kopcha, 2012). Just as technology use in science classrooms can range from low-impact to purposeful, technology itself, as it provides support for writing, can range from passive to a more sophisticated form of scaffolding**.** For example, there is likely to be little difference in terms of learning outcomes between an *electronic* science notebook (ESN) and a *paper* science notebook when

they provide the same level of support. However, ESNs can increase student understanding of science by providing relevant scaffolding of a student's use of argumentation through writing. When used to their fullest potential, ESNs can offer students an experience where they are actively participating in and writing about science (Leonardo Project, 2011). In this case, the ESN has advantages by offering a higher level of pedagogical support through prompts and hints as students write to learn science.

This brings to focus the need to consider the way the role of the teacher is altered as a result of more sophisticated uses of technology, and in doing so ensuring classroom teachers are prepared to introduce and facilitate technology use in a way that maximizes the learning opportunities for their students. Integrating technology requires understanding of more than the software interface being used (Graham, et al., 2012; Harris & Hofer, 2011). There has been extensive research on the benefits of incorporating technology to teach science (Anderson & Slough, 2012; Kulo & Bobzin, 2013; Sidawi, 2009; Varma & Linn, 2012), as well as on the benefits of using writing across the curricula (Gunel, Hand, & Parin, 2007). However, research is lacking when it comes to the nuanced ways the teachers and technology must work together to maximize the potential of technology use for learning science through inquiry and argumentative writing.

The following sections explain the three frameworks that offer a way to conceptualize the various tools, systems, and methods that a teacher can utilize in order to teach students in a technology-rich classroom. The first framework takes into consideration a teacher's Technological, Pedagogical, and Content Knowledge (TPACK) when identifying interacting areas of expertise that a teacher must utilize when planning, teaching, and assessing. The

Teacher Beliefs framework is used to look at how teaching beliefs are expressed in dialogue and entrenched in classroom practice, and particularly how those teaching beliefs impact the use of writing and technology to teach science. Lastly, the framework of scaffolding provides an over-arching theme throughout the areas of interest. These three well-researched frameworks, taken together, provide a lens through which to view the topic of ESNs.

TPACK

Classroom instruction involves complex human-technology interactions (DiGisi, Nix, Daniels, Kramer, & Cyr, 1999), and the Technological, Pedagogical, and Content Knowledge (TPACK) framework proposes a way to intellectualize the different connections that exist within that construct. Common relations include: (1) teacher/student, (2) teacher/curriculum, (3) teacher/specialists, (4) students/teachers/mandates, (5) students/students, (6) students/teacher/technology; and these are only a small portion of the numerous relationships in a classroom. It is important to note that the teacher is the most influential factor in the classroom (Gess-Newsome, Southerland, Johnston, Woodbury, 2003); however, the introduction of technology has the potential to dramatically alter the way instruction unfolds.

TPACK dictates that it is important to consider the change that occurs as a result of adding technology to a lesson or a classroom. The foundational precursor to TPACK, Shulman's (1986) PCK (Pedagogical Content Knowledge) framework formally acknowledged that it was not only important to understand the content one was teaching, but it was also vital to be able to plan and implement lessons in a way that promoted learning. PCK is what distinguishes a teacher from a subject matter specialist (Magnusson, Krajcik, and Borko, 1999). As an example of PCK, in addition to understanding a concept in science,

a teacher would also need to be aware of the materials that are available, and how they may be used, in order to teach that science concept to students. An example may be use of science notebooks. Science notebooks are prevalent in elementary schools (Ruiz-Primo, Li, Ayala, & Shavelson, 2004), and they are very useful in helping students understand a concept by using a specific tactic, such as writing or argumentation. A teacher's PCK would allow him/her to assess student understanding of the content, as well as modify the implementation of the notebooks in order to reach a learning goal for the students.

In the event that the science notebooks were integrated via a technological platform, such as a tablet device, the teacher's TPACK would be crucial to its success. Additionally, the TPACK framework allows researchers to consider how the teacher and the technology teach the content. For example, the role of scaffolding may be distributed between the teacher and a technology, such as an ESN. The way the teacher uses the technology to teach science will be related to his/her knowledge base concerning technology, pedagogy, and content.

Teacher Beliefs

When it comes to understanding the decisions being made in a classroom, teacher beliefs are more influential than knowledge (Pajares, 1992). Those beliefs manifest themselves in different ways (i.e., the extent to which technology is used) (Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012; Venkatesh & Davis, 2000). Additionally, there are multiple factors that influence a teacher's beliefs, such as cultural constructs (Meirink, Meijer, Verloop, & Bergen, 2009) or the students' self-efficacy

(Zimmerman, Bandura, & Martinez-Pons, 1992). By definition, those influences on those beliefs can be divided into two sources: external and internal.

Internal sources are what motivate the individual from within. For example, one's expectations can serve as an internal factor, with research showing that an individual often acts with an already pre-determined end in mind (Jessim & Harber, 2005). Expectations are often influenced by previous experiences, which are another internal factor that influence teacher beliefs. This can be seen in the classroom when teachers are choosing how often and to what extent to use technology. Self-efficacy describes one's belief concerning their ability to reach a goal or accomplish a task (Brigido, Bermejo, & Mellado, 2011), and it is another internal factor that can be influential concerning how teachers choose to incorporate technology (Watson, 2006). A teacher's self-efficacy concerning technology use influences how that technology is implemented (Abbitt, 2011; Holden & Rada, 2011), often seen simply by how frequently a teacher integrates technology into the classroom.

In addition to internal factors, there are external influences on a teacher's beliefs, such as social norms of the school, the support received from administration and peers, and barriers that may hinder a teacher. When reflecting on social norms, it is important to understand that a teacher enters the classroom as a person shaped by the culture he/she came from. However, schools and classrooms have their own culture. Cultures come with rules and expectations that a teacher must understand and accommodate to. Also, a teacher likely encounters administration and peers multiple times throughout a day, and those two groups of individuals will greatly impact how the teacher teaches. For example, administration may have expectations about what subjects receive priority or how teachers plan lessons. There

may also be expectations around technology-use or whether or not writing should be integrated across curricula. Lastly, for external factors, teachers may experience barriers. Barriers may include issues such as technical problems with technology or time constraints.

These internal and external factors, in combination with one another, shape a teacher's beliefs. The Technology Acceptance Model (TAM) proposed by Venkatesh & Davis (2000) takes into account the way that internal and external factors combine to ultimately impact the way that technology is used. The TAM conceptualizes how beliefs can be based on the usability and utility concerning a specific technology, and those beliefs influence intentions concerning that technology and eventually "use behavior" concerning that technology.

Usability is the term first introduced by Shackel (1991) pertaining to a system's or program's ease of use, which Preece and Rodger (2002) discuss in terms of "learnability." This is of particular interest from an educational standpoint because technology will only be used effectively once the teacher believes he/she understands the technology well enough to guide students' use of it. Another way technology integration failure can occur is if the system or program lacks pedagogical effectiveness (Wade & Lyng, 2000). How effective a tool is may also relate to the concept of "utility," which is used to describe how a technology can be practically applied in order to accomplish a task. There remains more to learn concerning how a teacher's beliefs concerning the usability and utility of a particular technology specifically impacts learning in the classroom.

This concept of "teacher beliefs" is a messy construct (Pajares, 1992). Traits, affect, beliefs, and knowledge do not exist in isolation. To better understand how they manifest

themselves in the classroom, the focus will be refined to science classrooms. Looking specifically at how science classrooms are impacted by teacher beliefs requires taking a closer look at now teachers believe science should be taught.

In looking to better understand teacher beliefs concerning how science should be taught, the PCK framework (Shulman, 1986), mentioned above, may offer some insight. It is likely that those beliefs are influenced by two internal components: (1) a teacher's content knowledge, and (2) a teacher's pedagogical knowledge. Additionally, albeit broadly, finding out a teacher's attitude towards the purpose of science education is a good place to start in order to understand how teacher beliefs contribute to the way science is taught in that classroom (Donald, Anderson, & Barker, 2013).

Though one's belief system is viewed as more affective (Van Driel, Bulte, & Verloop, 2007) than their knowledge, it isn't always simple to distinguish between a person's knowledge and a person's beliefs (Pajares, 1992). This may be because teacher beliefs are influenced by their understanding of the content (Enoch & Riggs, 1999). To look closer at a teacher's content knowledge one can investigate how well s/he understands the nature of science (Lederman, 2007), which will shape how she/he teaches science.

A teacher's beliefs concerning pedagogy will also impact the way that science is taught. Three types of knowledge converge to create a teacher's pedagogical style: (1) knowledge of learners, (2) knowledge of goals, and (3) knowledge of assessments (Morine-Dershimer & Kent, 1999). In order to better understand the way that a teacher's PK influence science specifically, the Science Teaching Efficacy Belief Instrument (STEBI) (Enoch & Riggs, 1999) offers a list of questions to ask teachers. These questions are asked to get a

better sense of the following, including but not limited to: (1) how comfortable a teacher is with students asking questions, (2) how a teacher feels about being observed when teaching science, or (3) who the teacher may hold responsible for students' poor performance.

Two issues, mentioned above, resurface here – how a teacher uses writing to teach science and the potential role that technology can play in helping students learn science. When thinking about effective strategies to teach writing, research has shown scaffolding to be a valuable strategy. This allows students to gradually take over the task of writing independently. Additionally, technology-use must be scaffolded for the learner. This is especially true when the technology is an emergent tool. Lastly, when thinking about scaffolding as a theoretical framework, there is potential for the technology to provide some of the support in the form of scaffolding. All of these complex issues, involving the support that students use when learning, are explained by taking a deeper look at the concept of scaffolding.

Scaffolding

Since Wood, Bruner, and Ross (1976) first used the word scaffolding and defined it as a "process that enables a child or novice to solve a problem, carry out a task or achieve a goal which would be beyond his unassisted efforts" (p. 90), the concept has been extensively developed. Considering that scaffolding can be discussed to mean a variety of things in a broad context, a more focused definition is needed. For the purpose of this research, Pea's framework for scaffolding in technology-rich environments (2004) will be most useful. Pea acknowledges the work of Vygotsky (1978), who coined the phrase "zone of proximal development," but Pea also takes in consideration more modern thinking on scaffolding,

which looks at epistemological views towards the nature of science in order to establish developmental levels of knowledge when applying scaffolding theory (Kuhn, Amsel, & O'Loughlin, 1988; Smith, Maclin, Houghton, & Hennessey, 2000). Additionally, Pea is clear to point out the difference between scaffolding as it was first discussed in psychology, in terms of child development, compared to the way scaffolding is used in the formal education setting, where learning content is the desired outcome. Another key component of the scaffolding framework, as offered by Pea, is his discussion on human-based and technology-based scaffolding. The two often work together to create what Tabak (2004) referred to as "distributed scaffolding."

Pea looks at scaffolding from two sources: social and technological (2004). Social scaffolds certainly play a role during the first steps of learning, in that a "more capable peer" (Vygotsky, 1978) can set examples and provide support. Additionally, teachers are responsible for a large majority of the social support in a classroom. Pea goes on to assert that computers and other technologies have diversified the meaning of scaffolding, and technological advances have created theoretical challenges for how to discuss the role of the technology. He concludes his exhaustive look at this concept by stating that regardless of source, the crucial component of scaffolding is to provide support as needed and have it fade away as learning occurs (Pea, 2004).

Research model

Integrating the frameworks of TPACK, teacher beliefs, and scaffolding, a model emerges that provides a way to conceptualize how they interact with each other and with the components that are of interest in a classroom where ESNs are being used. In addition to the

model shown in Figure 1, a rationale is given in order to explain why ESNs are of such value to science education in elementary classrooms.

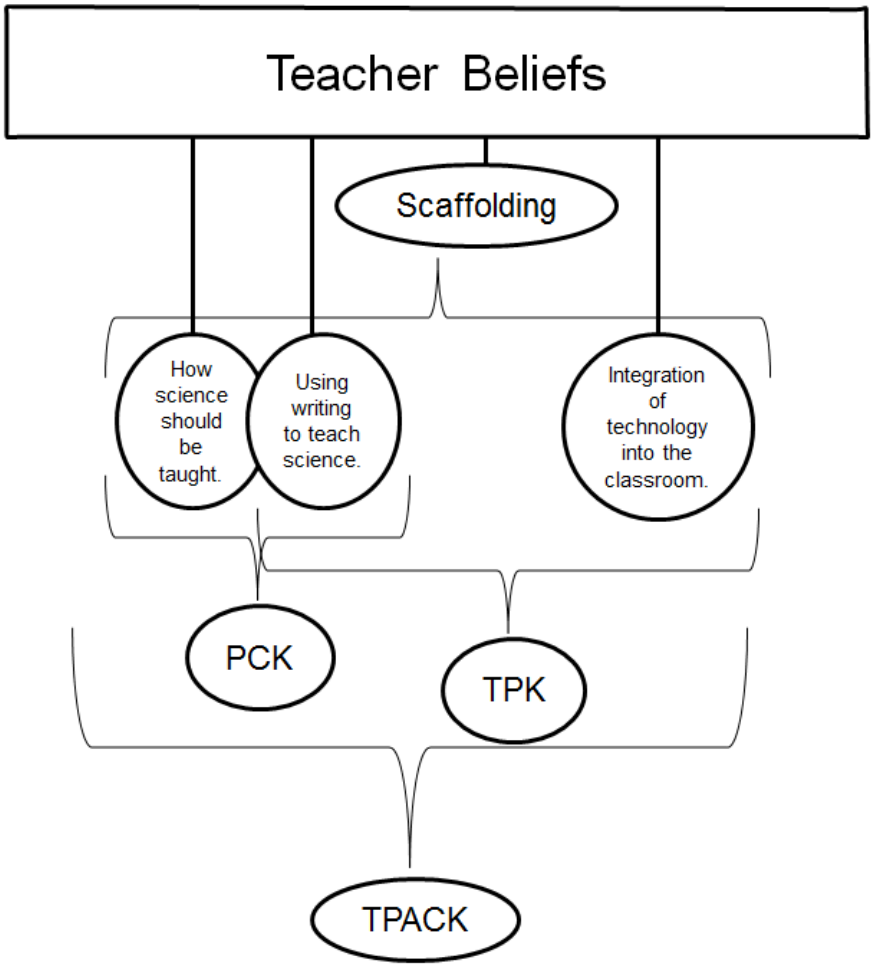

Figure 1. Relationship between Theoretical Frameworks.

Rationale

Looking at the way teachers use ESNs to teach science allows for a deeper understanding of a teacher's belief system, especially beliefs regarding: (1) how science should be taught, (2) how technology and writing can facilitate that process, and (3) how

technology and writing must be scaffolded in order to maximize learning. This is important because, in general, teachers are neither utilizing technology to its fullest scaffolding potential (Ng, 2012), nor are they incorporating writing into elementary education in a way that increases science understanding **(**Abell, 2006; McNeill, 2009). Gray, Thomas, & Lewis (2010) surveyed 3,000 teachers, and only half of them reported using technology "often" during instructional time, leaving most technology use directed towards administrative tasks. Considering that 99% of schools have access to the Internet and computers (Kleiner and Farris, 2002) there is certainly an infrastructure in place that would allow for teachers to change the way they use technology in order to improve learning outcomes. ESNs can provide opportunities for students to use writing and technology to be reflective and thoughtful as they engage in the inquiry cycle in the science class.

Helping teachers create a classroom where students write scientifically and practice inquiry that is guided not only by the teacher but also by an ESN is important for research in education. To help accomplish this, multiple teachers in multiple schools were used in hopes of gaining a better understanding of how a teacher's beliefs can impact their classroom practice, with the end goal being to provide strategically planned Professional Develop to individuals based on their beliefs. The research questions for this study are:

1) What are teachers' self-reported beliefs that influence their pedagogical decisions concerning writing and technology use to teach science?
2) How do these beliefs manifest in the classroom through established learning goals, use of instructional strategies, and/or implementation of ESNs?
3) How can understanding teachers' expressed and entrenched beliefs better inform PD?

Bearing in mind the need to better understand the extent to which teacher beliefs influence classroom practice while also considering the increased the urgency to answer those questions, the next chapter will take a closer look at what the literature says about the different elements of this research.

LITERATURE REVIEW

The integration of technology changes a classroom, and although ubiquitous and often beneficial, its application is not guaranteed to be flawless (Drayton, Falk, Stroud, Hobbs, & Hammerman, 2010). As technology becomes more sophisticated, it offers the ability to not only provide content to the students (Anderson & Slough, 2012), but also the capacity to act as a pedagogical agent and scaffold the students' learning (Sharma & Hannafin, 2007). With this, an educational challenge emerged for teachers as they made decisions concerning the incorporation of more sophisticated forms of technology into their classroom. At the core of those decisions was a system of teacher beliefs that impacted how learning was supported in the classroom (Clark, 2006; Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, Sendurur, 2012).

Teacher beliefs, according to Milner, Sondergeld, Demir, Johnson, Czerniak (2012) influenced decisions made based on technology-integration, thereby shaping the pedagogical strategies that were employed in a classroom. As an example, when lessons were being created that utilized technology, teachers were distributing the teaching responsibility (e.g., scaffolding) between themselves and the technology (Ertmer et al., 2012). A lesson could be designed where the technology provided the content, and the teacher could pace the delivery based on student performance. In that case, the technology would be providing what is known as hard scaffolding in that it directed the students' attention to particular pre-determined content (Belland, Glazewski, & Richardson, 2008). Whereas Belland et al. (2008)

stated the teacher's scaffolding role was more dynamic (i.e., soft) and could be flexible based on the needs of the students.

Elementary classrooms offered unique insight into this educational challenge with the implementation of Electronic Science Notebooks (ESNs), which promoted writing to teach science (Wiebe, Shelton, Patterson, Hardy, Carter, & Sheffield, 2013). Traditionally, writing had been supported by teacher-created handouts that provided students with hard scaffolds, such as sentence-starters (Miller, Lauffer, Messina, 2014) and soft scaffolding via monitoring student progress (McMaster & Campbell, 2008). Hard and soft scaffolding could be distributed between teacher and technology because of the emergent technology of computer-based writing tools, such as ESNs.

In reiterating the need to better understand how technology integration impacts a classroom, ESNs allowed researchers a way to refine their focus and look at the way technology altered how science was taught at the elementary level, particularly through writing and by using scaffolding at a pedagogical strategy. Given that there was evidence to support that teacher beliefs greatly affect the extent to which technology is used to impact teaching and learning (Ertmer et al. 2012), teacher beliefs, particularly those of elementary teachers, should receive a majority of the emphasis when working towards improving upon the way technology is integrated.

Taking the aforementioned challenges and relationships into consideration, three frameworks were helpful when constructing a model for research that strived to understand how teacher beliefs impacted the way technology was integrated in elementary classrooms teaching science through writing: (1) the Technological, Pedagogical, and Content

Knowledge (TPACK) framework (Koehler & Mishra, 2005, 2009), (2) the scaffolding framework offered by Pea (2004) and by Brush and Saye (2002), and (3) teacher beliefs, as informed by the Technology Acceptance Model (TAM) (Vanketesh and Bala, 2008; Venkatesh and Davis, 2000) and the framework underlying the Science Teaching Efficacy Belief Instrument (STEBI) (Enochs & Riggs, 1990). TPACK provided a general framework for the integration of technology such as the use of ESNs. Building off of TPACK, the frameworks of Scaffolding and Teacher Beliefs provided a more focused model around how teachers viewed the role of technology within the classroom in the context of teaching science and using writing.

These frameworks influenced the structure of this research concerning ESNs, as they encompassed the following: 1) teacher beliefs about how science should be taught, in general and via writing, 2) teacher beliefs concerning technology integration in the classroom – both in general and specifically when teaching science, 3) even more specifically, how teacher beliefs impacted the way technology was used to teach science via writing, and 4) more broadly, the distribution of scaffolding between the teacher and the technology when teaching science through writing. The three frameworks were combined into one model (*Figure 1, p.16*).

Looking at the four elements mentioned in the above paragraph collectively, a model emerged that provided a way to better understand how a teacher's beliefs affected the way s/he used technology to scaffold a student in order to promote scientific writing and a better understanding of the content (*Figure 1*). Scaffolding played an important role in the model because not only were teacher beliefs about scaffolding important, but it was also helpful to

see how the pedagogical strategy of scaffolding was shared between the teacher and the technology (Kim & Hannafin, 2011; Pea, 2004). The other three elements of: how science should be taught, using writing to teach science, and the integration of technology were included because they facilitated the discussion around how use of ESNs in the elementary classroom allowed for technology to facilitate writing in order to improve student understanding of science.

The elements of the research model centered around teacher beliefs because teachers had the most influence on what happens at the classroom level (Gess-Newsome, et al., 2003). Therefore, teacher beliefs influenced how ESNs were integrated into the classroom. ESNs offered assistance to the teacher not only by delivering content, but also by acting as a pedagogical agent through scaffolding (Rappolt-Schlichtmann, Daley, Lim, Lapinski, Robinson, & Johnson, 2013). Scaffolding was also connected to writing in the model because regardless of whether technology was used, elementary students were scaffolded as they learned to write (Fellows, 1994). Although the model contained science, writing, and technology shown as individual entities, the use of ESNs allowed for those elements to be looked at simultaneously. Thus the model was designed in order to look at how an elementary teacher's beliefs on scaffolding, science, technology, and writing all combined to impact the way science was taught when ESNs were being used.

Frameworks

TPACK. The TPACK framework (Koehler & Mishra, 2005, 2009) offered a way to formally recognize aspects that a teacher must consider when planning and teaching a lesson involving technology. In order for a teacher to be effective, there are basic and critical skills

that he/she must possess: 1) a deep understanding of the content they teach (Ball, Hill, & Bass, 2005; Shulman, 1986), 2) a firm grasp on pedagogy and the strategies that improve learning (Kennedy, 1999), and 3) knowledge about the tools available to them in order to improve teaching and learning (Graham, et al., 2012). The TPACK framework was based on the assertion that in order to successfully use technology in the classroom the teacher must not only understand content, pedagogy and technology, but also how the components are interconnected (Koehler, Mishra, & Yahya, 2007). Initially though, the components needed to be addressed independently, and the next paragraph will delve into what research said about the elements as separate entities.

These issues of Content Knowledge (CK), Pedagogical Knowledge (PK), and Technological Knowledge (TK) combined to form a kind of professional profile, creating a way for teachers to characterize themselves, reflect on their current level of proficiency, and address any room for improvement (Harris & Hofer, 2011). CK meant that teachers understood not only central tenets and concepts in a field, but also how those ideas are connected (Shulman, 1986). Pedagogical knowledge (PK) was used as a general term that encompassed understanding surrounding any technique that pertains to the overall aim and purpose of education (Shulman, 1986), such as composing a lesson plan or providing a student with feedback. PK was enhanced when teachers continually reflect upon and refine their teaching practice (Kennedy, 1999). Technological knowledge (TK) referred to understanding that related to the use of technology, such as how to use a basic operating system or how to maximize the potential of certain hardware and software (Mishra & Koehler, 2008).

While there tended to be a consensus in the research when it came to defining content and pedagogy (Borko & Putnam, 1996), it is the concept of technology that was problematic to define (Graham, 2011; Roblyer, 2005). Technology offered a unique challenge here because it changes so quickly (Angeli & Valanides, 2009), and it was said to be important that educators be purposeful and imaginative in their use of technology (Buckingham, 2013). Furthermore, in the context of TPACK, how technology was defined impacted the way content and pedagogy are discussed. To offer further clarification, technology was viewed as either "transparent" or "emergent." Transparent technologies (Mishra & Koehler, 2008) consisted of things such as calculators and overhead projectors. They were not particularly engaging or dynamic, but they are technologies that have, historically speaking, changed the way a classroom operates. "Emergent" technologies (Cox, 2008) offered unique challenges in the classroom, in that they may demand more of a cognitive load from the teacher and/or students (Russel & Hannon, 2012). Emergent technologies were seen in the Angeli & Valanides (2009) article, in which they called for teachers to do more than merely integrate technology into current practices; the author called for teachers, instead, to allow technology to transform what happens in their classroom in order for it to truly open up new possibilities for learning. Emergent technologies were also seen when Lee & Tsai (2010) looked at the web-based technologies change teaching and learning.

This distinction between the two forms of technology was important because of the way the two types of technologies interacted with a teacher's Pedagogical Knowledge (PK) and Content Knowledge (CK). Furthermore, this distinction provided rationale for using Technological Knowledge (TK) as a knowledge domain (Graham, 2011). To grasp how this

distinction between technology types was important for understanding each component of TPACK, it helps to look at how the parts interrelate.

In response to the need for a deeper theoretical understanding of technology integration in the classroom, the TPACK framework was discussed in the following combinations: Pedagogical Content Knowledge (PCK) (Shulman, 1986), Technological Content Knowledge (TCK) (Hofer & Harris, 2011), and Technological Pedagogical Knowledge (TPK) (Graham, 2011). PCK referred to the knowledge base teachers pull from pertaining to specific methods, resources, or strategies that are known to be effective in teaching a particular content (Dalgaron & Colgan, 2007). Shulman's PCK model (1986) introduced the idea that a teacher must not only have a strong grasp of the subject matter, but also an understanding of how to teach. Although Shulman's model did not provide a great deal of specifics concerning classroom practice (Settlage, 2013), the emphasis on pedagogy changed the way many view education. Transparent technologies, mentioned above, can be discussed in the context of PCK. It is TCK and TPK that referred to technologies that are more advanced and emergent. TCK (Technological Content Knowledge) explained the way a teacher understands the capabilities of a particular technology and how to use that technology to teach a specific content (Hofer & Harris, 2011). Mishra and Kohler (2008) pointed out that technology and content are reciprocally related, as teachers should not only use technology to teach the content, but knowledge for using technology is an important skill that should be applied to the content. The third combination, shown in Figure 2, is TPK (Technological Pedagogical Knowledge). TPK became increasingly important as technology increased in sophistication. Teachers and technology could both be pedagogical agents when scaffolding

learning in the classroom (Ng, 2012), but there remained a need to understand the complexity of this distribution of pedagogical responsibility.

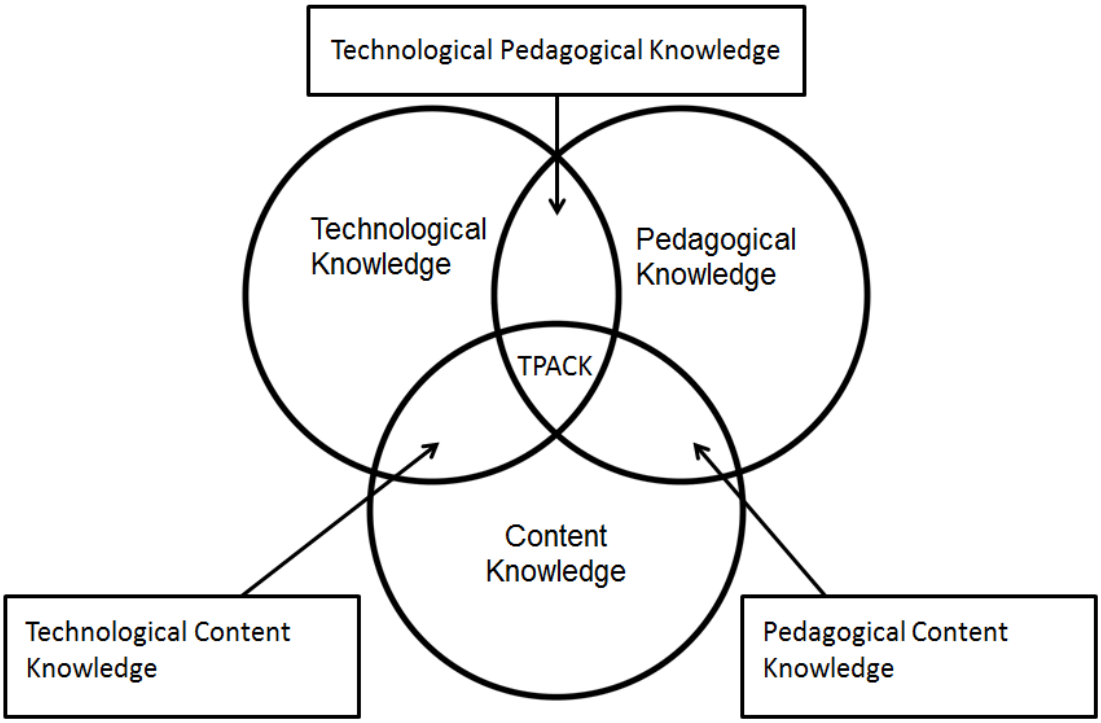

Figure 2. Technological, Pedagogical, and Content Knowledge (TPACK) Framework. (Adopted from Mishra & Koehler, 2008)

Mishra and Koehler (2008) stated that TPACK knowledge was the basis of high-quality teaching with technology, and Urhahne, Schanze, Bell, Mansfield, and Holmes (2010) stated that introducing emergent and sophisticated technologies to the classroom had the potential to change the role of the teacher. The next two sections look into theories that further the understanding of how the teacher and the technology dynamically co-exist in a

classroom because technology altered the distribution of responsibility, in that technology may potentially assume the task of delivering content (Henry, 2001), pacing the lesson (Milheim, 1990; Zevenbergen & Lerman, 2008), or providing feedback (Collins, Hawkins, & Frederiksen, 1990).

Scaffolding. Scaffolding was used and applied broadly in the fields of education and child development (Pea, 2004). The term "scaffolding" was used generally to describe the support provided or the process of giving assistance to someone as they are learning (Sawyer, 2006; Wood et al., 1976). This learning pertained to a skill or knowledge set. Scaffolding was used as a noun to describe a physical object or process, or as a verb (Pea, 2004). Both the noun and the verb usage were seen in the field of education. Not only was scaffolding often defined too vaguely, it was applied broadly as well (Pea, 2004). An example of such practice was seen when scaffolding was used synonymously with support (Puntambekar & Hubscher, 2005). Van de Pol, Volman, and Beishuizen (2010) expressed that individual students have unique needs and teachers cannot always be consistent and systematic with the way they provide scaffolding. This revealed a need to provide an operational definition for scaffolding in the context of a particular research study or classroom activity.

Before getting to the definition of scaffolding that may be used in the context of ESNs, it was beneficial to understand the history of the concept. It first appeared in the literature in the 1950s, when a cognitive psychologist, Jerome Bruner, was writing about the role that parents play when helping young children acquire language skills (Bruner, 1956), noting that reading to kids is an important first step to getting them to be independent readers. In the realm of education, Vygotsky's work from the 1930s was considered seminal;

although he did not specifically use the word “scaffolding” (Young, 1997). It was Wood, Bruner, and Ross (1976), whose work paralleled that of Vygotsky’s, where they highlighted the importance of scaffolding as a pedagogical tool. Their work highlighted two features of scaffolding that made it effective: (1) assistance from a more capable peer in order to get the learner to work beyond what he/she is able to do on their own and (2) fading as the learner makes progress so that the learner can then proceed independently. The former construct of scaffolding was described by Vygotsky when he coined the term “Zone of Proximal Development” (ZPD), that area in between what a person can achieve on their own and what they are not capable of doing without help (van der Veer, 1997). As a specific example, prompts and questioning were helpful strategies that are considered scaffolding (Simons, 1994). Over the decades that followed, ZPD was studied and written about extensively (e.g. Hannifan et al., 1999). The research conducted during the most recent decade has been impacted by the integration of technology (e.g. Lawless & Pellegrino, 2007); thereby further refining the construct of scaffolding.

In looking at scaffolding as it applied specifically to education, there were different types of scaffolding methods that had been researched and deemed effective. For example, Rieser (2004) wrote about two complimentary methods, structuring and problematizing. Structuring supplied learners with tasks and questions that facilitate learning, and problematizing engages learners by giving them an authentic scenario for applying what they are learning (Reiser, 2004). As an extension, “distributed scaffolding” relied on the synergistic nature of knowing, doing, and communicating when it came to learning (Tabak, 2004). With distributed scaffolding students were not allowed to simply acquire knowledge;

they were expected to apply that knowledge and become the more capable peer within a community of learners so that the cycle can continue (Tabak, 2004).

In addition to the types of scaffolding, Saye and Brush (2002) divided scaffolding into two groups: hard and soft. Soft scaffolding was a dynamic form of support. It was given based on feedback from the learner, and it was more individualized and tailored to an individual's needs. This has historically been provided by the teacher, as they are trained in proper pedagogical strategies for improving learning. Hard scaffolding anticipated the needs of the students prior to starting the lesson, thereby making hard scaffolding a more fixed form of support. Historically these have been provided by either a handout or a textbook. (Saye & Brush, 2002)

Scaffolding, whether hard or soft, in many forms can be provided by a teacher (van de Pol, Volman, & Beishuizen, 2012), a peer (Hayes, 2013), or technology (Yu, Tsai, & Wu, 2013) – perhaps even a virtual peer (Kim, Hamilton, Zheng, & Baylor, 2006), thereby combing the latter two. Granted, classrooms today are likely to have all three, and scaffolding became a more complex issue with the introduction of technology, which was why the framework offered by Pea (2004) provided a way to conceptualize how scaffolding could be provided by social interactions or interactions with technology. Ultimately the issue became not only how teachers, peers, and technology are scaffolding student learning, but also how teachers scaffolded the integration of technology (Ruggiero & Mong, 2013).

Scaffolding was offered as a framework because it applied across many areas that are impacted by the use of ESNs: scaffolding students as they learn science, scaffolding students as they learn to write scientifically, scaffolding the use of technology, and how the role of

scaffolding was shared between the teacher and the technology (See Figure 1). In a quasi-experimental design study on developing scientific practices by using argumentation, upper elementary students learned more content and maintained a more positive attitude concerning science when they were scaffolded through the process of learning science (Hong, Lin, Wang, Chen, & Yang, 2013). This approach has also been used successfully with ESNs (Wiebe et al., 2013). In continuing to think about how ESNs were used, scaffolding students as they learn to write in a science setting was more than simply having students write about steps in a lab or take notes about what they were doing (Fulwiler, 2007). Writing in science was about scaffolding students through the process of conceptual change (Fellows, 1994; Levin & Wagner, 2006; Mason & Boscolo, 2000) and metacognition (Zohar & Barzilai, 2013) as well.

In addition to scaffolding the content and writing, there remains a need to better understand how the teacher and the technology balance that scaffolding role. This brought the focus back to Teacher Beliefs as a factor that influenced the way technology was used in a classroom (Kim, Kim, Lee, Spector, & DeMeester, 2013). In doing so, Kim and colleagues offered an explanation as to why technology use differed so widely among teachers – teacher beliefs.

Teacher Beliefs. Given that the teacher is at the center of the TPACK model, it is important to understand the beliefs that drive instructional decision-making (Kim et al., 2013). Some of the influences on teacher beliefs existed internally for the teacher, such as self-efficacy (Newton, Leonard, Evans, & Eastburn, 2012) and expectations (Jussim and Harber, 2005). Other influences may be external to the teacher, such as a teacher's peer

group and administration (Milner et al., 2012). The external and internal components, both, impacted the decisions that teachers make. What differed among individuals was the degree to which each of those factors impacted beliefs, which in turn impacted behavior (Venkatesh and Bala, 2008; Venkatesh and Davis, 2000). This is where a gap in the literature exists. Specific to the use of ESNs, there were two areas of interest that played into teacher beliefs: how individuals integrated technology (Venkatesh and Bala, 2008; Venkatesh and Davis, 2000) and how effective they believed they were at teaching science (Enochs and Riggs, 1990). The Technology Acceptance Model (TAM) theoretical framework, provided by Venkatesh and Bala (2008) concerning technology use, served as a guide for both data collection and data analysis when conducting research around ESNs (see Figure 3). It is important to note that the TAM looked at both internal and external factors that influenced a teacher's decision concerning technology use.

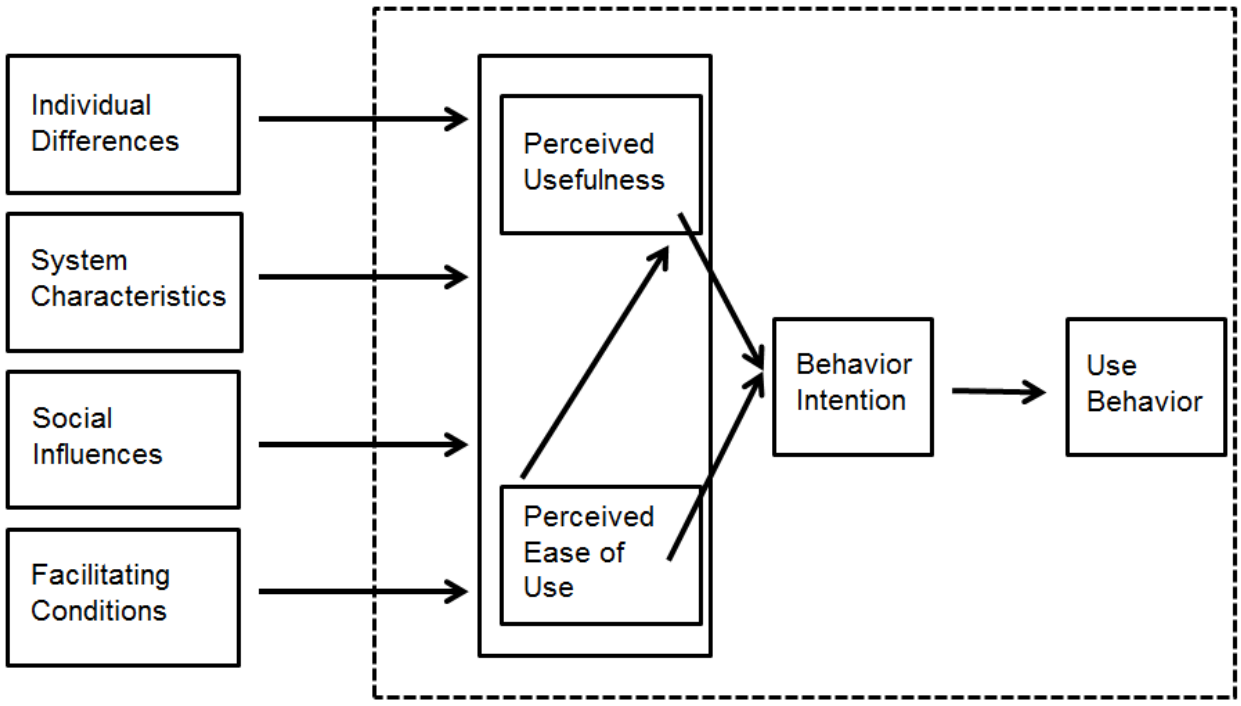

Figure 3. Technology Acceptance Model (TAM) (Adopted from Venkatesh & Davis, 2000).

Internal beliefs have the potential to impact the teacher's learning goals for his/her classroom. In general, the teachers' expectations for the learners' success played into how the lesson was structured (Jussim and Harber, 2005). This was also reiterated by Ng, Nicholas, and Williams (2010) in their discussion about the way beliefs evolved, as one gains experience, from being teacher-centered to student-centered. Specific to the use of technology, Kim et al., (2013) suggested that the way a teacher chose to integrate technology

related to a teacher's beliefs about the nature of knowledge and the effective ways to teach. Lastly, teachers self-reported that their overall passion for the technology and ability to problem-solve played a role in how successfully the technology was integrated (Ertmer et al., 2012). All of this is understood while also keeping in mind there was an incongruity between the "expressed" and "entrenched" beliefs held by teachers (Ertmer et al., 2012; Keys, 2005).

External factors influenced the way a teacher designed a lesson and implemented a technology or learning strategy. For example, the social norms or culture of the school affected the beliefs that were held by the teachers in that system (Meirink et al., 2009). It was shown that the administration at a school and the peer group that a teacher works had the greatest influence on a teacher's beliefs (Milner et al., 2012). In looking specifically at technology use by a teacher, the degree to which the technology was easy to use affected a teacher's decision to use it, mainly based on the time it took a teacher to plan a lesson involving the technology (Clark, 2006). When using technology, barriers (real and perceived) had a pronounced impact on a teacher's belief concerning its effectiveness as a tool (Kopcha, 2012). Barriers included a lack of training and/or professional development (Mouza, 2009), problems with student behavior (Keengwe & Wachira, 2010), or a time constraint (Kopcha, 2012).

Whether the influence was external or internal, the framework presented in Figure 1 allowed for discussion concerning the following areas pertaining to the impact of teachers beliefs on the use of ESNs: 1) how content knowledge influenced instruction, 2) how writing was used to improve student understanding of science content, 3) the role that technology

played in teaching science via writing, and 4) how technology and the teacher worked together to scaffold student learning.

Use of Writing to Teach Science

Writing, regardless of the field of study, has been shown to improve understanding, as it provided an opportunity for the organizing of ideas (Graham & Perin, 2007) and active construction of new understanding (Anders & Guzzetti, 1996). By allowing learners time to categorize their thoughts, there was potential to increase the degree to which they understood the subject (Bangert-Drowns, Hurley, & Wilkinson, 2004). When looking specifically at science, there was a push to improve upon the current level of instruction offered (CCSS, 2010). In doing so, elementary science had received more attention than had historically been the case. Given that research revealed writing improved content knowledge (Abell, 2006; Baker et al., 2008; Bangert-Drowns et al., 2004; Graham, Gillespie, & McKeown, 2013), it seemed appropriate that writing should became an integral part of science instruction in elementary classrooms.

When looking at the way science was currently taught in upper elementary classrooms, there existed a deficit in the amount of writing being incorporated (NEAP, 2012). Both policy decisions (McCarthey, 2008) and teacher-beliefs influenced how writing was incorporated into a lesson. In thinking of the influence of the teacher, it was important to note that only 1/3 of teachers, when asked, said they associated writing with learning science (Milner et al., 2012). Of those who attempted to use writing to teach science, they encountered problems, such as time to plan and assess the assignments (Baker, et al., 2008). Attempting to increase the amount of writing started with understanding how those policy

goals and barriers affected teacher beliefs and practices. Pearson, Moje, and Greenleaf (2010) stated that changing the lack of writing in science classrooms needed to start with a teacher understanding how beneficial writing was to learning, 2010).

Research continued to reiterate the benefits of integrating writing into science. Writing being a frequent part of inquiry-based classroom instruction has shown to increase student understanding in science (Cervetti, Barber, Dorph, Pearson, & Goldschmidt, 2012; Rivard & Straw, 2000). Rivard and Straw (2000) described writing in a way that focused on the thought process behind writing, similar to the idea of writing promoting metacognition. Mason and Boscolo (2000) connected learning gains with metacognition when they had an experimental (writing) group and a control group (no writing), both comprised of 4th graders learning about photosynthesis. They concluded that writing allowed students to be more meta-conceptually aware of their knowledge and how it changed, thereby improving students' understanding and allowing for greater conceptual change in the experimental group (Mason and Boscolo, 2000). Although a meta-analysis by Bangert-Drowns, Hurley, & Wilkinson (2004) showed only a small, yet positive, correlation between writing and learning, they did conclude that the gains were particularly prevalent when the writing promoted meta-cognition and implementation was sustained.

When thinking of how to use writing to teach science, one should consider how scientists use writing to carry out and practice science, and that these metacognitive processes should guide the implementation of writing in the context of teaching science. Scientists write in order to better formulate ideas, deeply consider hypotheses, or thoroughly reflect on findings. They also write to inform or persuade others and to share findings. Carter,

Ferzli, and Wiebe (2007) spoke of this as Writing in the Discipline (WID). They drew on the theory of situated learning (Lave, 1988) to show that authentic, genre-specific writing experiences (e.g., completing a lab report), led to an increase in students' comprehension of science when compared to those who wrote more generally, disconnected from any specific discipline (e.g., journaling or note-taking). In summary, this research provided broad support for teaching science through writing in discipline-specific ways, such as using science notebooks.

As an example of the use of writing to teach science that is counter to WID, writing across disciplines could also include students writing letters. When 11th grade students were given the assignment of explaining chemistry to 7th graders, those who were in the experimental group were better able to explain and articulate stoichiometry than those in the control classroom (Hand, Yang, & Bruxvoort, 2007). It was concluded that that type of writing required students to think in a metacognitive manner, which helped them better internalize and remember the content.

Of particular interest when thinking of ways that students can use writing to learn science is the scientific habit of sharing findings and persuading others through the use of argumentation, which is when evidence is used to support a claim. Argumentation is not solely carried out through writing, but when discussed here they are often discussed together. Beyond being cited in the standards (NRC, 2011), argumentation was shown to be beneficial to learning science (Cervetti et al., 2012). Currently argumentation isn't heavily tested, but its presence in science classrooms was increasing as it has continuously been shown to boost achievement (Ruiz-Primo et al., 2010).

In thinking about the ways writing and argumentation impact learning, it is also important to consider the role of teacher (McNeill, 2009)**.** Unfortunately, research revealed that teachers often struggle and encounter 'practical problems' when attempting to use writing frequently in their classroom (Baker et al., 2008), and writing in science class was often used as an assessment tool (Gunel, et al., 2007). Although providing feedback is essential to developing a student's writing skills, feedback was referred to as a time-intensive process (Gunel et al., 2007). Teachers self-reported that finding time to provide proper feedback was the great hindrance, as they struggled to respond to their students' writings in substantive ways (Abell, 2006). Feedback should not only be given as quickly as possible, but also it should be done in a manner that slowly increases the responsibility of the learner (van de Pol, Volman, & Beishuizen, 2011). This suggested the role of scaffolding was important in improving writing and learning.

To that end, technology can be a helpful tool for teachers and students, as it can assist with providing feedback and with scaffolding the students' writing. As mentioned above, writing and argumentation are both skills that require time, practice, advice and critiques. However, there was little research around the nuanced ways in which the scaffolding load was constantly shifting between the teacher and technology as a result of what happened in the classroom. In order to understand this better, research needs to take a deeper look at how an individual teacher's beliefs affect how the teacher and technology scaffold writing.

Technology Use in the Science Classroom

Technology was important not only in life outside of the classroom, but it had the power to improve learning outcomes in science class (Zacharia, Olympiou, & Papaevripidou,

2008). Similarly, it could be a valuable tool for students to use when practicing critical thinking and problem-solving (Kim & Hannafin, 2011). However, the focus on learning through technology was divergent from the historical view educators had about technology; once the focus was literacy *in* technology (Halpin, 1999), whereas in most recent work it was literacy *through* technology. As the role of technology in classrooms evolved, so did the way teachers understood and used technology. This echoed the need to better understand teacher beliefs concerning successful technology integration (Ertmer, 2005; Kim, Kim, Lee, Spector, DeMeester, 2013).

To provide examples as to the way technology has most recently been used, it is important to understand that students are often encouraged to become proficient at science and technology simultaneously. Varma and Linn (2012) showed that when students were allowed to observe and manipulate a virtual lab about global warming, the technology allowed them to achieve a higher level of interactivity with the represented phenomena, and as a result they were better able to understand the complexities of the scientific concepts. This technology-based simulation was an example of technology allowing for students to observe change on a different timescale, thereby making the viewed results of global warming available within minutes. Time was not the only variable that technology made more tangible for students, thereby making the concept more concrete to them. Technology was also used to increase student understanding around the topic of energy (Kulo & Bodzin, 2013) by affording students the chance to investigate a topic that might not be taught without the use of technology. Going back to the Kim and Hannafin article (2011), they acknowledged that evidence linking technology use in schools to problem-solving skills has

been scarce, and they commented on the challenges teachers faced as a possible reason for that lack of evidence. This, again, pointed to the need to understand teacher beliefs around technology.

There are barriers that interfered with technology being used properly in the classroom, and there was a connection between the degree to which teachers encounter barriers and the extent to which they used technology (Inan & Lowther, 2010; Mueller, Wood, Willoughby, Ross, & Specht, 2008). Potential barriers included: (1) the technology's ease of use (Clark, 2006); (2) the teacher's vision, beliefs, and level of perseverance (Inan & Lowther, 2010; Park & Ertmer, 2008) about overcoming obstacles presented by the technology; (3) the amount of time it takes to learn the skills necessary (Clark, 2006); and (4) the management of student behavior (Wachira & Keengew, 2010). The degree to which these barriers impacted the classroom was influenced by how the teacher viewed those barriers. In turn, teacher's perceptions were impacted by a teacher's current level of knowledge about how to use technology.

To better understand technology use in the classroom, Urhahne, Schanze, Bell, Mansfield, and Holmes (2010) took a thorough look into the teacher's role when technology was being used. The researchers looked at eight teachers who implemented one of four approaches for teaching in computer-supported environments. They concluded that the role of the teacher was too often neglected in educational research. Additionally, Urhahne et al. suggested five principles the teacher must consider if technology integration is to be successful. They stated, "For successful implementation of computer-supported projects, the teacher has to (1) envision the lesson, (2) enable collaboration, (3) encourage students, (4)

ensure learning, and (5) evaluate achievement" (Urhahne et al., 2010). The way a teacher viewed and applied each of those five principles was impacted by his/her beliefs concerning the role of technology and the teacher.

In addition to considering the pedagogical role of the teacher, implementing technology without the content knowledge needed to teach science was not successful in increasing student understanding of scientific concepts (Harris and Hofer, 2011). Perhaps this was partly due to the fact that teacher content knowledge was positively correlated to efficacy for teaching, in general (Newton, et al., 2012). It could also be the interconnectedness of technology, content knowledge, and pedagogy (Koehler & Mishra, 2005) that led to a synergistic outcome where the positive effects of technology-use and high content knowledge cannot be distinguished. Harris and Hofer (2011) explicitly mentioned things a teacher must consider when planning and integrating instructional technologies: "curriculum requirements, students' learning needs, available technologies' affordances and constraints, and the realities of school and classroom contexts" (p. 211). Although the components cannot be separated entirely, when teachers were planning a lesson that involved technology, research suggested teachers' decisions should be student-centered and focused on content foremost, and their secondary focus should be on how technology can support the activities used in that lesson (Graham, et al., 2012; Harris and Hofer, 2011).

In conclusion, combining technology with science is a logical combination in primary school, in that it allows for teachers to implement rich learning tasks around inquiry through technology; however Stein, Ginn, and McDonald (2007) warned that if technology was introduced when teachers had a limited understanding of inquiry, both technology and

science were neglected. One way of using technology to teach science has been through dynamic graphical elements (i.e. simulations) that students can interact with (Anderson and Slough, 2012) or Electronic Science Notebooks (ESNs) that monitors the student's answers and then prompt the students to review predictions and compare those to results (Leonardo Project, 2011). The crucial element to technology integration is to making sure the technology offers something beyond the "non-technological" version of itself. How is the graphical image via technology *better* than one printed in a textbook? How is an ESN *better* than a paper notebook? For this research, the element of sophistication offered by technology is the scaffolding provided by the technology above and beyond the paper form. In this case the technology met the student where he/she was currently performing and enabled them to understand concepts within their individual Zone of Proximal Development (ZPD) (Vygotsky, 1978). For example, writing could have been taught via scaffolding through technology with that software programmed to look for a certain level of accuracy or key words in a student's answer. The software could then prevent the student from advancing to the next step or prompt the student to answer more thoroughly before he/she can move on to the next question. That would allow students to think critically about what they learned in order to explain it in writing. By being prevented from moving on before giving a satisfactory answer, understanding became the goal rather than simply completing the assignment.

Rationale

It was commonly discussed in the research literature that a gap existed between what research revealed what happened in practice in the classroom (e.g., DiGisi, 1999). Professional development (PD) can be a valuable tool for closing that gap. This study looked to see how professional development could take into account a teacher's beliefs about technology, scaffolding, and writing in science. In the past decade there have been numerous studies looking at professional development around technology-use, such as one that found 'teachers' personal subject construct knowledge' influenced how they viewed technology in general (Stein, et al., 2007). Stein et al. (2007) went on to discuss that limited knowledge and limited time practicing necessary skills contributed to the struggles experienced as technology was being used. In response, they designed a model that emphasized how PD could best serve the teacher; their model combined three types of experiences: reflective, theoretical, and practical. Although studies about writing to learn in the context of science exists (Mason & Boscolo, 2000; Nam, et al., 2010), there remained a gap in the literature pertaining to the role that teacher beliefs and professional development played on influencing effective instructional practice supporting students' writing to learn science in elementary school.

Across many curricula and age groups action research has shown to provide desired outcomes from Professional Development (Cullen, Akerson, & Hanson, 2010; Mamlok-Naamon & Eilks, 2012; Royer, 2002). Furthermore, the research-based revelations about struggles proved to be just as helpful as the research that showed success (Kennedy, 2005; Schlager & Fusco, 2003). One of the most promising articles about how to successfully

conduct PD took the angle of treating decisions made about teaching as a form of inquiry itself, thereby making professional development and reflection and form of action research (Cullen, Akerson, and Hanson, 2010). This viewpoint benefited teachers and students by helping teachers conceptualize how to make observations and draw conclusions about their teaching, and in doing so they were practicing inquiry process they wanted to teach to their students.

Research has suggested that Professional Development, in general, does not work if it fails to take into account the teacher's needs prior to implementing the PD. Van Driel, Beijaard, and Verloop (2001) said it was helpful to know a teacher's current "knowledge, beliefs, and attitudes" when designing PD. The needs of elementary school teachers varied among individuals, and professional development best served teachers when their beliefs informed the PD (van Driel, Beijaard, and Verloop, 2001). Some teachers lacked confidence in their content knowledge (Hill, 2009), and others struggled with how to implement technology well (Kopcha, 2012; Polly, 2011). Additionally, some teachers were unsure how to use writing as a tool for learning science content (Graham, Gillespie, and McKeown, 2013). Regardless of whether the struggles resulted from internal sources or are caused by external factors, those needs contributed to the unique profile for each teacher. Above all, PD needs to be efficient at identifying and addressing those needs. More specifically, Capps, Crawford, and Constas (2012) stated that PD needed to meet the teachers where they were at, while not making the teacher feel like their time was being spent learning something they do not believe they needed. More often, a successful PD existed when the teacher felt he/she

could express his/her feelings about what is needed, rather than just being told in a workshop-like setting (Braaten & Windschitl, 2011; Fullan, 2007; Kopcha, 2012).

Teachers were the ones making the everyday decisions that had the biggest impact on students' success (Gess-Newsome, et al., 2003), and decision-making occurred at the classroom level (de Jong, 2012). Teachers opted for using existing materials available in their classroom and made teaching decisions based on their own pedagogical view; they did this rather than implement some elaborate or robust teaching tool they perceived as too difficult to implement (Braaten & Windschitl, 2011). In addition to those internal choices, it was helpful to know the external factors, such as what materials they had available to them. The barriers that played into how teachers designed a lesson included those external and internal factors. Identifying those barriers for each individual was a priority in designing a successful PD (Buczynski & Hansen, 2010).

Research also demonstrated, just as proper scaffolding for students aid in learning (van de Pol, et al., 2011), the same was true for teachers as they acted as the learners (Webster-Wright, 2009). The concept of scaffolding was not only important to consider when developing PD, it was an important subject to address during the PD, as the teachers will be in the classroom providing the scaffolding for their students. In addition to teachers providing scaffolding, the ESNs served as a pedagogical agent by providing scaffolding directly, thus creating a need for the teacher to strategically think about how to synchronize their support with that provided by the technology. This all justified the use of the three frameworks: TPACK, TAM, and Teacher Beliefs.

METHODOLOGY

Introduction

This study was a mixed methods case study, during which data were collected through interviews and observations in order to better understand a teacher's classroom practice and stated beliefs. A majority of the data was qualitative; however, quantitative data (e.g. Likert scale scores and frequency counts) were also analyzed. The decision to use a mixed methods approach was informed by the work of Greene, Caracelli, and Graham (1989), where they discussed the notion of complementarity. Complementarity in the context of this study means that the quantitative analysis was done to elaborate upon and illustrate the findings of the more-abundant qualitative data. Additionally, Bryman (2006) discussed using the mixed methods approach for the sake of providing diversity and utility in applying the findings—supporting the decision to analyze the data qualitatively and quantitatively in this case study. By discussing the qualitative data, the findings demonstrated the complex nature of how teacher beliefs impact science instruction. The quantitative data allowed for classroom practices to be quickly discussed and succinctly analyzed.

Case studies are used to explore an issue or a phenomenon that is bounded by factors (i.e., setting, context, time) (Creswell, 2003). While Creswell (2003) and Yin (2003) chose to view case study research as a methodology, Stake (2005) did not. Stake (2005) believed it to be a choice concerning what is studied rather than a comprehensive research strategy. This study more closely aligned with Creswell's and Yin's definition in that it consisted of collecting detailed information from multiple sources, and analysis was done in order to find themes or patterns (Creswell, 2003). In this study, the cases were bound by teaching science

via an ESN (activity) in 4th grade classrooms (setting) over the course of the 2013-2014 school year (time). For this research, how teacher beliefs varied between teachers and evolved over time, and the impact of these beliefs on science instruction were of particular interest when examining these cases.

This study consisted of three phases: design, collection, and analysis. In addition, there were two phases to the analysis portion of the study. The design of this study was qualitative in that the three research questions were asking for qualitative conclusions. While qualitative data were collected in the form of teacher interviews and class observations, the data were then analyzed quantitatively (e.g., frequency counts for specific events) (Teddlie & Tashakkori, 2006). This type of analysis was described by Miles & Huberman (1994) as a way to use the same data source in multiple ways. The design, collection, and analysis therefore combined to classify this study as a mixed methods case study.

Mixed methods case studies can look very different from one another (Tashakkori & Teddlie, 2003). Some are fixed while others are emergent (Morse & Niehaus, 2009), which has to do with whether or not the study was originally intended to be a mixed methods study or whether the need emerged during analysis of the data. This study was considered an emergent mixed methods study because the final modes of analysis were not set until after an initial review of the data. Tashakkori & Teddlie (1998) discussed that mixed method studies typically have a dominant and less-dominant type. In the current study, the quantitative data made up a smaller (i.e. less-dominant) component. Concerning timing, studies can be concurrent, sequential, or multiphase (Creswell, 2003). For this study, a sequential design was used to analyze data collected concerning teacher beliefs. More specifically, this

research utilized an exploratory sequential design because the qualitative data collection and analysis led up to the data being analyzed quantitatively, all of which combined in order to produce the final interpretation of the data.

Study Context and Overview

This study took place during the course of one school year (2013-2014), while fourth grade teachers were implementing ESNs as participants in the Leonardo Project. The Leonardo Project was a multistate research project exploring the use of technology as a pedagogical agent. The Leonardo Project provided graphically-enhanced electronic science notebooks to students as a tool to support the inquiry process and promote the use of written scientific argumentation.

The purposes of this study were to: (1) understand how a teacher's beliefs affected how they scaffolded technology, writing, and inquiry, and (2) to apply this understanding for the purpose of improving Professional Development. As a part of this project all of the teachers attended a workshop, in October of 2013, during which they received professional development concerning how to navigate the software and deploy the technology. By studying each teacher in depth, they became the unit of analysis (Merriam, 2002), making it easier to understand how one's beliefs about science, teaching, writing to learn science, and using technology influenced what happened in their classroom.

Participants

Yin (2009) stated that candidates should be selected based on operational criteria. The operational criteria for this study were that candidates: (1) teach fourth grade, (2) be willing to allow for observations during pre-determined units, (3) be able to attend the PD

opportunity on October 5, 2013, and (4) be willing to be interviewed before and after the ESN implementation, which totaled more than two hours of interviews for each teacher. There were a total of thirty-one teachers participating in the larger study, but a "purposeful sampling," (Creswell, 2007) was done, based on the operational criteria; to narrow the case study participates to five individuals. Because beliefs can be heavily influenced by external contextual factors, using teachers from different districts was intentional, and because experience shapes beliefs, teachers with varying degrees of experience were selected. Additionally, these teachers were selected based on when they planned to teach the magnetism and electricity curriculum, as the classroom schedule dictated the observation schedule.

The five teachers in this study came from four elementary schools across two counties (See Table 2). Dana and Sam (pseudonyms) were in County X, which is a rural county. Dana taught at Elwood Elementary (pseudonym), and Sam taught at Riverdale Elementary (pseudonym). Taylor, Riley, and Emerson (pseudonyms) were teachers in county Y, which is also predominately rural. However, there was a great deal of difference between the two schools located in that county; Taylor taught at Mansfield Elementary (pseudonym), which had a majority of English-language learners while Riley and Emerson taught at Jackson Elementary (pseudonym), where there were fewer English language learners. It is important to note that Taylor and Riley had previous experience with working with ESNs through The Leonardo Project whereas Sam, Dana, and Emerson were new to Leonardo.

Data Sources and Collection

In order to address the research questions, three types of data were collected. Semi-structured interviews were given prior to the implementation of ESNs (baseline interview) and after implementation (follow-up interview) of the ENSs. The structure of these interviews was guided by the Technology Acceptance Model framework (Venkatesh & Davis, 2000) and the Technological, Pedagogical, and Content Knowledge Framework (Mishra & Koehler, 2007). The STEBI (Science Teaching Efficacy Belief Instrument) questionnaire, administered with a 5-point Likert scale (Likert, 1932), was used to assess a teacher's efficacy concerning teaching science in general (Enochs & Riggs, 1990). The STEBI was completed before and after the ESN implementation. Classroom observations were documented using a modified GEES (Graphically-Enhanced Elementary Science) protocol (GEES Project, 2011). This protocol captured specific aspects of a classroom using ESNs, supplementing detailed notes that were taken during the observation as well. The notes served to capture the overall setup, design, and implementation of the lesson. Figure 4 provides a look at the data collection phase of this research study. The collection is arranged in three columns in the order the data was collected.

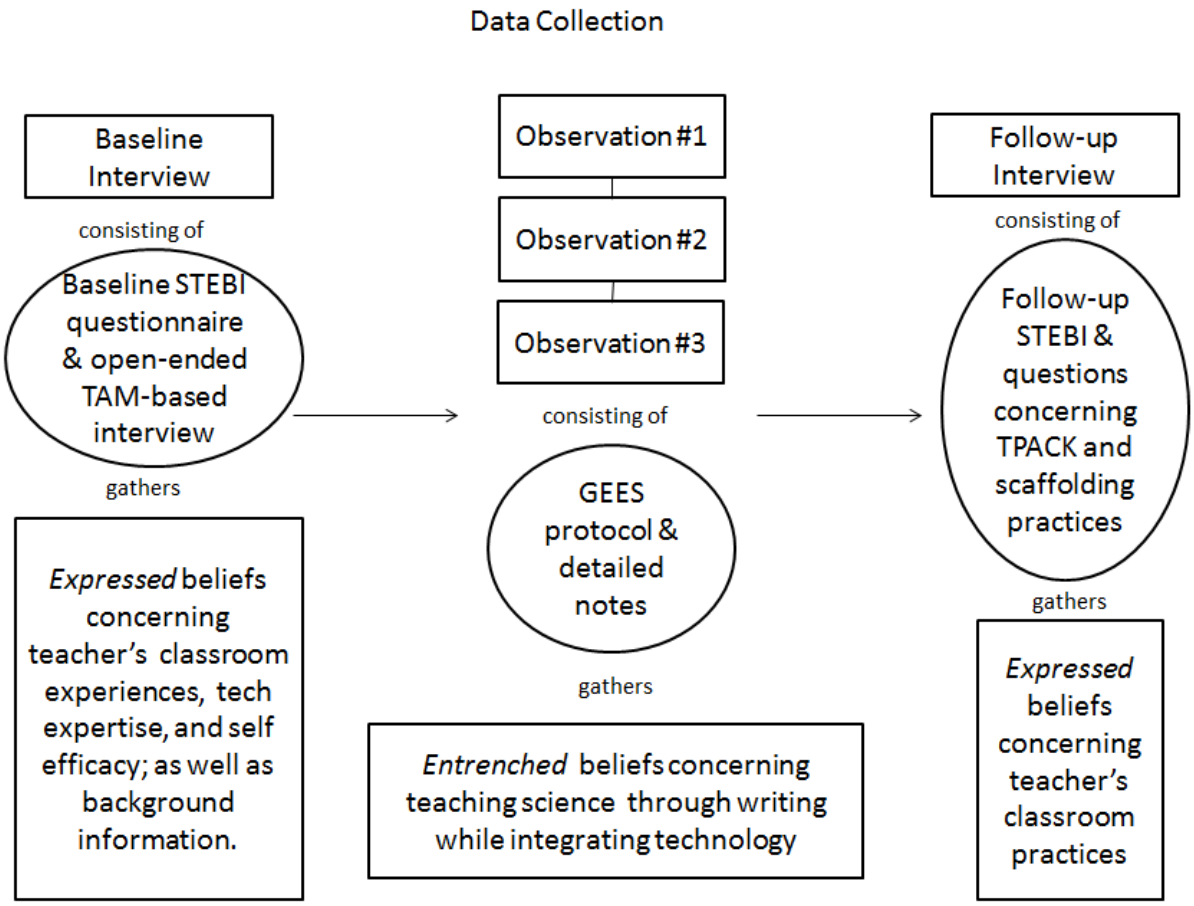

Figure 4. Data Collection Phase of the Research.

Interviews. Yin (2009) noted that interviews were an important component to case studies, and for this study the interviews conducted with teachers helped shaped the understanding of how their beliefs, influenced by internal and external factors, shaped the planning process and classroom procedures. The open-ended questions for the baseline interview and the follow-up interview were pre-determined, and each teacher was asked the same set of questions, but phrasing and order was changed as the interview unfolded in order

to be responsive to the interviewee's replies. No questions were omitted, but teachers were asked to elaborate at times. The interview procedure aligned with qualitative research practices outlined by Merriam (2002).

The interviews were conducted before (baseline) and after (follow-up) the implementation of the ESNs in order to document how the teacher's beliefs may have potentially evolved as a result of teaching with the ESNs. Interviews provided information about a teacher's: (1) expertise concerning technology in general, (2) expertise concerning technology to teach science, (3) use of science notebooks, (4) and writing to teach science, and (5) perceived norms. There were a total of 47 questions in the baseline interview, asking about what happens in their classroom, their expectations and support from the schools and district, as well as other perceived barriers they encounter. Also, as part of the follow-up interview, teachers were asked to assess their science content knowledge, the role they believed technology played in their classroom, and their overall pedagogical beliefs. The follow-up interview consisted of five open-ended questions. The questions asked during the baseline interview and for the follow-up interview can be found in Appendix A and Appendix C.

The baseline questions were guided by a Venkatesh and Davis (2000) article on technology acceptance and by a Kopcha (2012) article that discusses perceptions of barriers around technology-integration. In the Venkatesh and Davis (2000) paper, the researchers asked individuals to assess their experience, understanding, and current use surrounding technology by using Technology Acceptance Model (TAM) as the framework. In that research design, the model looked at four influences of technology acceptance: individual

differences, system characteristics, social influence, and facilitating conditions. The Kopcha (2012) article looked at the barriers that teachers perceived when attempting to integrate technology, and therefore some of the baseline questions asked teachers to identify those barriers.

In addition to the open-ended questions, teachers were also asked to identify, on a 5-point scale, their level of agreement with statements regarding their science teaching, efficacy, and outcome expectancy. The STEBI was originally used in the research conducted by Enochs & Riggs (1990). The goal of the original researchers was to use the STEBI to improve elementary education by increasing teachers' awareness of not only their self-efficacy, but also their outcome expectancy. Outcome expectancy refers to how much control a teacher believes he/she has concerning student learning (Enochs & Riggs, 1990). For this study, the STEBI was given to teachers prior to their use of the ESN (baseline STEBI), and they were asked to complete the same questionnaire following the implementation (follow-up STEBI), and any differences were addressed during the follow-up interview. This STEBI questionnaire can be found in Appendix B.

The baseline interview, follow-up interview, and STEBI provided data to answer the first research question, "What are teachers' self-reported beliefs that influence their pedagogical decisions concerning writing and technology use to teach science?" The second research question, "How do these beliefs manifest in the classroom through established learning goals, use of instructional strategies, and/or implementation of ESNs?" was answered by analyzing the data collected during the observations.

Observations. Data in the form of observations was collected in order to provide a detailed account of how classroom instruction unfolded; in particular, how the lesson played out while the ESNs were being used. In order to collect data in a uniform manner across classrooms, a protocol was used. The modified GEES protocol (GEES Project, 2011) used to guide classroom observation included: a synopsis of the lesson, a description of how the lesson starts and concludes, documentation of the instructional modes and the materials used, and excerpts of notable dialogue (see Appendix C). In addition to the GEES Protocol, supplemental notes were taken, with particular attention given to the role the teacher played in scaffolding technology, in general, and the way the teacher and the technology scaffolded the students' writing. Although the researcher was present for a majority of the days that the ESN was being used, three days for each teacher had the GEES protocol completed.

Data Analysis

Figures 5 and 6 represent the data analysis phases of the study. The first phase of data analysis took place at the intra-teacher level (Figure 5), and the second phase of the data analysis divided teachers into two distinct cases (Figure 6). Further detail concerning the first phase of data analysis (Figure 5) can be found following the figure.

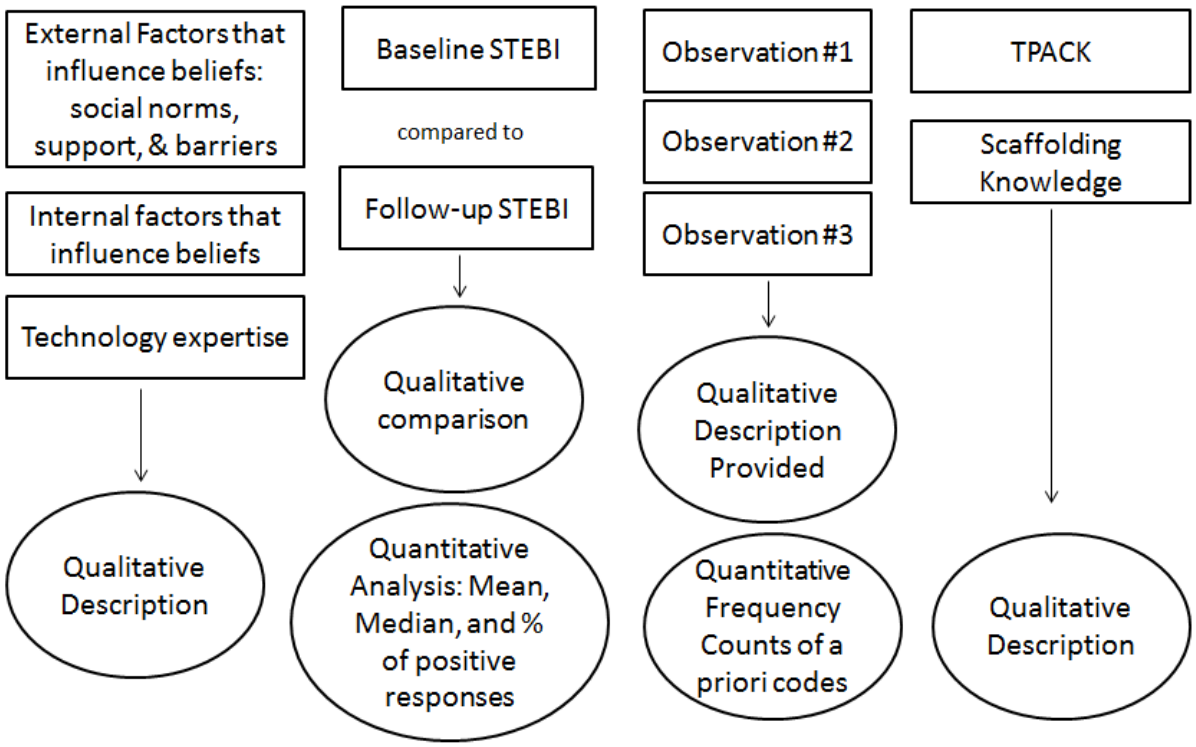

Figure 5. Phase One of Data Analysis.

Interviews. In case studies, it is important to form thick, rich descriptions of the data. The first data analyzed were the responses to the baseline interview questions. This was done in order to answer the first research question concerning a teacher's expressed beliefs. The baseline interview gathered background information on individual teachers and asked teachers to self-assess their technological knowledge, potential barriers, and expectations from the district. This data was collected in order to gain an understanding of the beliefs

these teachers held and the external and internal factors that may drive those beliefs. Analysis of this data was done by summarizing the interview at length, and that summary was then further summarized in order to provide a succinct look at the following themes: social norms, barriers, and support. The follow-up interviews were also organized into the themes based on the teacher's knowledge concerning: technology, pedagogical, and content. As previously noted, both the TAM and TPACK theoretical frameworks guided this thematic development.

Analysis of the STEBI. Following the analysis of the baseline interview, the STEBI data were analyzed. The first step in analysis of the STEBI was to reverse code negatively worded items so that an overall summary score could be generated from an average of items. In addition to reverse coding negatively worded items, the questions were grouped and coded for two different areas of teacher beliefs: outcome expectancy and efficacy. These two constructs were identified by Enoch and Riggs (1990) as part of the development of the STEBI. This grouping by construct can be seen in Table 1.

Table 1. Coding of the STEBI questionnaire.

Question	Direction	Category
When a student does better than usual in science, it is often because the teacher exerted a little extra effort.	Ascending	Outcome expectancy
I will continually find better ways to teach science.	Ascending	Efficacy
Even if I try very hard, I will not teach science as well as I will most subjects.	Descending	Efficacy
When the science grades of students improve, it is often due to their teacher having found a more effective teaching approach.	Ascending	Outcome expectancy

Table 1 Continued

I know the steps necessary to teach science concepts effectively.	Ascending	Efficacy
I will not be very effective in monitoring science experiments.	Descending	Efficacy
If students are underachieving in science, it is most likely due to ineffective science teaching.	Ascending	Outcome expectancy
I will generally teach science ineffectively.	Descending	Efficacy
The inadequacy of a student's science background can be overcome by good teaching.	Ascending	Outcome expectancy
The low science achievement of students cannot generally be blamed on their teachers.	Ascending	Outcome expectancy
When a low-achieving child progresses in science, it is usually due to extra attention given by the teacher.	Ascending	Outcome expectancy
I understand science concepts well enough to be effective in teaching elementary science.	Ascending	Efficacy
Increased effort in science teaching produces little change in students' science achievement.	Descending	Outcome expectancy
The teacher is generally responsible for the achievement of students in science.	Ascending	Outcome expectancy
Students' achievement in science is directly related to their teacher's effectiveness in science teaching.	Ascending	Outcome expectancy
If parents comment that their child is showing more interest in science, it is probably due to the child's teacher.	Ascending	Outcome expectancy
I will find it difficult to explain to students why science experiments work.	Descending	Efficacy
I will typically be able to answer students' science questions.	Ascending	Efficacy
I wonder if I will have the necessary skills to teach science.	Descending	Efficacy

Table 1 Continued

Given a choice, I will not invite the principal to evaluate my science teaching.	Descending	Efficacy
When a student has difficulty understanding a science concept, I will usually be at a loss as to how to help the student understand.	Descending	Efficacy
When teaching science, I will usually welcome student questions.	Ascending	Efficacy
I do not know what to do to turn students on to science.	Descending	Efficacy

Once the STEBI information was coded and grouped by construct, it was analyzed qualitatively and quantitatively. Quantitatively, direction was taken from Wenner (2001), where they looked at the percentage of positive responses to the STEBI prompts. Mean and median were also provided for the STEBI: (1) as a whole, (2) for the efficacy items only, and (3) for the outcome expectancy items only. Qualitatively, a comparison of the responses was provided in terms of how the responses changed and to what degree.

The second research question was answered by looking at the observational data. In order to analyze the observational data, *a priori* codes were established using the GEES protocol, found in Appendix C. Tallies were made of key observed events and frequency counts were used to analyze that data. The frequency counts illustrated how the lesson was taught (i.e., mode of instruction) and what materials were used. This was done in order to see how the teacher and technology interacted, as well as how the teacher interacted with the student and with the ESN technology. In addition to providing a quantitative look at unfolded in the classroom, a narrative of the lesson was developed. The narrative focused on the

teacher's interactions with the technology, students' interaction with the technology, and the teacher and technology balance during the lesson. Analysis of the observational data was instrumental in doing two things: (1) answering the second research question and (2) providing an emergence of two cases used for the second phase of analysis. Those two cases were examined in the second iteration of analysis in order to provide additional information when discussing the third research question.

Phase 2 of Data Analysis. Once the first two research questions were answered, it was used to guide a re-framing of the cases (teachers). After the first phase of analysis, the classroom observational data appeared to be dichotomous, in that those who were using Leonardo for the first time shared the pedagogical role with the technology differently than those who had prior experience with Leonardo. Figure 6 shows how data were analyzed during the second phase of data analysis. Case A consists of those new to Leonardo, and Case B represents those who were returning.

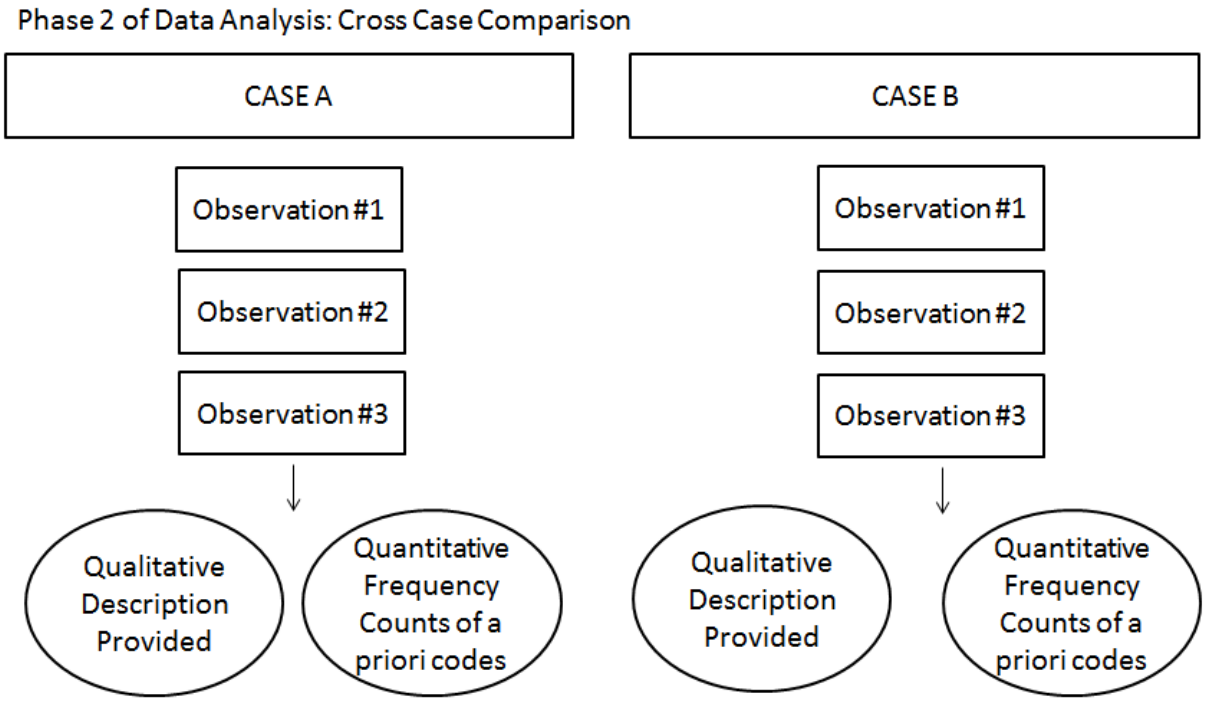

Figure 6. Phase 2 of Data Analysis.

The Role of the Observer

As a predominantly qualitative study, this took place in a naturalistic environment, where the researcher was immersed in the culture of the classroom, intervening or interfering as little as possible. The researcher spent time in the classroom prior to the implementation of the ESNs, in order to overcome the novelty effect (Phipps & Merisotis, 1999). The research was able to examine the issue of technology and writing to learn science in an intimate

fashion, and understanding the intricacies of the classroom helped capture authentic data. Yin (2009) suggested caution should be taken concerning: (a) bias, (b) conflict between roles and responsibilities of the researcher and the teachers, and (c) time management in those roles.

Limitations

There are limitations to this study. Generalizations cannot be made with case studies. All implications concerning PD can only be applied to the teachers in this case study. Also, education research requires working within the confines of the classroom and school system, which at times can be unpredictable. Additionally, results are influenced by the biases of the researcher.

FINDINGS

Analysis of the data took place in two phases in order to discuss three research questions. During the first phase, the first two research questions were answered through the development of five individual cases. Those two questions ask about teachers' expressed beliefs and how those beliefs manifested themselves in the classroom. In order to answer those two questions, the data was analyzed at the individual teacher level. Table 2 lists the teachers and schools which make up the cases. The data sources include: baseline interview, baseline STEBI, classroom observations, follow-up interview, and follow-up STEBI. A background on each teacher is provided below with information on his/her teaching experience, science expertise, technology knowledge, and current understanding of the school and district they work in. That information will be followed by findings from the first phase of data analysis, where each individual teacher represents a case. In order to provide a recapitulation of data found in the interviews and classroom observations concisely, a summary at the end of each case will synthesize the information into themes that emerged. The themes which cut across cases will be discussed at greater length in Chapter Five.

Through this preliminary pass of the data, two cases emerged while analyzing the classroom observations. This second phase of data analysis focused solely on the classroom observations and a cross case comparison carried out between two emerging groups of teachers. This was done in order to answer the third research question pertaining to professional development. The first grouping, Case A, consists of Dana, Sam, and Emerson who were implementing an ESN for the first time. Case B consists of Riley and Taylor who

were returning to the Leonardo Project; they had used the software and technology during the previous school year.

Introduction to the Five Individual Cases

Before providing background details on the individual teachers, the relationship between them will be explained. Dana and Sam teach in the same county but at different schools. The county is considered rural. Sam's school is a high performing school. Taylor, Riley, and Emerson teach in the same county, which is also a rural county. Taylor is at a school with a high ESL population. Riley and Emerson teach at the same school, directly beside one another. Table 2 offers a quick look at the relationship (pseudonyms are used).

Table 2. Teachers by County and School

Teacher	County	School	Years of Experience	Board Certified
Dana	X	Elwood	<1	No
Sam	X	Riverdale	18	No
Taylor	Y	Mansfield	8	No
Riley	Y	Jackson	16	Yes
Emerson	Y	Jackson	>30	Yes

Case 1 – Dana

At the time of the study, Dana was in her second month of teaching. She was hired a few weeks after the start of the school year, and due to her limited time in the classroom she wasn't able to provide many examples of how she taught science. With a Master's degree in Elementary Education, Dana felt somewhat prepared, but it is important to note that once she was hired, the only preparation she received from her district was being handed a red

notebook. She saw the Leonardo project as a way for science instruction to be modeled in order to improve her own instruction, but her lack of technological knowledge made it difficult to problem-solve in the event there was an issue. In addition, Dana was an incredibly calm teacher, who spoke softly and showed a great deal of patience with students, and with a small class of less than 15 students, her quiet demeanor worked well as keeping the students quiet as well. Dana's lack of familiarity with the district expectations meant she was only able to speak to what she understood to be the expectations of the administration at her school. Most of this she understood as a result of her fellow 4th grade teachers. Dana taught with four other 4th grade teachers, and the four of them, including Dana, co-taught in order to reduce the planning load. Co-teaching required Dana to teach some subjects, such as science and social studies, twice, but it eliminated some subjects from her teaching load. She stayed in the same classroom throughout the day, and the students rotated to make the scheduling possible. Concerning the use of ESNs in her classroom, she has no reservations but also no real expectations. She only expressed gratitude for the planning load being taken off of her for a while, and she was optimistic that her students would learn from the experience.

Case 2 – Sam

At the time of the study, Sam was veteran teacher in her 18th year. In addition to longevity in the classroom, she was the main science instructor for 4th grade, and the school's unofficial technology specialist. Sam graduated from East Carolina with a degree in Child Care Services in 1996 (now known as Early Childhood Education). It was through the course of her work in the classroom that she became knowledgeable in higher elementary pedagogy and technology-integration in the classroom. She noted that her eventual plans were to land a

position as an IT coordinator at a school or a remediation specialist. In addition to technological knowledge and content knowledge, she excelled in classroom management. Students were very aware of the routine, and no teacher intervention was typically required if students finished a task early; they quietly read while waiting patiently. Sam has worked at other elementary schools in the district, and she not only understood the expectations from the district, she was also helping create them. She was in the process of planning for the initial meeting of a focus group, whose purpose was to establish county-wide pacing guides and standards from elementary science. Sam prided herself in the way she and the other teachers collaborated. She team taught with the teacher next door, and they were given a great deal of autonomy from the principal. At the time of the interview she had not attended the PD in preparation for Leonardo, but she was interested in participating for two reasons: 1) she was quite tech-savvy so she thought she would be the ideal person to pilot it for her grade level and 2) electricity and magnetism were her least favorite science topic to teach so she welcomed help, and to not have to lead the instructions for these units.

Case 3 – Taylor

At the time of the study, Taylor was in her eighth year of teaching, and she was just finishing up her Master's degree. She missed a day of school during the time of the ESN implementation because she was attending her graduation. Her content knowledge and technological knowledge could both be considered high, which helped with the implementation of the software. Her ongoing challenge was classroom management. Her students entered the classroom struggling with reading and behavior, and she worked hard to overcome those deficits. The 4th grade teachers collaborated together often, and Taylor and

one other peer are considered the teacher leaders of that grade. She seemed to understand the expectations of the district and school, but she was not satisfied with the way teachers in that county were supported. Although she is not a veteran teacher, she is a veteran of the Leonardo project. She is quite familiar with the content, the software, the iPads, and the expectations of Leonardo. She chose to participate in the project again because she approved of how the ESN promoted scientific argumentation, and believed it helped her low SES students be exposed to this new technology.

Case 4 – Riley

At the time of the study, Riley was in her sixteenth year of teaching, and had spent the duration of her career teaching fourth, fifth, and sixth grade. She has a deep understanding of the content, and models scientific learning when she teaches. She is comfortable with the use of technology, in general, and when teaching. In addition she attends professional development sessions when they are offered around technology, and has become a lead teacher at her school, delivering the professional development to her peers. She manages a classroom by establishing clear guidelines and high expectations; she is firm and consistent when students are not compliant. She plans and socializes with other fourth grade teachers, especially during lunch when her room is where all fourth grade teachers gather. She is not new to Leonardo so her expectations are for it to run smoothly and for her to play a more present role in delivering the content. She is thankful to not be the first teacher to implement during the school year, as she was the previous year because she felt like she spent too much time trouble-shooting the program and hardware.

Case 5 – Emerson

At the time of the study, Emerson was in his 30th year of teaching, and at his current school for twelve years. He earned a degree from UNC-Wilmington in Elementary Education, and a Nationally Board Certified Teacher. His classroom procedures were well-established, and he is strong in both content knowledge and pedagogical knowledge. Although he would not identify himself as a tech-savvy individual, he frequently used the SmartBoards™ in his room because of the encouragement from the administration to do so. Although Leonardo was implemented at his school last year, this is the first year he was a part of the project. He decided to participate this year because Riley spoke highly of the program, and he was also interested in improving the way he uses science notebooks in his classroom.

Phase 1 of Analysis: Teachers as Individual Cases

The first two research questions are answered by looking at the teachers as individual cases. Two tasks are accomplished through this process: (1) expressed and entrenched beliefs are observed, and (2) any emerging themes are identified in order to inform the analysis of the data concerning the third research question.

Research Question 1. The first research question is, "What are teachers' self-reported beliefs that influence their pedagogical decisions concerning writing and technology-use to teach science?" Figure 3 of Chapter Two shows the factors that intersect to influence a teacher's beliefs and practice concerning technology. These factors are also applied to teacher beliefs and practices concerning writing. To improve analysis and discussion, the external factors were divided into three categories: social norms, supports, and barriers. The internal factors that influence beliefs are explored through the open-ended questions and the STEBI. Below are the findings that relate to the first research question, and they are presented in the following order: open-ended questions from the baseline interview, baseline STEBI, follow-up STEBI, and open-ended questions from the follow-up interview. They are discussed at the individual teacher level then thematically synthesized.

Case 1 –Dana

As a beginning teacher, Dana was still learning about what was expected of her and what she needed to do in order to be successful. She answered questions based on her currently level of understanding, but she was clear to point out that she was still unclear about a lot of details.

Baseline interview. Dana's baseline interview took place in her classroom on October 23, 2013. Given Dana's lack of experience as a classroom teacher, she was hesitant answering some of the open-ended questions in the baseline interview concerning what her district or school expected. She was still learning about her school and district, so when asked about expectations and support, she would often start her responses with, "I think…" Also, when asked about specifics concerning how internal and external factors impacted her classroom she spoke about what she was planning to do, not what she actually did. This is because at the time of the interview, she had previously taught only one unit of science.

External factors. The external factors that influence Dana's beliefs are divided into three categories: social norms, support, and barriers. There were three subtopics within each of the three categories. The first subtopic is "teaching science." Concerning social norms around teaching science, Dana stated that she planned often with one other teacher who taught science. For their most recent science unit, earthquakes, students, regardless of which teacher was facilitating the lesson, would have received a very similar set of lessons. Dana commented that she did a lot of the preparation in order to teach the lesson [e.g. make pans of Jell-O] but it was the other teacher who paced the lessons. Dana mentioned the pacing guide numerous times throughout the interview. Pacing in the classroom was always based on the objectives listed in the 9-week plan as seen on the county-wide pacing guide. Dana made it clear that a teacher can change the order of events as he/she deems appropriate, but for each 9 weeks, he/she must work with specific objectives, and all teachers are expected to have common assessments and benchmarks Dana understood that to mean all teachers throughout the county, but she wasn't sure how that was possible. When asked about expectations for

how much time and focus science receives, Dana said, “If we are not getting a concept in math that day then, unfortunately, sometimes we don’t get to do science.” Here, like at most schools in North Carolina, science is not a protected subject. When asked about using the designated math time to teach science, Dana said, “They would not approve. I don’t know.”

In shifting to think about the social norms that Dana’s students may experience concerning science, Dana noted she was displeased with the lack of sophistication in the science lessons. She remarked on how different it [learning science] was compared to when she was a student, and she spoke of the things she wished the students could be exposed to – equipment and the thought-process of solving problems. Neither Dana nor her colleague, who had been teaching for four years, was familiar with science notebooks. Dana did reference a science learning log, and when asked to describe the learning log, it appeared to be used like that of a science notebook. She discussed this further and compared it to the ESN made available through Leonardo and confirmed that there appeared to be little difference in the learning log and a science notebook, merely a difference of naming.,

Concerning the social norms concerning technology, Dana spoke about how the school pushed for increased technology use, and she stated that this emphasis was, “definitely seen in the upper grades.” As far as expressed expectations from the school administrators, they were broad. For example, Dana said the administration expects it to be used “in each of [the] lessons; now to what degree, I think that varies.” Although barriers are explicitly addressed later on, when speaking about social norms, Dana frequently referred to barriers when asked about norms. She commented that, “unfortunately teachers don’t have the technology they need to teach science.” She went on to say that, “watching videos online

is as tech-savvy as its gets." Furthermore, the equipment in her room was limited; she had three computers, a document camera, and a SmartBoards™; however the SmartBoards™ did not work at the time. She had reported this issue, and because they share a technology coordinator with other schools, it was likely take a few days for this to be fixed.

Finally, social norms concerning writing are mentioned, and although Dana does not teach the ELA section for her students she said, "Writing is always there. It gets more emphasis than anything else." Writing is expected to cross into each subject that is taught. That expectation is a norm of the school. Dana often incorporates writing into the science lesson. When asked for further clarification on how she uses writing to teach science, she commented on it promoting "critical thinking." She was not able to elaborate further, such that writing did not seem to be specific to science other than the prompt may have been about the science lesson. She also stated that sometimes the focus is on "writing in complete sentences and making complete thoughts." She did not mention writing that was specific to the genre of science.

In addition to the external factor of social norms, the support that teachers receive also influences their beliefs. Dana recently started teaching, so she should be noted that she is likely not as aware of the support offered by the school and county as some of her colleagues may be. She was only aware of what support was available based on e-mails she received. According to Dana, these e-mails inform teachers about upcoming PD events, opportunities to pursue further education, and information about programs that can benefit teachers or their students, such as The Leonardo Project. Dana has not had the chance to take advantage of many of these programs yet, but she seemed to appreciate the opportunity and viewed it as

supportive. She said, “I am very thankful that Ms. Léonard forwards emails about PD. I don’t have time to go online and find something on my own.” She commented that an e-mail from Ms. Leonard is actually how she found out about The Leonardo Project.

When Dana was asked about the support she received in order to be prepared to teach science, she mentioned “the red notebook.” This was given to her when she started. She referred to this notebook frequently, as it was her main source for preparing to teach science. It contained a pacing guide, a list of vocabulary terms, and questions students should be able to answer at the completion of a unit. She was hired after the start of the semester, and she was shown to her room, which was void of supplies other than that red notebook. The district did not supply teachers with kits or with detailed information on how to teach science so Dana was quite dependent on the red notebook and other teacher’s plans for science. Dana was not aware of any professional development opportunities for science.

The support for integrating technology into the classroom came in the form of after school meetings, where teachers helped other teachers by guiding them through ways that they used technology in their classroom. Dana had not been able to attend any of these sessions, but she had asked other teachers for one-on-one help. As previously mentioned, the school shared a technology coordinator/facilitator, so the more experienced teachers, in terms of technology, helped their fellow faculty members more than any other source.

All teachers were asked about support when it came to using writing in the classroom. Dana was not aware of any support from her district or school that was geared towards writing in the classroom.

When speaking with Dana about the third category, barriers, she spoke often of time being a barrier, with science was not a protected subject. During the end of the grading period, Dana would double up on math and skip science. Dana, who frequently mentioned that she was not happy with the level of science being taught at the school, said that while science nominally was allocated 200 minutes a week, which was not always the case. She noted that the daily schedule was not something that is made at the teacher-level or grade-level.

In addition to feeling short on time, Dana was also short on resources. Not all of her technology was reliable, other than the network, which she described as "hard wired and fast." The equipment she had available to use did not always function as it should, and it was not always reliable.

Whether it was time or resources, Dana spoke about the shortcoming with a positive attitude. She commented on being willing to make the best with what she had. In addition to not being overly bothered by the lack of supplies or money, she didn't seem interested in brainstorming ways to change it either.

Internal factors. Dana had been teaching for 2 months when she was interviewed and when asked specifics about her beliefs concerning teaching science, she was not able to provide a rich description or specific details on her instructional strategy. In discussing an activity that her students did recently, she described what her students did, but she did not mention the concepts that they needed to understand, other than the overall topic of "earthquakes." Often in discussing specifics concerning science teaching or learning, she reflected on how science was taught when she was young learner. She spoke of this as if it

was the ideal way to teaching science, which consisted of using an authentic science lab for over an hour every day where they were "exposed to the materials and introduced to the scientific process." Although Dana was generally not able to discuss specifics about how she taught science, when asked about how she may teach electricity, she mentioned the book she would use to plan from. When asked about writing to teach science, she admitted this was something she didn't do very well with.

In self-assessing her beliefs about her technology use in general, she gave herself a "4" on a 0-7 scale. Her comment was "my six year old uses my iPhone better than I do." When assessing her efficacy in applying technology to teach, she gave herself a "3" on the same scale (See Table 34).

STEBI. On the same day that Dana answered the open-ended questions, she also responded to the Science Teaching Efficacy Belief Instrument (STEBI), where she answered questions concerning her outcome expectancy and efficacy when teaching science (Table 3). The response choices ranged from "strongly disagree" to "strongly agree" with a "disagree," neutral response, and "agree" as options as well. Table 3 shows her baseline responses, which were collected prior to Leonardo's implementation. It also shows her follow up responses, which were recorded at the conclusion of the Leonardo implementation.

Table 3. Dana's STEBI Responses: Baseline and Follow-up

Question	Category	Baseline	Follow-up
When a student does better than usual in science, it is often because the teacher exerted a little extra effort.	Outcome Expectancy	3	3
When the science grades of students improve, it is often due to their teacher having found a more effective teaching approach.	Outcome Expectancy	4	5
If students are underachieving in science, it is most likely due to ineffective science teaching.	Outcome Expectancy	2	4
The inadequacy of a student's science background can be overcome by good teaching.	Outcome Expectancy	3	4
The low science achievement of students cannot generally be blamed on their teachers.	Outcome Expectancy	2	2
When a low-achieving child progresses in science, it is usually due to extra attention given by the teacher.	Outcome Expectancy	3	3
Increased effort in science teaching produces little change in students' science achievement.	Outcome Expectancy	2	4
The teacher is generally responsible for the achievement of students in science.	Outcome Expectancy	3	4
Students' achievement in science is directly related to their teacher's effectiveness in science teaching.	Outcome Expectancy	2	4
If parents comment that their child is showing more interest in science, it is probably due to the child's teacher.	Outcome Expectancy	2	3
I will continually find better ways to teach science.	Outcome Expectancy	4	4
Even if I try very hard, I will not teach science as well as I will most subjects.	Outcome Expectancy	3	3
I know the steps necessary to teach science concepts effectively.	Outcome Expectancy	2	4

Table 3 Continued

I will not be very effective in monitoring science experiments.	Outcome Expectancy	3	3
I will generally teach science ineffectively.	Outcome Expectancy	4	3
I understand science concepts well enough to be effective in teaching elementary science.	Outcome Expectancy	2	3
I will find it difficult to explain to students why science experiments work.	Outcome Expectancy	4	4
I will typically be able to answer students' science questions.	Outcome Expectancy	3	4
When a student has difficulty understanding a science concept, I will usually be at a loss as to how to help the student understand.	Outcome Expectancy	4	4
When teaching science, I will usually welcome student questions.	Outcome Expectancy	4	4
I do not know what to do to turn students on to science.	Outcome Expectancy	4	3

That analysis of the baseline and follow-up STEBI can be found in Table 4.

Table 4. Mean and Median of Dana's Baseline and Follow-up STEBI

	Baseline median	Follow-up median	Baseline mean	Follow-up mean
All Items	3	4	3	3.57
Outcome Expectancy	2.5	4	2.6	3.5
Efficacy	4	4	3.36	3.63

In looking solely at the baseline STEBI, Dana responded positively to 10% of the questions concerning outcome expectancy, and she answered positively for 55% of the questions concerning efficacy, with an overall positive response rate of one-third. This is consistent with how she answered the open-ended questions; she had confidence in her ability to plan and teach science, but she was not always confident concerning how much the students were actually getting from the lesson. Comparing the baseline STEBI and follow-up STEBI for positive responses, Dana's outcome expectancy increased to 50% positive responses, and her percentage of positive responses concerning efficacy increased slightly to 64%, with her overall positive response rate increasing to 57%. A majority of the growth between the baseline and the follow-up STEBI occurred in the area of outcome expectancy, meaning Dana gained a sense of control over how students performed.

There were two significant changes that took place between the baseline and follow-up STEBI, and both were concerning Dana's outcome expectancy. For, "If students are underachieving in science, it is most likely due to ineffective science teaching," her baseline response was "disagree," but she "agreed" during the follow-up. Additionally, for the prompt of, "Increased effort in science teaching produces little change in students' science achievement," she "agreed" during the baseline and "disagreed" in the follow-up. This represents an increase in the belief that she had influence [i.e., positive outcome expectancy] on how students performed in her class.

Final interview. During the final interview she was, again, asked about her beliefs concerning how science should be taught, and a closer look was taken at how technology knowledge, content knowledge, and pedagogical knowledge impacted her use of ESNs. Of

interest is both those elements that did and did not change between the baseline and follow-up interview.

Technological knowledge. One element that did not change was that Dana continued to struggle to use technology in a sophisticated way. She commented that she showed videos she found online or asked students to research topics on the internet, but she also said, "We did not use a whole lot of technology (pause) for science purposes." She commented twice that not knowing how to use the SmartBoards™ limited her. Having a small class size allowed her students to use the few computers she had in the classroom. Otherwise, this was a fairly low-tech class. In thinking about the role that technology plays to teach students, Dana recognized that Leonardo could be used to lead to higher engagement from the students. However when she did use technology, she reiterated that she was very dependent on her fellow teachers for guidance in its use.

Concerning how beliefs and efficacy impact technology she stated, "I would love to use it a lot more than I do. Umm… I think I don't use it because I don't know a lot of things to do with it… I know there are interactive games and things you can do, but I don't know how to do that." She did buy a book to learn more, so the desire to change is there. When asked if she would attend a workshop, she stated, "I would love to learn how to do... because, like, again I know the SmartBoards™ can be of great use, but I don't know how to use it." Not having this type of support from the school is barrier to using technology effectively in the classroom. In addition, her pre-service education didn't necessarily prepare her because she stated, "The technology class that we took in college was how technology is great and

wonderful and didn't show you how to do those things and how to, like, make that stuff so it works."

Pedagogical knowledge. When asked about the way she taught other units in science, she mentioned the way she introduced *ecosystems*. Here she said, "I wrote the word Ecosystem on the board, and you know, let's take it apart. What does it mean? What do you think we are gonna be talking about?" In describing a lesson, she referred to her method as "old school," because she would show pictures and ask questions to teach a lesson. Comparing this to the way Leonardo led the science lesson, Dana said, "He helped more so than having to come up with something on your own." She also liked that Leonardo paced the lesson for the individual students because she complained that, "When they are reading out of their science book, they flip through the whole book and are looking at a subject that doesn't have anything to do with what we are talking about." Leo removes that barrier to learning.

Because Dana changed the way she grouped students over the course of the Leonardo implementation, she was asked about how she chooses to use group work, individual work, and whole class discussion. She stated that she tends to use more whole class discussion without the access to technology that she would like, and she also added that this is partly driven by her desire to make sure students understand before they continue on. She also spoke about how she didn't use whole class decision to conclude lessons taught by Leo by saying, "when Leo was over with, it was over with, and we went on to the next thing, and we never went back and talked about it." She reflected on how that was a mistake, and if she does Leonardo again she wants to change that.

Content knowledge. When asked about her content knowledge, Dana said, "I learned from using Leonardo. I learned fourth grade science this year. It was a good refresher of things." She admitted that electricity and magnetism were two subjects she was not comfortable with, and she actually learned from using Leonardo. She stated that she spent the weekends preparing for the upcoming week, which aligns with what was seen in the observations because during the second week of the implementation she was more aware of what Leo was teaching, compared to the first week.

Scaffolding. Dana spoke about scaffolding when asked, but she was not necessarily clear on the specifics, saying, "With the scaffolding I had a low class this year. A lot of the kids were on the same level. We did a lot of things as a group." She did say she would have students who understood the content, help others who were struggling. She also stated that with using Leonardo, she wasn't sure where to step in because unless students raised their hands, she couldn't tell what they were looking at or what they understood. Of course, she could sometimes tell from their face, but that is still easier to do when she is up in front of the class.

Summary. The themes of Dana's data center around the two frameworks of: (a) teacher beliefs and (b) TPACK. Concerning beliefs, Dana did not present herself as a "teacher leader." In addition to lacking experience, she also did not speak about a desire to be a teacher leader. She made the best out of the situation she was given, but she did not feel like she could influence it greatly. Furthermore, she valued a calm classroom, and that emerged as a priority for her which heavily influenced the decisions she made in a classroom. During the interviews, Dana spoke more about student behavior than she did student learning

In thinking about the TPACK framework, Dana admits she is still learning the content, so she would not be considered to have a high degree of content knowledge, but she was confident in her ability to learn it as needed. Continuing with the TPACK framework, pedagogically speaking, teachers teach based on what they want students to *know, understand, and do*. Dana touched on *"know"* very little; she merely gave the topic as "earthquakes." She did not mention *understand* at all, and she focused mostly, albeit still very little, on *do*. She only elaborated (i.e. talked more) when asked more specific questions, and even then she was vague. Using writing to teach science lies at the intersection of pedagogy and content knowledge; however Dana's use of writing within the context of teaching science was not science specific (i.e. She specifically stated that she focused on sentence structure and grammar, only, when her students were writing about science.), so her use of writing does not speak directly to her pedagogical content knowledge concerning writing to teach science. Lastly the TPACK framework includes technology knowledge, and given the binary of sophisticated or unsophisticated, Dana self-reported, and classroom observation confirmed, that her use of technology lacked in sophistication.

Case 2 -Sam

Sam teaches in the same district as Dana, and they have similar school-level administration which provides more autonomy when designing lessons compared to the other district in this study. Sam, unlike Dana, is experienced and confident, and she spoke with appreciation about this autonomy. Also, Sam was able to speak more so to the factors that influence the decisions she makes in the classroom. Sam's room is located in an isolated

hallway with only one other teacher, and the two of them create a small community among their two classes of students, with little influence from others in the school.

Baseline interview. Sam's baseline interview took place in her classroom in September of 2013, two months prior to her implementing Leo in her classroom.

External factors. A majority of the collaboration that Sam participates in takes place with two individuals in the school, a colleague who teaches beside her and a CRT, Curriculum Resource Teacher. Sam and her colleague share students, and the students travel between the two of them daily. This means Sam teaches some subjects [e.g. science] twice, and her colleague teaches other subjects [e.g. English Language Arts] twice. In addition to her neighbor, Sam plans with the CRT. Concerning the CRT, Sam stated, "She will sit down with us and go over what the expectations are for the school year." While Sam ultimately makes the decisions about how lessons are carried out in the classroom, the CRT and her colleague have a significant influence.

Concerning the social norms of science instruction, Sam comments on how historically science has not received a great deal of attention, and a majority of the decisions have been made at the classroom or school level, but in the past year a focus group has been created, at the county level, to look at the standards in place and decide how the county can best support teachers to meet the objectives. The goal is to increase consistency in the way science is taught across the county Sam referred to this as an "interesting time in the county." When asked more specifically about the work of the focus group, Sam read directly from an e-mail she has received that stated the group would, "take a detailed look at the standards for each grade level, determine what more is needed in regards to science at each grade, and

begin to describe [inaudible] rigor and expectations of the standards… receive resources that can be used for your grade-level science instruction, and utilize google docs to share resources."

Sam was able to speak in detail about the work that the focus group was planning on doing because she is one of the teachers in the focus group. For starters, they would look at the current objectives and discuss what resources teachers would need to be successful in meeting them. Twice Sam mentioned that vocabulary would be pushed because of the 5th grade science test. She also mentioned that pacing guides would be created, but it was important to the focus group that the teachers maintain as much autonomy as possible. When asked about science notebooks, Sam did not believe they would be pushed or expected or even discussed at the district level.

The social norms around technology are somewhat driven by Sam. She stated that she is considered to be the unofficial technology guide for the school. Her colleagues call on her when they need a technology-based questioned answered, and she is often a leader in technology integration in the classroom. It should be noted her that she only has one computer in her classroom—She commented on how she preferred computers within individual classrooms, and if she could just have a few more computers in her class she would be able to do stations and circuits. She did purchase IXL, a means of assessing and monitoring student learning, for her students to use in her classroom. She does have access to three computer labs, and She stated it is expected that teachers utilize those labs "on a regular basis", and the upper elementary teachers do so often because they give students their assessments online. Sam was asked if a teacher could go a semester without using the labs

and it not be mentioned, and she responded with, “absolutely not.” She mentioned another elementary school in the county that she once taught at, and because they lacked computer labs, that school worked on getting more computers in individual classrooms..,. She answered, “Yes,” without hesitation to the question of, “Are a majority of teachers here implementing technology when they teach?” When that technology question was specific to science instruction, she hesitated and offered the caveat, “At the fifth grade level, yes; …ummm fourth grade, some; third grade, maybe some, but I would not think in the lower grades because they have a totally different assessment.”

While Sam is a teacher leader in establishing social norms concerning technology, Sam tends to follow when it comes to norms around writing. Sam does not formally teach writing to her students because that is the subject taught by her colleague; however, Sam stated, “we are really supposed to write across the curriculum.” Sam talked about the ways she uses writing in science, but she was not able to give specific examples of genre-specific writing in science. She did say, “If I do an experiment with the kids, I obviously want them to write down the steps and explain, so they at least know the process…but I am guiding it as opposed to them doing it.”

Another external factor is support, and in general, Sam was happy with the amount of support she received. Sam stated that almost every professional development opportunity that was provided to them by the county was based on technology integration. The specifics around how teachers use technology may vary at the school level, but at the county level the expectation was that technology was heavily integrated into classrooms. Specific to her school, Sam felt supported. If she wanted software, she said all she had to do was ask. Her

exact words were, “pretty much whatever I want, I go to Rick and I get.” Rick is her principal and she described him as “pretty supportive.” She went on, “He will find a way; it may not be as soon as I want it, but he will find a way.” Concerning PD, she stated the county was “very good at the continuation of technology support,” meaning that the county has frequent meetings at schools and they send e-mails with links and follow up information.” Although, a majority of decisions around PD are made by school-level administrators who decide what their teachers receive on-site. Until recently, with the formation of the focus group the county has not put a great deal of resources or time into supporting science instruction. Although Sam is one of the teachers providing that support via the focus group, she does not know of any plans for organized PD concerning science, so there is still a need for the county to formally support teachers in the form PD.

Shifting focus from support to barrier, Sam mentioned them in passing, but then quickly discussed how she overcame them. For example, she mentioned the following, “We all [i.e., the entire school] used to have headphones…they were broken in no time.” Her solution for this was to buy a class set at The Dollar Tree so students had their own pair. In terms of technology, she had more computers in her classroom when she was teaching at another school in the county, but the school she is at now has more computer labs. She felt like the biggest hindrance to technology use was when other people broke things that were available for check-out, and she gave “clickers” as an example. She did not speak of barriers for teaching science or for incorporating writing. Those things she felt were very much within her control.

Given that all other teachers in this study mention time as a barrier, it is interesting to note that Sam pointed out how little time factors into her decisions. She understands that students are different, and she doesn't want anything to pace them other than their learning. She said, "If it takes me more time to teach a topic one year than another year, I think you need to gear it towards the children." Also, "If I need to go an extra week on math, I am going to go an extra week on a math topic." Lastly she says in reference to time, "It is not even a concern of mine."

Internal factors. Sam spoke about the internal factors that influence her beliefs, and two important topics of interest were: 1) The way she believes classroom management should look, and 2) how she believes students should be assessed. Concerning classroom management she states, "I am a very structured person." She described her classroom by saying, "We do groups, but within an organized system, where everyone has a role, voice levels are monitored, you know, timers are used." She rarely has to discipline her students past a warning and she believes that is because she teaches at a very fast pace and she varies her instruction. This makes her classroom look very calm and structured. This is especially true for science because she believes tasks requiring group work tend to excite them, so they need to be reminded to stay calm. She restated, multiple times, that she rarely has behavior problems.

Thinking about assessment, she spoke about how important it was to have multiple forms of assessment. She uses multiple website for online assessment (e.g., Pearson and IXL), and she also has students write a lot in order to assess their current level of understanding, which is something she chooses to implement, as opposed to a school-wide

expectation. She often uses open-ended questions so students can write about what they have learned, but she has to balance her desire to provide more structure with the understanding that sometimes a teacher must be flexible. In addition to her own use of assessment tools, the assessments that were given at the county and state level drove a majority of her decisions. She referred to assessments when asked about writing, incorporating technology, and teaching science.

She spoke about her personal beliefs and experiences concerning technology. As someone who is not only confident in her ability, but also understands the importance of supporting her students as they use technology, she reiterated the importance of balance – students need to be competent in using technology but not solely dependent on it. In continuing to address balance, her comment was, "Technology has just become such a big part of our world that I think it would be a disadvantage to children not to use it because they need to be comfortable with it. I think their expectations in all jobs in the future are going have to deal with technology…ummm… so we need to utilize it in schools with the subjects they are learning because they are going to have to utilize it in their jobs." Yet she also says, "One of the downfalls to technology, that I have seen, is our kids are… need instant gratification, and they are overly stimulated sometimes. When it comes to their attention span, it is much shorter than it has been in the past." Sam spoke with confidence in her ability to use technology, but she knows it isn't a replacement of the teacher. To conclude her internal beliefs concerning technology she says, "It is a tool. It is a really good tool, but you still need an actual person who can guide you, and sometimes a computer doesn't know what you are thinking."

STEBI. Sam answered questions on the STEBI concerning her outcome expectancy and efficacy when teaching science. Sam's baseline STEBI responses were collected at the same time as the baseline interview. Table 5 shows how Sam responded to the baseline STEBI and follow-up STEBI, the latter of which was completed at the conclusion of the Leonardo implementation.

Table 5. Sam's STEBI Responses: Baseline and Follow-up

Question	Baseline	Follow-up
When a student does better than usual in science, it is often because the teacher exerted a little extra effort.	4	4
I will continually find better ways to teach science.	4	4
Even if I try very hard, I will not teach science as well as I will most subjects.	4	4
When the science grades of students improve, it is often due to their teacher having found a more effective teaching approach.	4	4
I know the steps necessary to teach science concepts effectively.	4	4
I will not be very effective in monitoring science experiments.	4	4
If students are underachieving in science, it is most likely due to ineffective science teaching.	3	3
I will generally teach science ineffectively.	4	4
The inadequacy of a student's science background can be overcome by good teaching.	4	4
The low science achievement of students cannot generally be blamed on their teachers.	3	3
When a low-achieving child progresses in science, it is usually due to extra attention given by the teacher.	4	4

Table 5 Continued

I understand science concepts well enough to be effective in teaching elementary science.	4	4
Increased effort in science teaching produces little change in students' science achievement.	4	4
The teacher is generally responsible for the achievement of students in science.	4	4
Students' achievement in science is directly related to their teacher's effectiveness in science teaching.	4	4
If parents comment that their child is showing more interest in science, it is probably due to the child's teacher.	4	3
I will find it difficult to explain to students why science experiments work.	4	4
I will typically be able to answer students' science questions.	4	4
I wonder if I will have the necessary skills to teach science.	4	4
Given a choice, I will not invite the principal to evaluate my science teaching.	4	4
When a student has difficulty understanding a science concept, I will usually be at a loss as to how to help the student understand.	4	4
When teaching science, I will usually welcome student questions.	4	4
I do not know what to do to turn students on to science.	4	4

Although there is only one change between Sam's baseline STEBI and follow-up STEBI, mean and median were calculated. That information can be found in Table 6.

Table 6. Mean and Median of Sam's Baseline and Follow-up STEBI

	Baseline median	Follow-up median	Baseline mean	Follow-up mean
All Items	4	4	3.91	3.87
Influence	4	4	3.8	3.7
Efficacy	4	4	4	4

Sam answered positively on a large majority of her questions (91% of the Baseline STEBI; 86% of the follow-up STEBI), and the responses that were not positive were all neutral, meaning Sam had no negative responses. When looking at outcome expectancy and efficacy, 100% of the efficacy questions were answered with a positive response in both the Baseline and follow-up STEBI; therefore, all of the neutral responses were concerning the issue of outcome expectancy. Sam had no negative responses.

In looking at the only prompt that had a different response, which was "If parents comment that their child is showing more interest in science, it is probably due to the child's teacher," Sam's baseline response was "agree," and her follow-up responses was "neither agree nor disagree." Sam was asked about this change, but she was not able to provide a reason.

Final interview. During the final interview she was, again, asked about her beliefs concerning how science should be taught, and a closer look was taken at how technology knowledge, content knowledge, and pedagogical knowledge impacted her use of ESNs. Some of the information from the baseline interview was also re-stated by Sam in the follow-up interview.

Technological knowledge. Sam has a high level of technological knowledge and integrates it into her classroom regularly. Because of this she is able to reflect deeply about how technology changes a lesson, for better or for worse. When asked about technological knowledge, Sam defaulted to talking about technological pedagogical knowledge (TPK). As an example, she spoke about the way her students were engaged in the lesson more so than normal because of the use of technology. Additionally, technology allowed her students to be less intimated to respond to questions. One down side she saw, to the Leonardo in particular, was the way students were allowed to answer questions and move on even if they did not answer them thoroughly or thoughtfully. Sam noted that when she can read the students' responses in (near) real-time, she is able to ask students to reconsider their answer when they don't provide a thorough explanation.

Pedagogical knowledge. Sam has taught for many years, and she self-reports her pedagogical practice as sound. Although confident, she is reflective and always looking for ways to improve. As an example, she commented that she struggled this past school year to push her students to think more in depth. When asked specifically about pedagogical practices for teaching science, she said that she pushes a great deal of reading and vocabulary because she knows that is key to understanding the subject deeply given the little amount of time they have. She went on to comment that she worries that when she is teaching science content that she doesn't elevate questions to a high level, and she referenced Bloom's Taxonomy when speaking to this. She was impressed with the intensity of Leonardo's questioning, and she commented that she learned about asking students to apply knowledge

through using the ESNs, and she is glad that students were pushed to write when using Leonardo.

Content knowledge. She is confident in her content knowledge, and she didn't necessarily learn anything about Electricity by implementing the ESN, as some teachers did. When asked about content knowledge she noted that she has taught fourth and fifth grade for quite some time so she was familiar with the curriculum and the content.

Scaffolding. Speaking generally, she said, "If you lower your expectations, you will get lower results. Let them [i.e. the students] meet you." She sees her role as one who has to give students the tool to meet those high expectations. In all subject areas, she uses KWL a lot in her class, so she asks students to access their own understanding, and they repeat that thorough the unit so students are able to see what they learn as the days pass. In commenting specifically on the way one could scaffold with Leonardo, she suggested a "mini unit" on electricity and magnetism prior to starting the software.

Summary. In looking collectively at the data, Sam provided information concerning her beliefs about integrating technology and writing when teaching science. In addition, Sam presented herself as a teacher leader in the following areas: (1) integrating technology into the classroom, (2) teaching science, and (3) pedagogically established a culture for rigorous learning and high expectations. In all that she spoke about, writing was the only area where Sam seemed less confident as a practitioner. In looking at her data through the TPACK framework, Sam was not able to speak about technological knowledge, pedagogical knowledge, and content knowledge as isolated ways of understanding what was needed in a classroom. This is especially true for technology and pedagogy. Sam saw technology as a

powerful pedagogical tool, and although she did not think technology was the answer for every pedagogical challenge, she understood how to effectively use it to increase student understanding.

Case 3 – Taylor

As a veteran of the Leonardo project, Taylor felt confident about the upcoming implementation. The year prior to this, she taught science to two classes, where one class was a part of the Leonardo ESN implementation and the other class was taught without the Leonardo implementation. This allowed her to experience the ESNs and reflect upon the ways that the implementation could be improved. She speaks to that in her baseline interview, saying, “My kids just don’t get that experience with the iPads, so that experience with the iPads is great.” However, she commented that data from last year showed that the control group learned more compared to the experimental group, and as a result of that she will be increasing student-to-student and whole group discussion this year when utilizing ESNs.

Baseline interview. Taylor’s baseline interview took place in September of 2013, which was a little over two months prior to her implementing Leonardo. Taylor’s interview lasted twice as long as expected due, mainly, to her verbosity.

External factors. In trying to better understand the social norms, support, and barriers that Taylor perceived, she was able to provide some information, but overall there was a lot of uncertainty expressed by her. On one hand, Taylor had a good feel for the expectations and norms of the school, but her impression from the county was that they communicated very little in terms of expectations. This sometimes resulted in Taylor getting information

from the county, yet there never being any other mention of it or follow up at the school level. Taylor was asked about norms concerning teaching science, and she immediately mentioned the training she received around "interactive science note booking." Twice she refers to notebooks, but when elaborating on note booking she refers to the kit-based curriculum. When pressed for clarification about the notebooks, she again referred to kits. Concerning the kits, with recent budget cuts, schools are receiving two kits [i.e. a kit for animal behavior and a kit for weather] now when they used to be given four science-related kits. Taylor says, "Besides that, you are on your own." In order to supplement the two kits that were not purchased, schools referred teachers to wiki pages in order to gather information. Taylor expressed frustration that the pages were not updated in the manner the county promised they would be. She went on to say, "We don't really have much guidance." She has not received any training for the kits she is using with her students now. Also, there are no textbooks available to offer guidance.

In describing what science looks like in the classroom, she said, "with our population, we use a ton of videos," and she gave examples of the websites she used to find these videos. The schedule for her school is different this year; there is no longer any team teaching. Teachers now have to teach all subjects, and the schedule allots 50 minutes a day for science or social studies, and in a usual 6-week grading period, social studies will receive four weeks while science instruction will receive two. She commented, "That is just the way it worked out," noting that the science units just take less time.

During the interview Taylor spoke about the norms around technology in two distinct ways. There is the way teachers use the technology, and that can be very different from the

way students use technology. According to Taylor, the students in her class have not had as much exposure to technology outside of the classroom, compared to other students their age. Many of them are using an iPad for the first time during the implementation of the ESNs. Taylor speaks to how this may explain why students last year showed higher learning gains in the control group, saying, "It is a lack of technology skills." Although we don't use the language of "cognitive load," we discuss that perhaps using the technology may not leave a lot of mental processing available for learning the content. Concerning how the teachers use technology, Taylor at one point said, "So school-wide, I don't really think there is an expectation." She went on to comment that a huge majority, "like 95%," of teachers use technology on a very regular basis, and she provided examples. Taylor added, "A lot of teachers are using Edmodo." In addition, all classrooms have SmartBoards™ and there are a couple of laptops carts shared among each grade; although they are six years old, according to Taylor. Thinking about her own technology use, Taylor says, "The SmartBoards™ intimidates me because every time I go to use it, something goes wrong." Also, it isn't mounted where she would prefer it to be. "I still haven' figured out, classroom management wise, how to make it work."

There was an internal contradiction to the way Taylor spoke about how her students use technology. Once she stated, "Our kids are using technology quite a bit…I would love for them to use technology more, but they don't have that experience at home to practice." She commented that using technology should make the process [of learning] faster, but it actually slows her students down. She referenced a lack of technology-centered experiences outside of school, which means there are many skills her students, specific to technology-use,

simply don't have. For example, her students have poor typing skills. She tries to help this by heading up a typing club. As far as specific examples of programs students are using on the technology, Taylor states, "We do a lot with Razkids," and "We have a lot of subscriptions, such as BrainPop." She can't comment specifically on other grade levels, but for fourth graders she says, "I know our grade level uses it a lot, and especially with our ESL population we do a lot of background building with technology and videos."

Just as Taylor's comments on technology seemed inconsistent, the same is true for her statements concerning writing. Her first comment was, "To be honest, last year writing was taken out of our [daily] schedule." The expectation now is that "our kids were supposed to integrate it [writing] the whole day, but when you have everything else going on they [i.e. students] weren't writing papers." This resulted in poor scores so this year the writing block is back because the assumption is that teachers may not have been integrating it. This year they have three days where they have students write 35 minutes. She talks about what a struggle that is for her students, but she did provide an example of her using writing in science by talking about when her students had to create a menu during the nutrition unit." After talking about the shift to focus more on writing, she says, "Reading is our big push. Writing is pushed to the side. We always asked for more writing help and last year we were given a book and our school did like a book club with this book for three meetings." This was a disappointment to her because it was not a successful attempt to provide teachers with support that they need and asked for. Taylor acknowledges that teaching writing is her biggest weakness so she would appreciate help in this area.

In looking at the external factor of support, Taylor mentioned that there is often a lot of push for teachers to try things, but there is no follow up and there is a lack of support. She mentioned that is likely because everyone is so short on time, so she seems to understand the why behind the deficit in support. She commented that everything is done with the best of intentions, but the reality is that teachers are overwhelmed with what is expected of them. They also don't know what to latch onto because some of the ideas don't come to fruition so that can be frustrating.

When asked about how she goes about getting supplies she needs, she mentioned that financial support comes from three thrift stores around the county. The thrift stores are run by the PTA, and teachers can work there in order to make $4/hour for themselves and $4/hour for their schools. Taylor has done this in order to buy supplies to support activities students do in science. She said with slight exasperation, "on top of everything else you can go work nights from 5:30 to 7:30." This is how she supported an "adaptations activity" in science, where students used tools that mimicked bird beaks. In continuing on about financial support, she stated "We don't do a ton of fundraisers," and, "I've never really thought of a wish list because we don't have a lot of options."

Science instruction is not supported as it once was, as evidenced by the reduction in kits being available. Taylor added that because the teachers all plan together, the lack of kits materials doesn't necessary impact the students. In addition to supplies being cut, Taylor noted that teachers have less time available now to teach science, saying, "We supposedly have a flexible schedule, but it is literally… there is not even a break, like there is not even a bathroom break." She added, "It [the schedule] is very mapped out." Because science and

social studies share a time block, science isn't protected like math and literacy time, so each teacher may or may not actually teach science in a school day.

When thinking about the support science receives county-wide, she stated, "We don't do a lot of collaboration, county-wide, on science, and I feel like…and that was a discussion we had because at the end of last year we had a half day or something where we all just got together and brainstormed… and that was the biggest thing, we are making up our own science quizzes and we are all finding our own articles." She wants a more unified approach, county-wide, to teaching science. Although they do have a wiki to guide them, but there is not collaboration, where she says, "What we base our instruction off of is the county, like, wiki, with the, like… it's…not a pacing guide, but is has the essential questions so it states the standards and your essential questions for the unit."

While other teachers in her county mentioned technology-based PD, Taylor did not feel supported to implement technology. She did mention that her principal supports their technology needs to the best of her ability, but it takes a while for teachers to get what they need. Concerning issues with Internet connectivity, she stated, "I know, Alison, our principal, she really pushed to get it fixed this year, but…something… whatever they did, we still didn't get it fixed." Issues remain concerning connectivity.

Issues around technology are certainly a barrier, another external factor. Taylor states, "Internet is a huge issue at our school…It depends on where you are at in the building." She spoke about the one day when benchmarks were being administered, and she said, "Students had to go and sit outside the bathroom to get logged into the internet." She also commented that it isn't unusual for 30 minutes a day to be spent solving issues with technology. She

continued, “Sometime the internet works well.” She was asked if it hindered planning with technology and she acknowledged that it does. When pushed to further discuss other barriers, she commented that her population of students presents its own challenges, but she understands no one can control that. She is concerned that her students don’t read on grade level, struggle to communicate with their parents, and aren’t challenged like their counterparts in a neighboring county.

Internal factors. Despite the struggles she faces with her students, Taylor works very hard to overcome obstacles, and she is confident in her ability while also constantly reflecting in order to improve, when possible. She is candid about her disappointment when students don’t work as hard as she expects them to. That occurred the day of the interview when students didn’t try hard to complete an activity that she worked very hard to set up. Not only does Taylor expect self-reflection from herself, she asks her students to think about what worked and what didn’t, so they did “plus-deltas” after the failed activity.

Taylor makes it her priority to teach students “basic foundational skills.” She considers communication an issue her students struggle with. It is interesting to note that 42 minutes into the interview she commented that students are at a disadvantage because they have been spoon fed by parents so they struggle to think for themselves. As she processes other questions, she comments 6 minutes later saying, “This is really good for me to think about this stuff,” because she realizes she may be spoon feeding students too much as well.

Taylor was asked for more specific examples about how she believes students learn and how science should be taught. In terms of science pedagogy, she does believe that science requires a certain way of thinking, and she feels writing can be used to improve

learning, in saying, “Writing, I feel, does help and with science. I always try to reflect on what we did.” She mentions science notebooks because she often asks students to “create charts, menus, and explain what they think is happening.” She said she tried to leave enough time to have a reflection where students can write about what they have learned, but she admitted time prohibited this most days. She also believes technology needs to be used more, and she stated, “I feel like there is so much more with technology that I could use that I don’t,” but she was also proud of the technology-use with students. She believes she is moving in the right direction with technology integration. She also gave this example about scaffolding, “I wish you could just say ‘explore this’,…and I have tried it a few times by giving them the opportunity to do it.” She struggles with giving students enough support to be successful, while also not giving them so much structure that they don’t have to think for themselves. She discussed sentence starters and wondered if that was what was best for her students. She also noted that what worked well for her ESL population also seemed to work well for the rest of her students.

One other internal factor explored was her classroom management style. Taylor feels like classroom management is” huge.” She says, “If you don’t have the classroom management, which I struggled with, I’ll be honest, I struggled with…and we started to do PBIS [Positive Behavioral Interventions and Support]…but now we are done with that because we are doing *Leader in Me*.” She continues, “I really feel like my class has improved over the last three years, where I feel like I did get more of a handle on classroom management, sitting those expectations.” Her biggest struggle with classroom management is getting students to successfully work in groups. She wants to do centers, but she has to trust

students first. Additionally, there is a clipping system, and students can clip up or clip down depending on their behavior that day. She believes that students need to take responsibility for their actions, and she believes as the teacher she needs to focus on the positive behaviors she wants them to see.

STEBI. Taylor's baseline STEBI and follow-up STEBI responses are shown in Table 7. The higher the number, the great sense of efficacy or influence [i.e. outcome expectancy] Taylor believed she had.

Table 7: Taylor's STEBI responses: Baseline and Follow-up

Question	Baseline	Follow-up
When a student does better than usual in science, it is often because the teacher exerted a little extra effort.	2	4
I will continually find better ways to teach science.	5	4
Even if I try very hard, I will not teach science as well as I will most subjects.	3	2
When the science grades of students improve, it is often due to their teacher having found a more effective teaching approach.	2	3
I know the steps necessary to teach science concepts effectively.	4	4
I will not be very effective in monitoring science experiments.	4	4
If students are underachieving in science, it is most likely due to ineffective science teaching.	2	3

Table 7 Continued

I will generally teach science ineffectively.	5	4
The inadequacy of a student's science background can be overcome by good teaching.	4	4
The low science achievement of students cannot generally be blamed on their teachers.	4	2
When a low-achieving child progresses in science, it is usually due to extra attention given by the teacher.	2	3
I understand science concepts well enough to be effective in teaching elementary science.	4	4
Increased effort in science teaching produces little change in students' science achievement.	4	4
The teacher is generally responsible for the achievement of students in science.	3	4
Students' achievement in science is directly related to their teacher's effectiveness in science teaching.	4	3
If parents comment that their child is showing more interest in science, it is probably due to the child's teacher.	2	3
I will find it difficult to explain to students why science experiments work.	4	2
I will typically be able to answer students' science questions.	4	4
I wonder if I will have the necessary skills to teach science.	2	2
Given a choice, I will not invite the principal to evaluate my science teaching.	4	5
When a student has difficulty understanding a science concept, I will usually be at a loss as to how to help the student understand.	4	4
When teaching science, I will usually welcome student questions.	5	5
I do not know what to do to turn students on to science.	4	4

Once questions were coded and grouped, median and mean were found for the entire STEBI questionnaire, as well as mean and median for the questions addressing outcome expectancy and for questions solely addressing efficacy. That information can be found in Table 8.

Table 8. Mean and Median of Taylor's Baseline and Follow-up STEBI

	Baseline median	Follow-up median	Baseline mean	Follow-up mean
All Items	4	4	3.57	3.52
Influence	2.5	3	2.9	3.3
Efficacy	4	4	4.18	3.73

In looking solely at the baseline STEBI, Taylor responded positively to 40% of the questions concerning outcome expectancy, and she answered positively for 90% of the questions concerning efficacy, with an overall positive response rate of two-thirds. This is consistent with how she answered the open-ended questions; she had confidence in her ability to plan and teach science, but she was not always confident concerning how much the students were actually getting from the lesson. Comparing the baseline STEBI and follow-up STEBI for positive responses, Taylor's outcome expectancy stayed the same at 40%, and her efficacy responses were 73% positive, which means two questions she responded to positively in the baseline STEBI so did not do so in the follow-up. Her overall positive response rate was 61% in the follow-up STEBI. A majority of the growth between pre-implementation and post-implementation occurred in the area of outcome expectancy, meaning Taylor gained a sense

of control over how students performed. Some of the increase in positive responses can be accounted for by Taylor going from a neutral response to a positive response.

The more drastic changes, although not in the positive direction, were seen in three questions. Those charges are given in Table 9.

Table 9. Significant shifts in Taylor's responses – Comparing Baseline STEBI to Follow-up STEBI.

	pre-STEBI response	post-STEBI response
When a student does better than usual in science, it is often because the teacher exerted a little extra effort. (Outcome Expectancy)	Disagree (2)	Agree (4)
The low science achievement of students cannot generally be blamed on their teachers. (Outcome Expectancy)	Disagree (4)	Agree (2)
I will find it difficult to explain to students why science experiments work. (Efficacy)	Disagree (4)	Agree (2)

Final interview. During the final interview she was, again, asked about her beliefs concerning how science should be taught, and a closer look was taken at how technology knowledge, content knowledge, and pedagogical knowledge impacted her use of ESNs.

Technological knowledge. During the follow up interview, Taylor spoke about decisions she makes concerning technology-use in her classroom, which is different from the baseline interview where she was focused on the lack of students' technology skills. She made using technology priority. Specifically, she used BrainPop, WebQuest, and "many other sites," and she also found short videos on YouTube to engage students. It was easier for

her to use the technology than for the students to use laptops because laptops were shared between classes, which meant they were rarely charged.

Pedagogical knowledge. When asked about pedagogical practices, Taylor quickly mentioned "trust." She stated that it was important for students to "want to work hard for the teacher." She constantly balanced pushing the content with making sure she was allowing herself to be flexible based on her students' needs, culture, and personalities. Taylor also understands that in order to impact student learning, she needs to communicate with parents. She made it a common practice to text and e-mail parents with updates. She commented that "creating community" helped her and her students. To Taylor, Pedagogy isn't only about how to teach but also how to make learning possible.

Writing to learn and reading in the content area are pedagogical strategies that Taylor frequently uses. It was with the help of her Master's program that she learned strategies to use writing and reading to promote student learning. She did talk about the struggles she faces getting her students to write. They lack the confidence, and she doesn't always take the time to provide the necessary feedback. She was clear that she required students to use complete sentences, and she reminds students that in scientific writing they needed to use the word "because."

Content knowledge. Taylor considers her science content knowledge her weakest area. She commented that it isn't that she doesn't understand science, but she acknowledges that finding sources is hard so she worries she isn't challenging her students enough. This is the intersection of pedagogy and content knowledge. When talking about how she taught

science, Taylor was dependent on outside sources in order to provide her students with rigorous science lessons.

Scaffolding. One way that Taylor scaffolds her students writing and reading is through the use of a word wall, where she introduces new vocabulary once students learn the current vocabulary, and the word wall grows over the course of the school year. Additionally, Taylor considers feedback an important component of scaffolding. She uses a scale of 1-5 to provide her students with quick feedback, and she also has them self-assess with a 1-5 scale. She makes sure her students understand that they are accountable for their own learning, but she is accountable to providing them with the necessary materials and support.

Summary. In looking collectively at the data Taylor provided concerning her beliefs about integrating technology and writing when teaching science, Taylor presented herself as successful at integrating technology into the classroom. She is aware of the weaknesses that her students have in this area, but she plans and implements technology and non-technology based strategies to help them. Concerning teaching science and writing, Taylor acknowledged that she is less confident as a practitioner. Concerning her beliefs as a teacher, she is constantly searching for balance between how she internally believes a classroom should operate and the external factors that interfere with this happening. In Taylor's case, those external factors were: (1) ambiguous and ever-changing expectations from the district/school, (2) ambiguous and ever-changing norms around science teaching due to limitations concerning time and money, and (3) barriers, such as professional development with no follow through as well as unreliable equipment and network.

In looking at her data through the TPACK framework, Taylor was comfortable with her technological knowledge, although she is always looking for ways to improve. Pedagogically, she had an understanding for what students needed in order to be successful. Her weakest area was science content knowledge, and she relied on technology, to supplement the kits, in order to give her students access to science material.

Case 4 –Riley

At the time of the study, Riley was a veteran to the classroom and a returning teacher to Leonardo. She expressed confident in her ability to teach science well, and she was a teacher leader in her school. As examples of that leadership, she was frequently the one who piloted any new technology, and her classroom was the place were all fourth grade teachers had lunch.

Baseline interview. Riley's baseline interview took place in his classroom in March of 2014 prior to the implementation of the Leonardo Project. During the interview she answered many of the questions in length, and even without being directly asked about support and barriers, she frequently expressed her dissatisfaction with the lack of support she felt.

External factors. The first questions asked of Riley were about social norms. When asked about expectations from the school district concerning how science should be taught, she responded with, "That's a tough question." She then mentioned a curriculum guide, which she feels was put into place because of the pressure to prepare students for the science test in fifth grade. In continuing to think about the expectation around teaching science, Riley goes on to say, "The expectation is to teach it but not a lot of support for it. Like, they have

cut back from giving us four kits to two kits. Our curriculum we have in the room doesn't cover the content, so they have kind of eliminated our…um….they have taken away what we have to use." She cites animal adaptation as an example of a kit they no longer have so the teachers have to build that kit on their own. That expectation is district-centered. When asked about the school's expectation concerning how science should be taught, Riley said, "I feel there is not a lot of push for science. Not that they don't want us to teach it, but math and reading get the focus." More generally speaking, concerning teaching, another social norm found at Riley's school is that teachers planned together at each grade level, so all of the fourth grade students receive instruction similar to one another in all subjects.

In looking at expectations concerning technology use, the school stressed technology integration as a priority. The school purchased a SmartBoards™ with funding from title I, and the PTA raised money to buy additional SmartBoards™, so one is in every classroom. For this reason, it is expected that all students utilize the SmartBoards™ fully. Riley was the first to have a SmartBoards™, and she is now considered the expert. A lot of her colleagues turn to her for instructional support relating to the SmartBoards™.

When Riley was asked specifically about the expectation concerning the SmartBoards™, she stated that teachers all expected to use it daily and administration expects it will be used to its potential. She goes on to add, "It is not just a projection screen. It is too expensive." Because of the expectation that the SmartBoards™ be utilized heavily, Riley took it upon herself to make sure she provides assistance to all the other teachers in the school in order to make their use of the SmartBoards™ more sophisticated. When asked for

an example, she stated, “Even just doing...showing... them how to download things from Smart Exchange.” Additionally, teachers use Google Docs to share teacher-to-teacher.

In looking solely at technology use to teach science, Riley said, “the last unit I did was on energy and we used thermometers…and an electronic…scale.” She also commented on the use of motors and solar panels. Riley stated that technology allows her students to “see” things that are microscopic. Although Riley gave examples of how she incorporates technology when teaching science, she did not comment on expectations surrounding technology use to teach science.

Riley was asked about expectation concerning incorporating writing, and her comment was, “When it [i.e. the writing test] comes back it will get pushed again,” But right now writing isn’t being emphasized because it isn’t being tested. She added that, “It [writing] is used now in order to enhance reading.” She was asked if writing was integrated into science, and she stated, “We do because we just don’t have enough time to do it all.” As an example, she stated that during the animal unit, students worked on nonfiction writing as well; where students did a research projects and focused on note-taking.

Riley was asked about the support that teachers are given in the form of PD, and she was asked more specifically about PD that focused on when it comes to teaching science, using technology, and writing. Pertaining to general PD, she recalled that the county provided support for reading at the basic level, and that was done in response to the growing ELL population. Riley was asked about the support teachers receive in order to help them teach science, and she talked about the PD teachers receive around the science kits and how to implement them in the classroom. This PD was supplied by the company who makes the

kits. She echoed the comments made by Taylor, noting that teachers were getting two kits instead of four. Riley expressed frustration that the PD was based on "what they thought the common core would be" so she wasn't confident that she was getting specific information about how to use the kits.

She has not received PD pertaining to using technology to improve student learning. A representative from the company who supplied the SmartBoards™ did a 2-hour question-and-answer session to help teachers use the SmartBoards™, which followed a one-day PD about how to use the SmartBoards™. Although she didn't feel supported by PD about technology, she did feel supported as she attempted to use technology day-to-day. For example, in the event that there is a technology problem, the county has a system where teachers put in a "help ticket." The IT person is shared between schools, but he is available for instant chat most of the school day. Riley commented that, "he is very reliable for help." Technology support also comes in the form of having access to technology, and here she doesn't feel supported because she doesn't have all of the equipment she needs stating, "I would like a laptop cart." She added that she doesn't mind sharing a laptop cart with another teacher, but at this point she only has access to six computers at a time, and she really wants to use them more when her class. Getting into the computer lab is an option, but it is rarely available when she needs to reserve it. "It isn't easy, but it is possible. The hard part is that you have to bring everything up there, but it is so packed." She does take her students to the lab once a week, but the setting doesn't allow for students to do research like she would like for them to do. When asked about how she would use the laptops, she added that she would like a typing tutorial because her students are not great [i.e. fast] at typing. Riley stated,

"Unless they get the support at home, they are really slow." She also mentioned that having computers in the classroom would allow for her to utilize Google Docs fully (She mentioned another teacher who used Google Docs regularly.), and it would give her students a change to use the basic software on computers, and she mentioned iMovie.

Having access to technology also means that teachers can get help when problems arise. The IT person is shared between schools, but he is available for instant chat most of the school day, and he responds quickly to "help tickets." Riley commented that, "he is very reliable for help." She did add that the network and the computer she uses are both reliable. She commented, "I am not sure what is different, but it is good now."

Like most teachers, the biggest barrier that influenced Riley's beliefs is time. Integrating seems like the pedagogically sound way to teach, but it is done out of necessity because there are so many topics to teach in a day. Speaking specifically about science instruction, two hours a week is all she has to devote to teach it, and there is no other time in the day that she can teach science other than the allotted time, stating, "I don't have a spot to take it from." In addition to time, money is a barrier. Her budget is limited to $400/school year for all of her supplies – from construction paper to glue to software. She added, "That doesn't go far." She can do a write-up and ask the principal, but that would require approval from a committee as well.

Internal factors. When asked what she believed about her role as a teacher, she said, "My job is to plan well and then facilitate, I think…especially with science, I love the fact that I can do more hands-on stuff." She added, "I need them to spit back to me what they learned." Teaching is "to me, setting it up, having them do it, and then they show me what

they have learned." She even went on to comment that if students couldn't demonstrate what they learned, she hadn't done her job. She stated it is also important to her that her students ask, "Why?" It is also her desire that students assess themselves in order to make them aware of their own learning.

She was asked about how to balance individualized learning and keeping pace with the curriculum. She acknowledged this need to find balance, and she stated she does sometimes just move on, but she said, "I don't necessarily sleep well knowing that." She stated twice, "I am fighting the system." She acknowledges that her test scores aren't great, but that is because she isn't interested in just getting her students to know how to answer multiple choice questions. In concluding the questions about her beliefs, she stated that she was, "advocating for the have-nots." Her students are encouraged to work with each other regardless of ability level and socio-economic status.

Lastly, she talked about the role of scaffolding. She stated that most of her students are used to be spoon fed, and for that reason they want her standing over them to make sure everything they do is right. She prefers to just give them boundaries and make sure they work within them. Concerning scaffolding, she also said, "it is making sure pedagogically that you [the teacher] are [is] on track with what they [students] don't know too." Another tool she uses is graphic organizers. She tells them what to draw early in the school year, but after some experience with them, she asks students to choose which graphic organizer they want to use. She mentioned that these allow students to feel successful at first, which is important for them. Riley also mentioned that scaffolding is used as a pedagogical tool when working

with students on improving their writing. She constantly pushes students to use the advanced vocabulary, which she feeds them at first.

In looking at her beliefs around technology and science, she said, “I want the technology to supplement it but it can’t be the all in all.” She said she planned out lessons for each unit, and she incorporated technology, such as a video, when appropriate. She said technology helps to save time and keep students on task. She likes hands-on experiences for her students, so she said, “I don’t want it to take the place of the hands-on.” Additionally, she values technology for its infinite knowledge base, which is a benefit to students, but she doesn’t want to rely on technology too much, adding, “all we need is for the server to be done and then it is like ‘now what do we do?’” She is usually prepared with a plan B, but it involves printouts, and she doesn’t always have those printed because she is trying to save paper. She concluded her comments concerning technology with, “I am not against it because of what it can offer, but it’s got to be the right technology and not just as a babysitting kind of substitute.”

STEBI. Table 10 contains the baseline and follow-up STEBI responses of Riley.

Table 10. Riley's STEBI responses.

Prompt	Baseline	Follow-up
When a student does better than usual in science, it is often because the teacher exerted a little extra effort.	5	4
I will continually find better ways to teach science.	5	5
Even if I try very hard, I will not teach science as well as I will most subjects.	5	4
When the science grades of students improve, it is often due to their teacher having found a more effective teaching approach.	5	4
I know the steps necessary to teach science concepts effectively.	4	4
I will not be very effective in monitoring science experiments.	5	4
If students are underachieving in science, it is most likely due to ineffective science teaching.	4	2
I will generally teach science ineffectively.	5	5
The inadequacy of a student's science background can be overcome by good teaching.	5	4
The low science achievement of students cannot generally be blamed on their teachers.	1	2
When a low-achieving child progresses in science, it is usually due to extra attention given by the teacher.	5	4
I understand science concepts well enough to be effective in teaching elementary science.	5	5
Increased effort in science teaching produces little change in students' science achievement.	4	4
The teacher is generally responsible for the achievement of students in science.	4	4

Table 10 Continued

Students' achievement in science is directly related to their teacher's effectiveness in science teaching.	4	4
If parents comment that their child is showing more interest in science, it is probably due to the child's teacher.	4	4
I will find it difficult to explain to students why science experiments work.	5	4
I will typically be able to answer students' science questions.	5	4
I wonder if I will have the necessary skills to teach science.	5	4
Given a choice, I will not invite the principal to evaluate my science teaching.	5	5
When a student has difficulty understanding a science concept, I will usually be at a loss as to how to help the student understand.	5	4
When teaching science, I will usually welcome student questions.	5	5
I do not know what to do to turn students on to science.	5	5

Once questions were coded and grouped, median and mean were found for the entire STEBI questionnaire, as well as mean and median for the questions addressing outcome expectancy and for questions solely addressing efficacy. That information can be found in Table 11.

Table 11. Mean and Median of Riley's STEBI responses.

	Baseline median	Follow-up median	Baseline mean	Follow-up mean
STEBI	5	4	4.52	4.01
Outcome Expectancy	4	4	4.1	3.6
Efficacy	5	4	4.91	4.45

In looking solely at the Baseline STEBI, Riley responded positively to 95% of the questions. In the follow-up STEBI she answered positively for 91%. Her mean dropped significantly between the baseline STEBI and the follow-up STEBI because instead of answering with the use of the "strongly" modifier, her responses were closer to neutral. When asked about her responses, she noted that she actually misread one of the questions and her response was recorded as the opposite of what she intended, which means her overall beliefs about her ability to teach and influence students is higher than what the STEBI shows. Also, to the prompt of, "If students are underachieving in science, it is most likely due to ineffective science teaching," her baseline response was "agree," and her follow-up response was "disagree."

Final interview. The final interview took place at Riley's room at the conclusion of the ESN implementation. She addressed why there may be a difference between the baseline STEBI and the follow up STEBI (See Table 10), and she stated that it had to do with what word she focused on – underachieving or science. She was thinking during the follow-up

interview that it may be true for content areas other than science. So, with that caveat added, her beliefs didn't change.

Technological knowledge. In terms of Riley's technology knowledge, she is confident in her ability. She stated that she uses the SmartBoards™ as much as she can. She even uses it when the students have to do recess indoors. She added that the SmartBoards™ are not just for her to use, and she frequently asks students to come to the front and demonstrate.

Riley spoke briefly about her high technological knowledge, but a majority of the time she was not able to separate technological knowledge from pedagogical practice. She elaborated on how students were using technology to create presentations, complete math lessons, or research topics. Specific to Leonardo, she said that when students are using ESNs, "I am not just over there grading papers." Riley doesn't view technology as something that can deliver content/learning without the presence of a teacher to facilitate and/or problem-solve.

Pedagogical knowledge. Pedagogically, Riley understands that no one lesson stands on its own. She is constantly integrating subjects, and when I asked her about this she said, "I don't just teach Biology. I am teaching the whole child at this grade." She also understands that each student learns in an individual way. Here she commented, "My goal is at fourth grade, over all, is to teach them how to be organized, and to be a little bit less 'spoon fed;' not throwing them in the deep end and yelling, 'swim,' but equipping them to be organized and accountable for what they do, allowing them to say 'this is what I have to get done today.' To her, authentic learning takes place when students take responsibility for it.

Content knowledge. Riley self-assesses herself as having sound content knowledge in science, which she attributes to 4H. She stated, “It is very important that I am the expert.” She did not elaborate here.

Scaffolding. In continuing to emphasize that students are individuals who have different needs, she tries to structure her class so that students can work on tasks based on their current level of understanding. It is also important to her that “students be able to help others when they are more knowledgeable.” Additionally, she uses assessments to group students, and she allows them to advance to another topic or level, while she spends time with students who made need to hear the material again. She doesn’t spend as much time as other teachers addressing the entire class, stating, “Having kids do it [i.e. take charge of their own learning or help others], keeps my voice from being the blah blah blah.”

In talking about scaffolding, Riley commented on the way that Leonardo introduced vocabulary and then added to it but checked for understanding along the way. She said this was something she would like to model when teaching without ESNs.

Summary. Riley stands out from the other 4 teachers in this study because, while she recognizes there is always room for improvement, she excels in all areas that are being studied. Her teacher beliefs are heavily influenced by her administration. While she acknowledges funding and time are barriers, she understands those are often out of the control of the people who work within the school building, and in the face of these barriers, she perseveres. However, she mentioned severing times that an unsupportive administration and “being micromanaged” is what bothers her more than any of the other barriers.

The TPACK framework asked about the intersection of technological, pedagogical, and content knowledge. Riley is a teacher leader in all of those. When technology is being considered for the school, she is an advocate for it and she pilots the equipment. Pedagogically, she doesn't view teaching solely as something she does to teach the content. She understands how important education, in general, is for students. She mentioned being able to put the "have nots" on an equal playing field. She wants to teach the content, but she is most passionate about teaching the child. Concerning her content knowledge, she has an advance level of understand of science. She does not view it as a collection of facts, but rather as a way of viewing the world.

Case 5 – Emerson

Emerson teaches at the same school as Riley, which is within the same county as Taylor. Emerson is new to Leonardo, and was recruited by Riley. He was excited to participate because he saw the advantage that Riley's students had from using the ESNs. Although new to Leonardo, he was not new to teaching. He has spent more than 30 years in an elementary classroom.

Baseline interview. Emerson's baseline interview took place in his classroom in May of 2014 prior to the implementation of the Leonardo Project. During the interview he spoke about the way he is trying to increase technology use in the classroom and the support he receives from the county. Although barriers were asked about and he spoke of them, he maintains a positive attitude in the face of adversity. He does what is asked of him, and he didn't complain at length about unreasonable expectations or barriers. As with other cases,

the external factors were considered to be: (1) social norms, (2) support, and (3) barriers, and internal factors are explored through open-ended questions and the STEBI questionnaire.

External factor. Emerson spoke about the role that the current administrative team played in establishing social norms because he said they are vocal about their expectations. He also referred to things that other teachers are doing, and he commented that all fourth grade teachers frequently collaborate when planning. He is dependent on this collaboration when it comes to teaching science.

Emerson was asked about social norms [i.e. expectations] concerning teaching science, and he said, "The easy answer to that is to teach the curriculum." His classroom practices are greatly influenced by the common core standards as well as by the requirements from the county that teachers use the kits. He noted that he found the kits very helpful for him, so when the county reduced the number of kits purchased, he had to turn to other teachers for help with planning the science units that were no longer supported by the kits.

When speaking about the social norms surrounding technology, he referenced the SmartBoards™ and also a couple of laptops carts shared among one grade level. Emerson also mentioned that the administration team had to pull together funds from multiple sources [e.g. PTA and Title I] to pay for the SmartBoards™ in the classrooms. Adding, "He is not ever saying you must do this amount of time…so it sorta is whatever we need," but Emerson added that the push to have assessments online is likely what is behind administrators wanting to see teachers using the SmartBoards™ daily, and Emerson notes that teachers are doing so. Addition, she stated, "generally the way it works is if there is a new batch of computers involved they go to the high school, and then whatever the high schooler had - it

trickles down to the middle school; and whatever the middle schoolers had - it trickles down to the elementary school, so by the time we get 'em…they are old," which he followed with, "but yeah I mean, I get it."

When asked about social norms and expectations for teaching writing, Emerson stated, "I like writing, but I hate teaching writing." He integrated it into his curriculum, but it was not something he excelled at. In thinking more about that he stated that an explanation for that may be the fact that 4th grade isn't a testing year for writing. In terms of incorporating writing in order to teach science, he spoke about how he started off many of the past school years with the best of intentions. He would ask student to use science notebooks to record what they did during science lessons, and although he implemented them well in the beginning, his failed to continue their implementation once students returned for the second semester. It is a personal goal for him to improve upon how he uses science notebooks, which is something that he hopes Leonardo helps with.

When answering questions concerning support Emerson referenced PD often. He was pleased with the level of support he received in the form of PD from the county. He stated that, if the county mandated it, they provided PD for it. He noted the significant amount of support he received in order to integrate technology, and he also mentioned the PD that focused on how to use the science kits as well.

Emerson succinctly mentioned three barriers: (1) funding, (2) lack of technology in the hands of the students, saying, "One-to-one would be ideal," and 3) not having a science resource specialist. The last two barriers are likely related to the first, but Emerson didn't elaborate on barriers.

Internal factors. Emerson is not particularly verbose. He doesn't naturally elaborate when giving answers. He is confident in his ability to teach and prepare his students, but he does not feel compelled to share his thoughts or influence the practice of others. Despite the fact that he has been practicing for more than 30 years, when I would ask theoretical questions, he would often start his answers when something along the lines of, "well, you probably know that better than I do."

He believed that what he did in his classroom had a direct impact on student learning and understanding. He had areas, such as writing, that he wanted to improve upon. He was driven by the belief that if he did better, his students would do better. Emerson was confident, but also willing to learn from other educators.

STEBI.

Table 12. Emerson's STEBI responses.

Prompt	Baseline	Follow-up
When a student does better than usual in science, it is often because the teacher exerted a little extra effort.	4	4
I will continually find better ways to teach science.	4	4
Even if I try very hard, I will not teach science as well as I will most subjects.	4	4
When the science grades of students improve, it is often due to their teacher having found a more effective teaching approach.	4	4
I know the steps necessary to teach science concepts effectively.	3	3
I will not be very effective in monitoring science experiments.	4	4
If students are underachieving in science, it is most likely due to ineffective science teaching.	3	3

Table 12 Continued

I will generally teach science ineffectively.	4	4
The inadequacy of a student's science background can be overcome by good teaching.	4	4
The low science achievement of students cannot generally be blamed on their teachers.	3	3
When a low-achieving child progresses in science, it is usually due to extra attention given by the teacher.	4	4
I understand science concepts well enough to be effective in teaching elementary science.	4	4
Increased effort in science teaching produces little change in students' science achievement.	5	5
The teacher is generally responsible for the achievement of students in science.	4	4
Students' achievement in science is directly related to their teacher's effectiveness in science teaching.	3	3
If parents comment that their child is showing more interest in science, it is probably due to the child's teacher.	3	3
I will find it difficult to explain to students why science experiments work.	4	4
I will typically be able to answer students' science questions.	4	4
I wonder if I will have the necessary skills to teacher science.	3	3
Given a choice, I will not invite the principal to evaluate my science teaching.	4	4
When a student has difficulty understanding a science concept, I will usually be at a loss as to how to help the student understand.	4	4
When teaching science, I will usually welcome student questions.	5	5
I do not know what to do to turn students on to science.	4	4

Once questions were coded and grouped, median and mean were found for the entire STEBI questionnaire, as well as mean and median for the questions addressing outcome expectancy and for questions solely addressing efficacy. That information can be found in Table 13.

Table 13. Mean and Median for Emerson's STEBI responses.

	Baseline median	Follow-up median	Baseline mean	Follow-up mean
STEBI	4	4	3.86	3.86
Outcome Expectancy	4	4	3.7	3.7
Efficacy	4	4	4	4

In looking at the Baseline STEBI, Emerson gave a positive response 76% of the time, with 60% of the responses concerning outcome expectancy being positive, and 91% of the efficacy-based responses being positive. He gave no negative responses, leaving 23% of his responses neutral. Comparing Emerson's baseline and follow-up STEBI shows that Emerson's responses did not change.

Final interview.

Technological knowledge. He is knowledgeable about how to use the technology, but he does not claim to be an expert. Since getting the SmartBoard™ in his room two years ago, he has learned a great deal about how to use it in order to support the students. He mainly uses the SmartBoard™ for "linking to YouTube videos and bringing in the outside world."

He wonders about sustaining the impact of technology, saying that, "after the 3rd day, they [i.e. students] prefer games, and it is good when used effectively, but it is easily a babysitter." When asked specifically about technology in science, he commented that while there are a lot of apps that help support learning in reading and math, it is hard to find science specific apps.

Pedagogical knowledge. While Emerson is confident in his pedagogical knowledge, he doesn't always feel like what takes place in the classroom is up to him. Therefore, we speaking about his ability to impact students learning he deferred to talking about the curriculum instead of elaborating on his pedagogical practices that support students learning. He added, "A lot of work is done for the teachers; whether they like it or not, there is curriculum." He mentioned the collaboration that takes place between the fourth grade teachers at his schools, and he noted that teachers have a specialty and they plan for everyone else.

Content knowledge. Emerson is very familiar with the 4th grade curriculum, and while he speaks in a modest way about his knowledge, he understands the curriculum and the content very well. He assessed his own content knowledge by noting that his science content knowledge is not his strongest area, so he does appreciate the help from his peers; however, he does understand the curriculum well.

Summary. In summarizing Emerson's interview data through the teacher belief lens, Emerson presents himself as someone who is very compliant with both the administration and the curriculum. He referenced the decisions of others when talking about what took place in his classroom. He doesn't necessarily lack confidence, as seen in his STEBI data, but he doesn't speak about himself as a teacher leader who is purposeful in the making decisions

about his classroom. Social norms and expectations have the greatest impact on his decisions, and he doesn't focus a lot of attention on barriers.

In looking at the TPACK framework, he was self-assessed as having sufficient content knowledge and pedagogical knowledge in order to be an effective teacher, although he referred to the fact that others in the school were more adept in these areas than he was. In terms of his technology knowledge, he used the technology that was in the classroom, but he understood that wasn't using to its greatest potential.

Research Question 2. The second research question is, "How do these beliefs manifest in the classroom through established learning goals, use of instructional strategies, and/or implementation of ESNs?"

Each observation will be discussed in the following sections: introduction to the lesson, how the students were grouped, the role of the teacher during the lesson, how the teacher and the students used technology, student engagement, how the lesson closes, notable dialogue between the teacher and students, and notable dialogue between researcher and teacher. An overview is provided of each lesson.

Additionally, the lessons are looked at collectively in order to establish a pattern of instructional modes and materials used. Tallies were taken to record how the class was structured in order to deliver content to the students and what material were used to do so.

Case 1 - Dana

Dana was observed three times over the course of a week. Not only was she new to Leonardo, but this was only her third month of teaching.

Observation 1. This is the third day of The Leonardo Project, and students are on starting the second Focus Question. Forty minutes have been allotted for science. Prior conversation between the teacher and the research revealed that the teacher does not have concerns about moving forward, but the teacher did express that she has not familiarized herself with the content yet. She is delighted to have the help with teaching science, not because she doesn't know the content, but because she doesn't have time to plan. Even with

the focus questions not saving, Dana doesn't complain. She believes her students are learning through this experience, and that is her priority.

Table 14. Dana's Observation #1 Notes.

Points of Interests	Notes
Introduction to the Lesson	There is not introduction other than passing out the iPads and telling students to log in and get started on the Focus Question 2.
Student Groupings	Desks are placed together in pairs so each student has one other person to work with.
Role of the Teacher	Teacher remains timid and uninvolved in the process. Students are well-behaved so teacher rarely intervenes. She does tell students to reread the material, when they come to her after 5 minutes and ask for hands-on material, which should have taken 10-15 minutes to get to.
Technology use	
Student Engagement	Students have struggled with basic directions in the past, and today they are rushing through the material to get to the hands-on part of the lesson. They are engaged and excited, but they were finished with the lesson in 30 minutes, and they still don't seem to understand the content.
How the lesson concludes	Teacher does not engage the class in a discussion nor does she offer a conclusion. She simply tells them to pack up the iPads and deliver to the teacher who will be using them next. All of the discussion is around procedure rather than content.
Dialogue between teacher and students	Students initiate a majority of the dialogue, and it is when they need materials or have a question.
Dialogue between teacher and researcher	Teacher asks the research about what she should say to the students to get started.

Observation 2. Students worked on Focus Question 4 during this lesson. When asked prior to the lesson, the teacher reiterated that she loved Leonardo, and when I asked about issues, she had no complaints. Because I had noticed that she was not having any type of closing discussion with students, I suggested a brief "wrap up" of the lesson. She indicated that she liked that idea. Additionally, the teacher had to provide more instructions and

assistance to the students in order to fill in the gaps left by Leo meaning she was going around to individual students and addressing their questions one at a time. It should also be noted that, Dana spends a majority of the time that students are working on the iPads to catch up on other things around the classroom.

Table 15. Dana's Observation #2 Notes.

Points of Interests	Notes
Introduction to the Lesson	The iPads were passed out about ten minutes past the start of science time and students began working.
Student Groupings	Because today's hands-on lesson was a little more intense (and to make the most of the supplies), the teacher placed students in groups of 4 or 5, and they could arrange themselves around the room. Many of them decided to sit, in the groups, on the floor.
Role of the Teacher	As the lesson started students were not getting enough instructions from Leo to know exactly what to do, so the teacher had to intervene in the lesson frequently. She had looked at the lesson ahead of time so she knew what they needed to do, so she gathered everyone's attention to show them how to arrange the switch so they can test conductors and insulators.
Technology use	The teacher did not interact with the technology. She relied on the students to navigate and problem-solve.
Student Engagement	They are highly engaged in the process, but they are not answering questions, asked by Leo, that indicate that are comprehending the material
How the lesson concludes	There was not a conclusion from the teacher.
Dialogue between teacher and students	She rarely intervened for pedagogical support. She would manage students' behavior when they were not on task, but she did not engage with them about the content on the lesson.
Dialogue between teacher and researcher	We discussed how much she likes Leo, and we talked about the need to set up the lesson and conclude it because Leonardo was not necessarily providing that.

Observation 3. When talking to Dana prior to the lesson, she indicated that she thought the third and fourth focus question could be completed in one day. At this point, she is becoming more comfortable with the curriculum, and now that she has looked through the entire unit she is comfortable making suggestions. Her schedule is more flexible that some, so she would like to combine the two focus questions to save on time, but that is not possible for every teacher. Based on what she has mentioned when planning to implement Leonardo, Dana has a lot of autonomy with her schedule (as long as math isn't cut short).

Table 16. Dana's Observation #3 Notes.

Points of Interests	Notes
Introduction to the Lesson	For the first time, the teacher provides a brief introduction so students know what to expect today. She also asks students to recall what they did yesterday.
Student Groupings	The groups are larger now with 4 to 5 in a group, and they continue to place themselves around the room on the floor.
Role of the Teacher	She is more comfortable with the content of Leonardo now, so she will engage more students in conversation, especially if those groups finish early. She remains dependent on Leo to teach a majority of the lesson.
Technology use	
Student Engagement	They work quietly, and they ask a lot of questions. Some groups are done in just 20 minutes, while other groups take twice as long. It is not easy to tell if students are reading as thoroughly as they should in order to understand the content.
How the lesson concludes	There is not a conclusion to the lesson.
Dialogue between teacher and students	Students reach out when they have questions.
Dialogue between teacher and researcher	Dana continues to speak highly of Leonardo.

Frequency counts for mode of instruction and materials used. In addition to summarizing the observations individually, they were looked at as a whole in order to get a

sense of the instructional mode of the teacher and of the materials used by the individual teachers. Table 17 shows summed frequency counts of pedagogical practices by the teacher for the three lessons that were observed, and the total time observed for the three observations is approximately 100 minutes.

Table 17. Dana's Frequency Count – Mode of Instruction and Materials Used.

Mode of Instruction	Frequency Count	Materials Used	Frequency Count
Whole Class Instruction	4	Printed Reading Material	0
Hands-on Activities	8	Computer/Technology	19
Homework/Classwork Review/Correction	0	Overhead Projector or LCD	0
Group Presentation (student)	0	Chalkboard/ Whiteboard/Chart Paper	0
Reading Textbook or Kit Materials	17	Videos/Film/Music	0
Teacher Demonstration	3	Demonstration Models	0
Small Group Work	9	Manipulatives/hands on Equipment	9
Data Collection and/or Manipulation	9	Worksheets	0
Individual Seat Work	8	Science Notebooks	19
Open Ended Inquiry	16		

Table 17 shows that Dana did not supplement the ESN with any additional materials. She did vary the mode of instruction slightly, in that she sometimes addresses the whole class while other times she had students working in small groups.

Case 2 - Sam

Sam was observed three times in an 8-day window. This was done approximately 11 weeks into the school year.

Observation 1. This was the first day of Leonardo so students are getting to touch the iPads for the first time. This is the first time they are logging into the system, seeing the interactive space on the CyberPad, and answering questions about electricity. The teacher was not prepared to introduce the iPads because she thought we would do it. She had not looked at the program since the PD that was offered by the Leonardo research team, which was over a month ago.

Table 18. Sam's Observation #1 Notes.

Points of Interests	Notes
Introduction to the Lesson	Sam was under the impression that the Leonardo team would be leading the lesson so she was not prepared to introduce the lesson; therefore, the researcher did so.
Student Groupings	Although it would not always be the case, today the students were working as individuals.
Role of the Teacher	Sam was not very involved with today's lesson.
Technology use	Students were using the iPads for the first time. They seemed to understand how to use the technology, but they were not comfortable with letting the technology guide them. They relied on input from the teacher and researchers concerning what to do next, even when instructions were on the screen.
Student Engagement	Students were highly engaged and focused.
How the lesson concludes	The teacher asked what everyone thought of Leo so far and she asked if they had any questions. Students took most of the allotted time to complete the tasks so they rushed out when done.
Dialogue between teacher and students	The teacher communicates expectations concerning behavior to the students, but the science and technology instruction was given by the researchers.
Dialogue between teacher and researcher	Teacher was excited to be part of the program. She really didn't have any questions or concerns, and once she realized that she would need to be prepared to lead the students she did so.

Observation 2.

Table 19. Sam's Observation #2 Notes.

Points of Interests	Notes
Introduction to the Lesson	Sam doesn't do much of an introduction. She passes out iPads and tells students to get started.
Student Groupings	Students work independently.
Role of the Teacher	She is calm and speaks very kindly her to students, but she maintains strict expectations. She does not interrupt students during the lesson to check for understanding. They let her know if they have a question, but she doesn't check with the entire class. When they are done, they already know to get out a book and wait quietly.
Technology use	All of the students use the iPads the duration of the lesson. The only issue is that students are struggling to either read directions or place faith in what Leo is telling them. For example, even when prompted to click submit and move on in the agenda, students raise their hand to ask what they should do next.
Student Engagement	This class is not just quiet, it is almost silent. They were on the activity with no off topic conversation, but other than checking their answers to see how well they understand the material, it is difficult to notice whether or not students are engaged in reading the material.
How the lesson concludes	Teacher doesn't formally close the lesson.
Dialogue between teacher and students	Students are comfortable asking the teacher if they have questions, but they rarely do. They also know what to do when they are finished.
Dialogue between teacher and researcher	Teacher stated that a huge benefit of Leonardo was that a few of her students were being pulled out, so with Leo they could catch up later and it wouldn't require that she take her attention away from other students.

Observation 3.

Table 20. Sam's Observation #3 Notes.

Points of Interests	Notes
Introduction to the Lesson	All students are starting on Focus Question 6 today. Teacher passes out iPads to each student and reminds them to start on FQ 6. There is no other discussion of content.
Student Groupings	Student work in rows, alone. A majority of them have in earbuds. They do not interact with each other. When they are done, they read their books.
Role of the Teacher	Teacher walks around and looking over shoulders to check progress, but she doesn't interact with them while they are working.
Technology use	All students are on the iPads, and There are no technology issues.
Student Engagement	Student engagement seems high. The concern is how quickly they progressed through Focus Question. Some were done in 15 minutes, and many were done in 20.
How the lesson concludes	When students are done, they read a book. There is not a discussion concerning the content.
Dialogue between teacher and students	Very little.
Dialogue between teacher and researcher	None noted.

Frequency counts for mode of instruction and materials used. In addition to summarizing the observations individually, they were looked at as a whole in order to get a sense of the instructional mode of the teacher and of the materials used by the individual teachers. Table 21 shows summed frequency counts of pedagogical practices by the teacher for the three lessons that were observed, and the total time observed for the three observations is approximately 100 minutes.

Table 21. Sam's Frequency Counts – Mode of Instruction and Materials Used.

Mode of Instruction	Frequency	Materials Used	Frequency
Whole Class Instruction	2	Printed Reading Material	0
Hands-on Activities	0	Computer/Technology	12
Homework/Classwork Review/Correction	0	Overhead Projector or LCD	0
Group Presentation (student)	0	Chalkboard/ Whiteboard/Chart Paper	0
Reading Textbook or Kit Materials	9	Videos/Film/Music	0
Teacher Demonstration	0	Demonstration Models	3
Small Group Work	0	Manipulatives/hands on Equipment	0
Data Collection and/or Manipulation	0	Worksheets	0
Individual Seat Work	8	Science Notebooks	10
Open Ended Inquiry	4		

Sam's primary mode of instruction was individual seat work. She addressed the class very little other than at the beginning of the lessons in order to get them started. She walked around to help students as individuals, and she did demonstrate if a student needed it, but that only occurred three times.

Taylor. Taylor was observed three times approximately 15 weeks into the school year, and her observations took place over the course of two weeks. Taylor has worked with the Leonardo Project in the past, and she is familiar with the content, material, and technology.

Observation 1.

Table 22. Taylor's Observation #1 notes.

Points of Interests	Notes
Introduction to the Lesson	Taylor has taught alongside Leo in the past so she prepares the students by letting them know that they need to read what Leo has to say and follow his instructions. She also reminds them that they need to answer in full, thought out sentences.
Student Groupings	Students are sitting in tables of four, but they do not work with anyone from their table today.
Role of the Teacher	She is very hands on and focused on the students and on their understanding of the content. She has high expectations for their level of engagement and participation.
Technology use	Technology is not cooperating, and students have expressed mild frustration with Leo.
Student Engagement	They know what is being asked of them, and they are very excited to have the technology. For some, it is their first time using an iPad.
How the lesson concludes	Unfortunately, this time period comes immediately before lunch, so there is a quick rush to close up the iPads and line up. Therefore, the lesson concludes with no discussion.
Dialogue between teacher and students	She talks mostly up front to let the students know that they are fortunate to have this opportunity, and that Leo is a great teacher, but they need to behave like great students and great scientists. She reminds them of how expectations.
Dialogue between teacher and researcher	The teacher is very excited to be able to participate and she is thankful that her students are getting this opportunity. She has no questions.

Observation 2. Most students are working on Focus Question 4 at this point. Also, Taylor has "check points" for the students. So they are to let her know when they revisit the focus question and when they are prompted by Leonardo to explain their predictions.

Table 23. Taylor's Observation #2 Notes.

Points of Interests	Notes
Introduction to the Lesson	Teacher does a class review asking, "What did we learn yesterday?" Students explained switches, and teacher reminds them to read everything Leo has to day.
Student Groupings	They are sitting in groups of 4, but until they get to the hands-on material they are working alone.
Role of the Teacher	She is very involved with the lesson. She stops the class to check on them, and she interrupts them twice to reprimand them for not
Technology use	Approximately half of the students are using headphones.
Student Engagement	The students are frustrated today by technology issues, such as their responses not saving. Because of this, they are frustrated and not able to focus on the content as they should. They continue to attempt the task at hand, but they are not particularly engaged. Although, 75% of the students work until they are out of time.
How the lesson concludes	After 40 minutes with the ESNs, 75% of the class is still working. The students have to pack up for lunch quickly so they were not able to finish or conclude. Teacher said she would conclude the lesson later in the afternoon when they had a flexible time slot.
Dialogue between teacher and students	Teacher had to interrupt 3 or 4 times to manage behavior. Teacher was very much in control of the pace of the lesson, and she directed students by prompting them and reinforcing what Leonardo was asking of them.
Dialogue between teacher and researcher	Teacher expressed disappointment that Leonardo isn't saving responses. She is contemplating asking students to record their responses in writing because she wants to be able to check their answers as well. Despite the challenge, she is still excited about participating because she knows it is good for her students to experience the technology.

Observation 3. At this point, a majority of the students have completed all of the focus questions, and they have moved on to the extension activities. This is the second day of the three day extension. The observation was originally scheduled to take place for days prior

to this, but Taylor was not at school that day because she was attending graduation. Taylor is the only teacher who assigned the extension activities to her class.

Table 24. Taylor's Observation #3 Notes.

Points of Interests	Notes
Introduction to the Lesson	The teacher introduced the lesson by asking students what went poorly in yesterday's lesson. They said they rushed and guessed, and didn't think. The teacher encouraged them to do better today, and she listed characteristics and behaviors she wanted to see: read wisely, LISTEN, guide with Leo, and follow directions. She also created her own Focus Question, "Should [School Name] use solar energy – why or why not?"
Student Groupings	Students worked individually today.
Role of the Teacher	She guided the students and pushed for them to read, think, and explain.
Technology use	Students were using the iPads today to read and answer questions.
Student Engagement	They seemed to be more engaged today, as they were more comfortable with the technology.
How the lesson concludes	Students are asked to write a paragraph in the science notebooks [paper], and the teacher checks them to make sure they are complete.
Dialogue between teacher and students	The teacher is very encouraging, and she is pushing them to do things even when those things are hard.
Dialogue between teacher and researcher	She said that days here continue to be "up and down," and she just has to play it by ear when students arrive. Sometimes they are focused and seem like they want to learn, and sometimes they are distracted and misbehaving. Today was a good day. Additionally, she enjoyed Leonardo again this year because she believes it is good that her students are exposed to this.

Frequency counts for mode of instruction and materials used. Table 25 shows summed frequency counts of pedagogical practices by the teacher for the three lessons that were observed, and the total time observed for the three observations is approximately 100 minutes.

Table 25. Taylor's Frequency Counts – Mode of Instruction and Materials Used

Mode of Instruction	Frequency	Materials Used	Frequency
Whole Class Instruction	8	Printed Reading Material	0
Hands-on Activities	6	Computer/Technology	20
Homework/Classwork Review/Correction	7	Overhead Projector or LCD	0
Group Presentation (student)	0	Chalkboard/ Whiteboard/Chart Paper	0
Reading Textbook or Kit Materials	15	Videos/Film/Music	0
Teacher Demonstration	5	Demonstration Models	0
Small Group Work	6	Manipulatives/hands on Equipment	6
Data Collection and/or Manipulation	6	Worksheets	0
Individual Seat Work	20	Science Notebooks	20
Open Ended Inquiry	6		

Taylor addressed the class and led them in reviewing or correcting their work often throughout the three observations. Her students mostly worked as individuals at their seat, but they would break into small groups for the hands-on activities.

Case 3 – Riley

Riley was observed with approximately four weeks left in the school year. Her three observation took place over a period of 10 days.

Observation 1. Today is the first day students are using the iPads/Leonardo. They participate in a tutorial, and they take a pre-test to assess prior knowledge.

Table 26. Riley's Observation #1 Notes.

Points of Interests	Notes
Introduction to the Lesson	The teachers explained how to use the iPad and how to navigate the Leonardo App. She had the iPad displayed on the SmartBoard™.
Student Groupings	Students were working solo although they sit where they can ask each other questions easily, if need be.
Role of the Teacher	Teacher explained the purpose of the ESN and how to use the technology. She was hands-off during this opening activity.
Technology use	All students spend the entire time on individual devices.
Student Engagement	Students were on tasks and appeared engaged in the activity the entire time.
How the lesson concludes	The teacher lets students know that they will start with electricity tomorrow.
Dialogue between teacher and students	She sets up the lesson at the beginning of the science block, but she doesn't interrupt them while they are working, often.
Dialogue between teacher and researcher	Teacher is excited to be returning to Leonardo. She doesn't have questions for the researcher, but she is open to the suggestion from the researcher of displaying the iPad.

Observation 2. Students worked on different Focus Questions, but for the most part they were on Focus Question 4, 5, or 6.

Table 27. Riley's Observation #2 Notes.

Points of Interests	Notes
Introduction to the Lesson	Teacher reminded students that they need pick up where they left off yesterday, and also they need to continue to read what Leonardo is saying and follow directions.
Student Groupings	Some were working solo, but most were using their own ESNs but also working in groups to complete the Focus Question.
Role of the Teacher	She walks around and checks on their progress and helps if they need it. She addresses the class to check-in on a couple of occasions.
Technology use	All students were using the ESNs the entire time. Approximately half of the students were still working in groups to complete the hands-on activities.
Student Engagement	They are all working at different paces, but they are all engaged in the activity at hand.
How the lesson concludes	Not noted.
Dialogue between teacher and students	She helps students when they ask for assistance, but other than that she allows them to pace themselves.
Dialogue between teacher and researcher	Teacher lets the researcher know that students are progressing at their own pace, and she thinks they will have plenty of time to get the post-test done by the end of the week.

Observation 3. Class started late today because they switched lunches with 5th grade. Most students are done with the electricity unit and taking the post-test, and the teacher anticipates that all will be done by the end of today or tomorrow.

Table 28. Riley's Observation #3 Notes.

Points of Interests	Notes
Introduction to the Lesson	Teacher handles the logistics – makes sure students know they should not be wasting time.
Student Groupings	Cooperative groups because of the way desks are arranged.
Role of the Teacher	More about logistics than content.
Technology use	None.
Student Engagement	They are becoming more comfortable with the technology so they are progressing faster through the app.
How the lesson concludes	Students who have finished the electricity unit are told to read and work quietly while classmates finish. Those who are still working, do so up until they are out of time.
Dialogue between teacher and students	Teacher handles logistics of pacing.
Dialogue between teacher and researcher	Teacher lets researcher know how students are progressing in terms of pacing, and she comments that students are less intimidated when answering questions for Leonardo. She also adds how helpful it has been to be able to pair students in order to help those who struggle with reading.

Frequency counts for mode of instruction and materials used. Table 29 shows summed frequency counts of pedagogical practices by the teacher for the three lessons that were observed, and the total time observed for the three observations is approximately 100 minutes.

Table 29. Riley's Frequency Counts – Mode of Instruction and Materials Used**.**

Mode of Instruction	Frequency	Materials Used	Frequency
Whole Class Instruction	13	Printed Reading Material	0
Hands-on Activities	2	Computer/Technology	18
Homework/Classwork Review/Correction	0	Overhead Projector or LCD	4
Group Presentation (student)	0	Chalkboard/ Whiteboard/Chart Paper	0
Reading Textbook or Kit Materials	16	Videos/Film/Music	0
Teacher Demonstration	2	Demonstration Models	0
Small Group Work	3	Manipulatives/hands on Equipment	4
Data Collection and/or Manipulation	0	Worksheets	0
Individual Seat Work	18	Science Notebooks	18
Open Ended Inquiry	4		

Riley addressed the class frequently because whenever one student had a question, she would answer it for the entire class to hear. She demonstrated using the SmartBoard™ at the beginning of two of the lessons. Her students worked individually at their seats for most of the lessons.

Case 5 – Emerson

Emerson was observed on the same days as Riley's because Emerson and Riley teach at the same school. Unlike Riley, this is Emerson's first time with Leonardo.

Observation 1. Because this is Emerson's first day implementing the ESNs, the researcher helps students logging in and offers suggestions for how to get the students started.

Table 30. Emerson's Observation #1 Notes.

Points of Interests	Notes
Introduction to the Lesson	None noted.
Student Groupings	Students are arranged in rows and they work independently.
Role of the Teacher	Helpful to students one-on-one
Technology use	Students use ESNs and teacher doesn't use any this day.
Student Engagement	Students are willing participated, but they are not particularly excited.
How the lesson concludes	Teacher collected iPads.
Dialogue between teacher and students	No content was discussed – it focused on using the technology.
Dialogue between teacher and researcher	Teacher is excited to be using the technology, and he thinks this is good for the students to be exposed to this.

Observation 2. Emerson has kept the students working at the same pace. If students don't finish and need extra time, they are given time to catch up during the morning. Almost all students are working on Focus Question 6.

Table 31. Emerson's Observation #2 Notes.

Points of Interests	Notes
Introduction to the Lesson	Teacher using the SmartBoard™ to point to the focus question/main topic for the day.
Student Groupings	Students work individually – there are no hands-on materials today.
Role of the Teacher	Teacher sets up the lesson thoroughly. He covers some of the content, asks students to recall prior knowledge, and he gets them thinking about the questions they will answer this day.
Technology use	SmartBoard™ by the teacher and ESNs by the students.
Student Engagement	Students seem to be focused and working, but they are not necessarily excited.
How the lesson concludes	Not Noted.
Dialogue between teacher and students	He helps them get started and he lets them work independently. He answers questions if they have them, but he doesn't interrupt.
Dialogue between teacher and researcher	The teacher is pleased with how it is going.

Observation 3. Students take the post-test.

Table 32. Emerson's Observation #3 Notes.

Points of Interests	Notes
Introduction to the Lesson	Teacher goes over the material to review with the students before they take their post-test.
Student Groupings	Working individually.
Role of the Teacher	Does not interact with the students a great deal today – until they are done with the post-test.
Technology use	SmartBoard – teacher. ESNs – students.
Student Engagement	Fairly engaged.
How the lesson concludes	Not noted.
Dialogue between teacher and students	Teacher addresses the entire class at the beginning of the science block.
Dialogue between teacher and researcher	Not noted.

Frequency counts for mode of instruction and materials used. Table 33 shows summed frequency counts of pedagogical practices by the teacher for the three lessons that were observed, and the total time observed for the three observations is approximately 100 minutes.

Table 33. Emerson's Frequency Counts – Mode of Instruction and Materials Used.

Mode of Instruction	Frequency	Materials Used	Frequency
Whole Class Instruction	7	Printed Reading Material	0
Hands-on Activities	0	Computer/Technology	18
Homework/Classwork Review/Correction	0	Overhead Projector or LCD	12
Group Presentation (student)	0	Chalkboard/ Whiteboard/Chart Paper	0
Reading Textbook or Kit Materials	17	Videos/Film/Music	0
Teacher Demonstration	4	Demonstration Models	0
Small Group Work	0	Manipulatives/hands on Equipment	3
Data Collection and/or Manipulation	0	Worksheets	0
Individual Seat Work	18	Science Notebooks	18
Open Ended Inquiry	5		

Emerson demonstrated some of the activities for his students, and he supplemented the material with a few facts about electricity or magnetism at the beginning of each lesson. He kept the SmartBoard™ on for most of the lesson with the Focus Question displayed, but he didn't reference the SmartBoard™ other than at the beginning.

Research Question 3. The third research question is, "How can understanding teachers' expressed and entrenched beliefs better inform PD?"

After analyzing the data in order to address the first two research questions, a theme emerged that placed the teachers into two distinctly different groups. In order to best answer this third research question, teachers will no longer be discussed as individual cases. Rather, Case A is comprised of teachers who were implementing Leonardo and ESNs for the first time. Therefore, Case A includes: Dana, Sam, and Emerson. Case B consists of those teachers returning to the Leonardo project, therefore were more familiar with the affordances, limitations, and applications for the ESNs. Case B includes: Taylor and Riley.

Qualitative data. Qualitative data were collected during the baseline interview and during the implementation of the ESNs. When interviewed about the support they received in the form of professional development, there was not a great deal of continuity among Case A. While Dana was only sure of a few opportunities to receive support; Sam, who taught in the same county as Dana, felt supported and was even participating in focus groups and delivering PD. Emerson also felt supported, but he felt it came as a result of mandates and a push for higher test scores. When looking at Case A as a whole, perception concerning professional development seemed to be highly individualized. Case B teachers spoke more critically of the PD they received. Teachers here spoke about PD that was delivered by individuals who were not familiar with the district or the curriculum, and there was also frustrated expressed about the fact that while intentions may be good, the lack of follow-up and thoroughness led to PD that was usually half of what it could be.

One other qualitative data point of relevance emerged during the implementation of the ESNs; it was not originally intended to be collected as data. With all teachers, researchers were on-site during the first day of the implementation to ensure its success. However, teachers depended on the researchers to varying degrees. Case A was especially dependent, relying heavily on the researchers to help with the implementation of ESNs. One teacher in this case, did very little talking during the first day and had not reviewed the material on the app since the PD provided to get all teachers started. Conversely, the teachers in Case B proceeded with the lesson as if the researcher wasn't there.

Quantitative data. The observation protocol allowed for collection of data pertaining to the mode of instruction that was taking place. Chi Square Analysis was performed to compare Case A and Case B in the following areas: whole class discussion and teacher demonstrations. The difference between the cases in the mode of whole class discussion was statistically significant ($\chi^2(1) = p < .001$). There was no statistically significant difference between the cases concerning teacher demonstrations ($\chi^2(1) = p = .26$).

Additionally teachers were asked to self-assess their technology expertise numerically on a scale of 1-7, with 1 representing a complete novice and 7 representing an expert. They were asked to differentiate between technology knowledge in general and technology knowledge that applies to teaching science. Table 34 compiles each individual's perceived expertise with technology.

Table 34. Summary of Teacher Beliefs concerning their technological knowledge.

	Perceived expertise with computers/software in general	Perceived expertise with computer/software for teaching science
Dana	4	3
Sam	6	6
Taylor	5	4
Riley	5	6
Emerson	5	4

Dana has the lowest perceived sense of expertise, which she also addressed during the interview. Sam and Riley are the lead teachers concerning technology at their schools.

DISCUSSION & IMPLICATIONS

The purpose of this study was the answer the following research questions: (1) What are teachers' self-reported beliefs that influence their pedagogical decisions concerning writing and technology use to teach science, (2) How do these beliefs manifest in the classroom through established learning goals, use of instructional strategies, and/or implementation of ESNs, and (3) How can understanding teachers' expressed and entrenched beliefs better inform professional development (PD)? In order to research those questions, data were collected in the form of interviews and classroom observations. The analysis of the data provided: (a) insight into the internal and external factors that influence a teacher's beliefs, (b) understanding of how beliefs impact classroom practice, and (c) information to consider when planning and implementing a PD for teachers. The overall goal of this study was to better understand how to support teachers as they used technology and writing in their science lessons. This required understanding the beliefs that impacted a teacher's decision. In this study, teachers were asked to self-assess their beliefs, knowledge, and practice. Also, formal classroom observations were conducted to see how technology was being leveraged and how science was being taught through the use of ESNs. After the findings are discussed below, this chapter will also include: (a) implications for PD providers, (b) thoughts on future research, (c) a discussion of limitations of this study, and (d) a conclusion.

Discussion

Research Question 1. In order to better understand teacher beliefs, teachers reported on the external and internal factors that potentially influenced their beliefs. Internal factors (see Figure 3) included self-efficacy, outcome expectancy, years in the classroom, and

knowledge concerning technology, pedagogy, and science. External factors that influenced a teacher's beliefs were norms, facilitating conditions, perceived support, perceived barriers, and perceived ability levels of the students.

Internal factors. Dana had the lowest mean of the STEBI results (Table 3) concerning both outcome expectancy and efficacy; she also had the fewest years teaching. However, years of experience did not necessarily coincide with a greater sense of efficacy or sense of control; Emerson had the most years in the classroom yet he didn't have the highest STEBI mean (Table 12) nor did his qualitative data indicate he was as confident as some of the others in the study with fewer years in the classroom. Riley and Sam had been teaching for a similar number of years, and they both had a high level of technological, pedagogical, and content knowledge (TPACK). Riley had the most positive response rate on the STEBI, indicating she was more confident in her ability to teach science and influence student learning than anyone else in the study. Although Riley and Sam both self-assessed as having a high TPACK, their beliefs concerning core instructional strategies for science did not align well. Sam, who had a slightly lower positive response rate on the STEBI than Riley, spoke about science as a collection of facts, and that she believed she needed to directly teach those facts to the students. In contrast, Riley spoke about science being more of a process she wanted her students to experience.

Another finding was that technological knowledge (TK) and content knowledge (CK) in the context of this study seemed to shape a teacher's perception of their teaching ability more so than pedagogical knowledge (PK). The teachers, who reported, via the STEBI, higher degrees of self-efficacy and a greater sense of influence over student learning, self-

assessed as having higher TK and CK compared to others in this study. Looking at Emerson, he had an average level of TK and CK but a strong grasp on PK; yet he didn't speak as confidently about influencing student learning as Riley nor Sam, who expressed a greater TK and CK than Emerson. Taylor understood the science content, but she said she knew she needed to understand it better. She had a well-developed understanding of pedagogical strategies; however, her TK was average, like Emerson's. Paralleling Emerson, Taylor was not as confident as Riley and Sam. An increased comfort level with technology may account for the confidence level of teachers in this context because ESNs are such a technology-focused resource. Concerning CK, it was mentioned above that Riley and Sam spoke about science differently, so while they both self-assess as having a high CK, a distinction was not made between science being a collection of facts verses a process, confounding the interpretation of the influence of CK on a teacher's beliefs concerning ESNs.

Analysis of the interview data revealed a dichotomy in the participants as either a leader or a follower. Roby (2011) described teacher leaders as those who have the "ability to shape the culture of the workplace." Dana, based on this definition, would be considered a follower. She referenced another fourth grade teacher often when speaking about what she does in the classroom. She is dependent on her colleague to help with plans and answer questions. Additionally, Dana did say during the baseline interview that she believed PD would be helpful in making her more self-sufficient. Taylor expressed a desire to be a teacher leader, yet she still felt like decisions she made in the classroom were driven by factors she could not control, such as expectations of her administration, and she remained dependent on her colleagues and school to help with decisions. Also, Taylor spoke about her strong

pedagogical practices, but she still struggled with classroom management. Dana and Taylor have the least amount of teaching experience among those in the study, which may contribute to their hesitation to take on a leadership role. Muijs, Chapman, and Armstrong (2013) make the case that in order for early career teachers to be leaders, the senior members of the staff and administration must be committed to "distributed leadership," thus giving teachers a chance to develop these abilities.

Sam and Riley, who spoke with confidence, have been teaching for many years, and they described themselves as teacher leaders. Sam planned and implemented PD for her school, and she participated at the county level with making decisions about how science should be taught. Sam possessed a great deal of autonomy concerning scheduling and content. Riley also reported a high skill level concerning all facets of TPACK. She did not necessarily find favor with the PD she was receiving, in that she spoke about it being from outsiders and not necessarily based on what she knew was best for her students. Unlike Sam, Riley didn't believe she had the ability to modify the daily schedule, but she did say that she always tried to plan based on the big picture concerning what her students needed, regardless of the pressures of assessments.

Breaking from the alignment of experience and being a teacher leader, Emerson had been teaching the longest among everyone in this study, but he was also happy to simply go along with what others asked of him. He set a great example with his classroom practice, but he was not inclined to lead others. He didn't necessarily lack confidence, he just spoke of his ability with humility and in such a way that indicated he wasn't one to put too much thought into things he didn't feel he could control. Here the role of personality, rather than

experience, may be what contributed to Emerson not speaking as a teacher leader. He did what he could in his classroom, and although he did express some frustration with the current administration, he dismissed it quickly. It should be noted that Emerson had enough years to retire. He was staying in the classroom because he genuinely enjoyed being there.

External factors. In shifting the focus to external factors, such as social influence and facilitating conditions (Table 3), there was a great deal of correspondence among the teacher responses. For example, when asked about barriers, they all mentioned time, funding, and testing. However, they didn't all speak about them in the same way. In addition, they all spoke about the expectations of their administrations and their students' ability levels.

Sam was the only one who believed she could easily overcome the problem of not having enough time. She prioritized student learning above all so if she had to take more time to re-teach something, she didn't hesitate to do so. This can be attributed to both facilitating conditions (i.e., she had a favorable perception of the support she received) and social influence. She had great rapport with her colleagues and administration. Because she didn't feel micro-managed, she used the autonomy to make learning her focus. She did mention that the decisions made by administration were likely due to the focus on assessment, but again she reiterated that she felt she could work within that requirement to help her students be successful. Concerning the barrier of time, Dana and Taylor expressed frustration with all that was asked of them given the time they had, and Taylor worried that student learning suffered because of it. Furthermore, Taylor spoke about the shortage of time as if her administrators should do something to remedy the problem. Taylor wanted to focus on writing more, but she did not believe she was given enough time. She also wanted to use

technology more, but here again she believed that a lot of instructional time would be spent trouble-shooting and scaffolding the technology. This belief was probably influenced by the low technological knowledge of her students, and this manifested in her classroom practice because students did not use technology as much as Taylor intended for them to. Dana spoke about the time shortage as simply part of the job.

More so than time, Riley and Emerson were frustrated with the pressure they felt due testing; although Emerson did not linger on the topic per his tendency to minimize issues when speaking about them. Riley went on to speculate that the PD she was mandated to attend was likely provided in response to what was being tested. On the topic of testing, Taylor, Emerson, and Riley all commented that the elimination of the writing test resulted in writing receiving less attention during instruction. Conversely, Riley stated at another time that she did not make her decisions based on the state test.

Ability level of students, as well as their needs, also seemed to influence some of the teacher's beliefs. Riley spoke a great deal about what she believed was best for her students, and she often explained that their needs where behind the decisions she made. Sam did this too, but a lesser extent. Taylor spoke more specifically about how the ability level and behavior of her students influence her beliefs about how to best teach them. She expressed worry at times when talking about her students, and she believed it was her job to be a positive influence for them. Dana did not reference her students a great deal, and neither did Emerson, although Emerson did say he continued to teach because of them.

Research Question 2. The second research question looked to better understand how beliefs operationalize to become entrenched behaviors in the classroom. When discussing scaffolding, a distinction may be made between the two types of scaffolding: hard and soft (Saye & Brush, 2002). In addition, Tabak (2004) referred to distributed scaffolding, a complimentary way to think of how the pedagogical role of scaffolding was shared between teacher and technology. These two concepts will help guide the analysis of this research question.

Dana did not scaffold the technology, the content, or the writing; so there was no distributed scaffolding between teacher and technology. Dana, who self-assessed as having low TK and CK simply passed out materials and depended on Leonardo to teach the students. On two of the three observations, she did not have a whole class discussion with her students about what they were learning. Additionally, she also did not believe she was supported in developing her TK so she did not integrate technology outside of the Leonardo project.

Sam was confident and had high TPACK, yet she too let Leonardo deliver and pace the lessons. Sam did monitor the students one-on-one, and she provided them answers when they asked questions, but she did not actively design the lesson nor did she allow for whole class discussion at the conclusion of a lesson utilizing Leonardo. Sam did read what students were writing, so while she did not scaffold the technology or the content, she did provide soft scaffolding to individual students.

Taylor actively scaffolded the technology for her students, and this may be impacted by her expressed belief that her students struggle to use technology. Taylor did not offer a lot of scaffolding of the science content on the ESNs, but she provided a great deal of hard and

soft scaffolding for the writing process. She had checkpoints established, where students had to check in with her before they advanced to the next screen on the ESN, and she also talked with them about the importance of using the word "because" when practicing writing like a scientist.

Riley, like Taylor, would interrupt the ESN lesson in order supplement with whole class instruction. For Taylor, this was planned in advance, but for Riley is was something that emerged as students asked questions. Riley did scaffold the technology and the content, but she did not scaffold the writing process.

Emerson felt like he could successfully teach the material without Leonardo, but he did express gratitude for the opportunity Leonardo was providing for his students. He offered a small amount of scaffolding for the technology and also provided additional hard scaffolding outside of Leonardo by displaying the focus question for the day using his SmartBoard™. Emerson did not scaffold the writing process.

For the teachers in this study, there wasn't a relationship between a teacher's TPACK and the way s/he scaffolded the technology, content, and writing. While a teacher with low CK and TK (e.g., Dana) offered little-to-no assistance with scaffolding the technology or the content; Sam self-assessed as having a high TPACK, yet she did not scaffold the technology for her students, nor did she assist Leonardo with delivering the content. Taylor and Emerson both have high PK and average TK and CK, but scaffolding looked very different in their classrooms. Emerson provided hard scaffolding to a small extent, and Taylor supplemented Leonardo to scaffold the writing process with hard and soft scaffolds. Riley did not scaffold

the writing process. She did scaffold the technology and the content, but not to the extent that Taylor did.

Concerning writing, Abell (2006) distinguished between writing *in* science and writing *to learn* science. Only one teacher, Taylor, demonstrated the latter. While Emerson spoke of about his intention to have students write in order to learn, this was not a practice he demonstrated during the observations. Based on the interviews, Riley, Emerson, and Sam understand the importance of writing to learn, but they did not ask their students to do so during the observations. Considering that Milner et al. (2012) indicated only 36% of teachers associate writing and science, the classrooms practices reiterate the call to prepare teachers to be able to help students write in order to learn science. Taylor wanted to focus on writing more, but she did not believe she was given enough time.

Concerning technology use, findings align with those by Ertmer et al. (2012) in that technology use is also influenced by the teachers' beliefs. Teachers need to have enough confidence to use the technology in a sophisticated way, but that also means that they need to be supported by their district with proper equipment and connectivity (i.e., facilitating conditions). Additionally, technology was more successful when students showed they were able to be responsible with the technology, and teachers need to have time to plan in order to ensure the technology is integrated properly into the lesson. Taylor wanted to use technology more, but she believed that a lot of instructional time would be spent trouble-shooting and scaffolding the technology. This belief was influenced by the low technological knowledge of her students, and this manifested in her classroom practice because students did not use technology as much as Taylor intended for them to.

Research Question 3. With better understanding of expressed and entrenched beliefs, that knowledge can be applied to planning and implementing better professional development for the five teachers in this study. Aligning with the scaffolding framework of this research, before planning a PD event it is important to understand what teachers already *know, believe,* and *do*. This was not done in this study, and some of the shortcomings in the implementation may be associated with that lack of top-down study design.

Concerning what teachers *know,* the TPACK framework provides a lens for examination of this knowledge during PD (Dilworth et al., 2012). As an example, Dana did not understand the technology as well as she could have, and she was highly dependent on the researcher in order to problem-solve and navigate the software. Sam had high TPACK, so although the start of the implementation did not go as planned, she was able to quickly adapt and implement the activities in Leonardo, but she did not provide additional scaffolding for writing. Knowing that, PD for Sam could have been more beneficial if it built on what she already did well in an attempt to improve the way her students used writing to learn science. Taylor and Riley were familiar with the Leonardo ESN, so a better understanding of their lessons learned in previous years could have resulted in a PD designed to advance the instructional utilization of the software in their classroom – for themselves and others. As an example, Taylor utilized the extension activities of Leonardo, but Riley did not. PD could have better supported them both concerning the extension activities. Emerson has a high PK so a more technology-based PD would have been more helpful for him. Additionally, Harris and Hofer (2011) speak about the ineffectiveness of using technology without strong CK, and

although all teachers were fairly adept in science, some were more content-prepared than others. Therefore, content knowledge needs to be assessed and addressed before the PD in order to best support the implementation of ESNs. Also, during the PD for ESNs, teachers need to be exposed to the process of writing to learn science (i.e., argumentation). Although Leonardo explicitly scaffolded writing, only one teacher in this study expressed ideas about how to have their students write to learn science in preparation for using the ESNs.

In addition to knowledge and understanding, teacher beliefs that pertain to science teaching efficacy and outcome expectancy can also inform PD. Using the teacher responses on the STEBI in order to engage in conversation with them would be a place to start. The end goal of that conversation could be about goals they want to accomplish and what steps need to be taken to get there. As an example, the STEBI asked teachers to respond to the following statement: "Increased effort in science teaching produces little change in students' science achievement." Sam, Taylor, Riley, and Emerson disagreed with that statement in the baseline STEBI. They do not need to be convinced that they work they do is important. Dana "agreed" with that statement on the baseline STEBI, so that could be addressed at a PD session. It isn't that she should be convinced to change her mind; instead, she just needs to be aware of the lens she views the work through. While Taylor disagreed with the statement mentioned above, she also disagreed with this statement, "When the science grades of students improve, it is often due to their teacher having found a more effective teaching approach." There appears to be some internal conflict here, or she misinterpreted one of the questions. Discussing this during the PD could have led to a discussion about what an

effective teaching approach alongside Leonardo looks like. Furthermore, the STEBI could be altered to include questions specific to writing and technology in the realm of science.

When looking at what teachers *do* before designing a PD, it would have been beneficial to have built on common practices of these five teachers rather than asking them to simply use the ESN during their science instructional time. Dana was not in the practice of using writing when teaching science; therefore she was not prepared to scaffold her students as they were writing using the ESNs. This is an area PD could address in order to prepare teachers like Dana better. Only one teacher, Taylor used writing in a way that aligned with how the Leonardo envisioned using writing – in order to learn. Because of that, she was better able to support her students as they were writing with the ESNs. However, she was only aware of this because of experience with Leonardo in the past. Riley was also a returning teacher to Leonardo, but she did not use writing in order to promote learning in science. Neither did Emerson or Sam, although they did use writing when teaching science, but it was not specific to the genre of scientific writing. Therefore, for these teachers, their class often consisted of science being integrated into a writing lesson, rather than writing being used to teach science. For example, Riley asked her students to write a non-fiction store about an animal when they were studying animal behavior. This misconception about writing to learn science verses writing in science could effectively be addressed via PD.

Finally concerning the third research question, a second phase of data analysis was done to look at this emergent finding of the difference between teachers who were returning to Leonardo compared to teachers new to Leonardo. The comparison between Case A and Case B showed that there was a significant difference between whether teachers had

participated in Leonardo before and addressing the class via whole class instruction (WCI). This is likely due to the fact that teachers, who are new to Leonardo, assumed the ESN would be in charge of delivering the content. While Leonardo can do so via hard scaffolding with little intervention from the teacher, the teacher is still the only pedagogical agent capable of dynamic scaffolding. This is likely something teachers realized as result of their experience with Leonardo. Because WCI is desirable in addition to Leonardo, PD strategies that help teachers new to Leonardo incorporate this pedagogy would be important.

Implications

PD Providers. For the teachers in this study, it would have been helpful to have taken into account teacher beliefs via the STEBI and current TPACK is a starting point. Additionally, when teachers are asked to assess their TK, PK, and CK, those terms should be defined. Perhaps even a rubric could be provided for PK, and in addition to providing a response, perhaps a justification could be given.

Walker et al. (2012) looked at how two different PD models impacted behavior, knowledge, and attitudes. Teachers who attended PD that only focused on TK, showed improved attitudes only. Teachers who attended a PD that focused on the TK in addition to CK and PK (e.g., problem-based learning), showed improvement in behavior, knowledge, and attitudes. Teachers in this current study would benefit from a PD that took into account how to effectively scaffold technology and how to use technology as a scaffolding tool.

School Systems. In addition to PD providers, school system leadership needs to understand these findings as well. Mulder, Swaak, and Kessel (2002) acknowledge that technology changes how lessons are planned and taught. This means that asking teachers to

implement technology should not come without time for teachers to prepare. Teachers in this study discussed time constraints and other barriers at length. While some barriers are inevitable in any given situation, teachers are often asked to implement technology under less than optimal conditions, often without a reliable network and access to fully functioning computing equipment. Furthermore, some of the teachers in this study were not necessarily able to troubleshoot, adding to the level of uncertainty and sense of lack of control.

Future Research

In thinking about improving the quality of science instruction in the elementary classroom, especially via technology integration, there are multiple stakeholders: students, parents, K-12 school systems, colleges of education, and teachers. In looking at those five stakeholders, one can consider how they each would be committed to improving the quality of science instruction. While they all have different agendas, resources, and parties to which they are accountable, assessing their beliefs should also be done in order to best understand how to improve technology integration into science classrooms. This could lead to greater alignment in practices.

Limitations

The findings from this case study cannot be generalized. The understanding that was gained by looking at the impact that beliefs had on practice can only inform PD that the five teachers in this study would receive. Furthermore, in asking teachers to self-asses their TPACK, the terms were not defined. Therefore, people may have been thinking about different types of technology when answering the questions. Likewise, science was not defined, so teachers may not have been speaking about their content knowledge based on the

same understanding of science. Lastly, as with most case studies, the biases of the researcher must be accounted for. The researcher was meeting some of these teachers for the first time, while having worked with others in the past.

Conclusion

This research provided space to discuss how teachers can best be supported as they learn to use technology in a more sophisticated way. In addition to providing insight to those who may conduct PD, these findings add to the literature concerning the three theoretical frameworks of this research: Teacher Beliefs, TPACK, and Scaffolding; and reveals the needs for future research.

When providing Professional Development, there will be certain aspects that will need to be consistent among all of the participants. In the case of PD or the Leonardo Project, teachers needed to be given the chance to progress through the curriculum as their students would, and they needed to be familiar with the basics of using the technology. Aside from that, teacher voice and beliefs should have driven the discussion. Those providing PD need to know three key things: (1) what teachers believe they need help with, (2) what teachers want their students to get out of any potential change in their practice, (3) and what barriers they believe they will face throughout the process. Simply asking teachers to talk those three element through prior to the PD may frame their mindset around them; therefore, leading a more productive PD session.

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APPENDICES

Appendix A

Baseline Interview

Teacher's Name _____ Date_____

External factors that influence beliefs

Social Norms

1. What are the expectations of the district/school for how science should be taught?
    a. What are the expectations concerning curriculum (esp. kit-based science)?
    b. What are the expectations concerning science notebooks?
    c. What are other teachers doing at your school?
    d. Do all teachers teach science or do you split Social Studies/Science?
    e. Does your school have a science resource specialist?
2. What are the expectations of the district/school for how technology (how often and to what extent) should be used?
    a. To what extent are teachers at your school incorporating technology?
    b. To what extent are teachers at your school incorporating technology into teaching science?
3. What are the expectations of the district/school for how to incorporate writing in your classroom?
    a. To what extent are teachers at your school incorporating writing when teaching science?

Support

1. What kind of support do you receive from the district/school to help with science instruction?
    a. Tell me a little about how the district prepares teachers for implementing new instructional materials? *(Looking for mention of PD)*
2. How much PD have you received that has been focused on technology-integration?
    a. Is there any follow up post-PD, during implementation, or after implementation?
3. What kind of PD do you receive from your school in order to help students become better writers?
    a. Is there any follow up post-PD, during implementation, or after implementation?
4. If you need assistance with technology, what is the process and wait-time for getting that assistance to you?
    a. Does your school have a designator tech person? If so, who is it (media center coordinator, tech specialist, another teacher)?

Logistical Barriers

1. Do you have all the AV/Computer equipment you need?
2. How reliable is your AV/Computer equipment?
3. How reliable is your network?
4. Do you have all the computer software you need?
    a. Is there software you would like? Do you feel you can ask for it?
5. How much time is set-aside for science during your week, and how flexible is the scheduling?
    a. Is it protected (morning) or unprotected (afternoon) time?
    b. How many minutes per week?
    c. How many days per week?
    d. Can you allot extra time if you need to?

5. Do you have a budget for spending on supplies (tech and otherwise) – what is the standard procedure for you ordering supplies?

Internal factors that influence beliefs

1. How long have you been teaching?
    a. 4^{th} grade? Other elementary grades?
    b. Electricity?
2. What role do you believe classroom management plays in student learning?
    a. Does teaching with science require a different set of classroom management skills or procedures? (safety, clean up, student behavior in labs) –
3. How important is it for you to have all students "on the same page?" How do you periodically assess for student understanding? How do you feel when you reach a point that regardless of understanding, you simply must move on?
4. Do you believe teaching science requires different pedagogical strategies compared to other subjects?
5. How do you teach Electricity? – kits provided hands on experiences
    a. What materials, activities do you typically use?
        i. Are the solely responsible for deciding about activities and materials?
    b. Ask about specific learning goals. Are these unique to your classroom?
    c. What misconceptions do you believe students have about electricity? (Ask about misconceptions coming into the class, and about misconceptions after the first lesson or hands-on activity.)
    d. What specific strategies do you have to help scaffold/support students? (Important: ask for examples)

e. How do you usually check for understanding?
f. How does your approach to teaching Electricity differ from other science areas you teach?
g. Why are these specific approaches you use effective?
h. How do they compare to other approaches teachers use?

6. How do you teach _____?
    a. What materials, activities do you typically use?
    b. Ask about specific learning goals
    c. What misconceptions do you believe students have about _____?
    d. What specific strategies do you have to help scaffold/support students?
    e. Ask about assessment
    f. How does your approach to teaching _____ differ from other science areas you teach?
    g. Why are these specific approaches you use effective?
    h. How do they compare to other approaches teachers use?
7. How often are students assessed on their science understanding through writing?
    a. How do you work with students to improve the quality of their writing?
    b. Are you familiar with paper science notebooks? If so, ask them to elaborate on how they are used.
8. What role does technology play in teaching your students about science? How often do you incorporate technology into a science lesson?
    a. What do you believe are the real or potential benefits of these technologies for science teaching and learning? (look for mention of scaffolding, in general, and writing).
    b. Can you give some examples (doesn't matter what subject) of way that you have used technology to enhance student understanding. (Important: ask about the reasons behind the decisions made concerning integrating technology.)
    c. Do you believe technology saves time, takes more time, or doesn't make a difference in the amount of time it takes students to learn a concept?
    d. Do you have general concerns about the use of technology (i.e., laptops/tablets, ESNs) in the science classroom?
    e. Are there concepts, activities, etc that you think technology can address more effectively than a teacher?
    f. Do you have concerns about whether technology takes away control from the teacher?
9. How comfortable are you with technology-use in general? (0-7)

How comfortable are you with using technology while teaching? (0-7)

Appendix B

STEBI

Teacher's Name _____ Date_____

Answer the following questions with:

Strongly Disagree, Disagree, Neither Agree nor Disagree, Agree, Strongly Agree

1. When a student does better than usual in science, it is often because the teacher exerted a little extra effort.	SD	D	N/U	A	SA
2. I will continually find better ways to teach science	SD	D	N/U	A	SA
3. Even if I try very hard, I will not teach science as well as I will most subjects.	SD	D	N/U	A	SA
4. When the science grades of students improve, it is often due to their teacher having found a more effective teaching approach.	SD	D	N/U	A	SA
5. I know the steps necessary to teach science concepts effectively.	SD	D	N/U	A	SA
6. I will not be very effective in monitoring science experiments.	SD	D	N/U	A	SA
7. If students are underachieving in science, it is most likely due to ineffective science teaching.	SD	D	N/U	A	SA
8. I will generally teach science ineffectively.	SD	D	N/U	A	SA
9. The inadequacy of a student's science background can be overcome by good teaching.	SD	D	N/U	A	SA
10. The low science achievement of students cannot generally be blamed on their teachers.	SD	D	N/U	A	SA
11. When a low-achieving child progresses in science, it is usually due to extra attention given by the teacher.	SD	D	N/U	A	SA
12. I understand science concepts well enough to be effective in teaching elementary science.	SD	D	N/U	A	SA
13. Increased effort in science teaching produces little change in students' science achievement.	SD	D	N/U	A	SA
14. The teacher is generally responsible for the achievement of students in science.	SD	D	N/U	A	SA
15. Students' achievement in science is directly related to their teacher's effectiveness in science teaching.	SD	D	N/U	A	SA
16. If parents comment that their child is showing more interest in science, it is probably due to the child's teacher.	SD	D	N/U	A	SA
17. I will find it difficult to explain to students why science experiments work.	SD	D	N/U	A	SA
18. I will typically be able to answer students' science questions.	SD	D	N/U	A	SA
19. I wonder if I will have the necessary skills to teach science.	SD	D	N/U	A	SA
20. Given a choice, I will not invite the principal to evaluate my science teaching.	SD	D	N/U	A	SA

21. When a student has difficulty understanding a science concept, I will usually be at a loss as to how to help the student understand.	SD	D	N/U	A	SA
22. When teaching science, I will usually welcome student questions.	SD	D	N/U	A	SA
23. I do not know what to do to turn students on to science.	SD	D	N/U	A	SA

Appendix C

Follow-up Interview

TK - How would you describe your technological knowledge? How may your TK have changed as a result of using Leonardo?
CK – How would you describe your pedagogical knowledge? How may your CK have changed as a result of using Leonardo?
PK – How would you describe your pedagogical knowledge? How may your PK have changed as a result of using Leonardo?
Scaffolding – Describe how you normally scaffold learning in your classroom? How may this have changed as your students were using the ESNs?

Appendix D

GEES Classroom Observation Protocol

DESCRIPTIVE INFORMATION:

Researcher:

Teacher/Grade: School:

Condition: *Control/Experimental (highlight one)* Materials:

Date: Start time: End time:

Number of Students: # Males: # Females:

Classroom Set-up (describe or sketch set up below):

DIALOGUE BETWEEN RESEARCHER AND TEACHER:

I. LESSON INTRODUCTION

Instructions: Provide a brief description of how the lesson started and mark whether each of the indicators was present or absent.

Introduction Emphasis	Present?	Evidence/Explanation
a. Provides overview		
b. Relates lesson to previous lessons/activities		
c. Assesses prior knowledge		
d. Uses science notebooks*		
e. Uses graphics**		

*Scale: 1- Present 0- Absen t*Notebooks use will be addressed in detail later on in protocol.**Graphics will be addressed in detail later on in protocol*

III. LESSON CLOSURE
Instructions: Write 1-2 sentences describing how lesson ended.

Event Log Coding Scheme

Mode of Instruction	Code	Materials Used	Code
Whole Class Instruction	WCI	Printed Reading Materials	PRM
Hands-on Activities	HOA	Computer or Computer Technology	CT
Homework or Class work Review/Correction	WRC	Overhead projector or LCD	OP
Group Presentation (student)	GP	Chalkboard/Whiteboard/Chart Paper	CWC
Reading Textbook or Kit Materials	RT	Videos/Films/Music	VFM
Teacher Demonstration	TD	Demonstration models	DM
Small Group Work	SGW	Manipulative/hands on equipment	MHE
Data Collection and/or Manipulation	DCM	Worksheets	WS
Individual Seat Work	ISW	Science Notebooks	SN
Open Ended Inquiry	OEI		

IV. NOTABLE DIALOGUE
Instructions: transcribe any notable classroom dialogue in the box below.

Notes concerning the following:

a - student groupings

b- teacher roles

c - learning activities

d - technology used by teacher

e - time spent using technology

f - student engagement