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High-needs schools in the United States contend with a disparity in resource allocation, a higher rate of teacher and administrator turnover, an always narrowing curriculum due to increased accountability measures, and a heightened culture of surveillance. These realities shape what has happened and what seems possible for teachers, especially impacting their ability to integrate and enact science and engineering in elementary schools. Increased accountability pressures heighten the culture of surveillance, narrow the curriculum, and reduce teacher autonomy and professionalism. These realities impact science and engineering instruction by dictating how and what teachers teach. Science often gets pushed to the margins in favor of tested subjects and institutional demands constraining teachers' practice. There are few, if any, accounts of teachers who exercise their professional agency to navigate these tensions productively. The purpose of this study is to raise teachers' voices, their ideas, the dilemmas they face, and how they navigate those dilemmas with their professional agency.

This study employs a narrative inquiry design to explore elementary teachers' professional visions for science and engineering in high-needs schools, the dilemmas they encounter when working to enact science and engineering, and the nature of teachers' STEM-linked professional agency as they creatively wrestle with and work through these dilemmas. Data include over 65 interviews and 18 STEM journey maps. Data analysis included coding teachers' narratives using in vivo codes, construction of themes based on emergent patterns, and cross-narrative analysis.

This analysis led to the description of elementary teachers' professional visions for science and engineering in high-needs schools as ideal images of engagement, instructional and curricular connection, instruction that broaden student pathways, and teaching for altruistic reasons. As teachers worked to enact their professional visions, various sociocultural conditions of their schools and districts facilitate and constrained that work. When teachers experienced conflict between their professional visions and institutional ideals and demands, they encountered dilemmas focused on the roles of teachers and ideal curriculum and pedagogy. As teachers wrestled with dilemmas, they enacted STEM-linked professional agency. Moments of STEM-linked professional agency were visible in moments when teachers described science and engineering as both highly thinkable and doable. This led to the understanding of STEM-linked professional agency as a phenomenon within certain contexts of schooling when teachers created change within their workplace to align practice with vision in ways that were innovative and responsive.

CHANNELING YOUR INNER SCIENCE WARRIOR: THE NATURE OF TEACHERS' PROFESSIONAL AGENCY IN HIGH-NEEDS SCHOOLS

by

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Approved by

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APPROVAL PAGE

This dissertation, written by Alison K. Mercier, has been approved by the following committee of the Faculty of The Graduate School at The University of North Carolina at Greensboro.

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There is no joy without gratitude[1] – Brené Brown

Courage is contagious.
Thank you for being brave with your life.
You've made me more daring with mine.

To the teachers in my study, thank you. Your stories and your courage inspired me every day.

To Sue, my mother, thank you.
From the very beginning, you have given me that sense of love and belonging; you give me courage.

Those who have a strong sense of love and belonging have the courage to be imperfect.

Thank you for loving me, for supporting me, and for believing that I could accomplish anything—even when I didn't fully believe in myself. You gave me the courage to be imperfect and to accomplish truly great things.

To Merc, my dad, thank you.
One of my students once called me Ms. Merc for an entire year. He said it was his way of showing his love. There's been no greater compliment. Thank you for your constant love and nurturing me into the woman I am today.

Love is not something we give or get;
it is something that we nurture and grow.

Curiosity is a shit-starter.
But that's okay. Sometimes we have to rumble with a story to find the truth

Heidi, look what you started.
Thank you for helping me rumble with all kinds of stories, but mostly my own.

Choose courage over comfort.
Choose whole-hearts over armor.
And choose the great adventure of being brave and afraid at the exact same time.

To my committee members, thank you.
Jane, Jewell, and Sam, thank you for pushing me to see things in new ways, to become a better scholar, thinker, and researcher. Thank you for being mentors, advocates, and cheerleaders and seeing me through this great adventure.

[1] All italicized words are quotes from Brené Brown.

We don't have to do all of it alone.
We were never meant to.

To Michelle, Montana, Salem, and Tierney, thank you.
I was never meant to do this alone, thank you for the love, support, and collaboration. I would never have accomplished this without all of you by my side.

What we know matters,
but who we are matters more.

To my extraordinary, brilliant friends in "the office," thank you. Thank you, Amy, Arren, Christy, Dearing, Doris, Emily, Lauren, Paul, and Ti'Era for the advice, hugs, trips to the library, tissues, Diet Cokes, celebrations, commiserations, playlists, campus IDs . . . for being who you are.

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CHAPTER I

INTRODUCTION

> Elle's fourth-graders cluster around communal tables, reading silently from personal baskets of books. The books range from first grade to middle school level, with some books written in bilingual text. Music plays softly in the background while Elle reviews beginning consonant sounds and word families with a small reading group of students learning English while the reading specialist works with two students reviewing figurative language. As the song ends and the reading specialist exits the room, Elle collects the students' attention. The students notice that something is different about their routine schedule. In response to the quizzical looks on their nine- and ten-year-old faces, Elle explains that instead of their usual core literacy lesson (one that comes from a semi-scripted curriculum and manual) the class is going to squeeze in a science lesson. A chorus of gasps and cheers ring through the cinderblock classroom. One girl in the middle of the room, asks what some of her peers are wondering too, "Why?" Elle smiles warmly and explains, "Well what you're reading really makes more sense if you have experiences to go with it. Remember what we say in this room? The more we do and say, the more we learn." (Elle's Re-Storied Narrative, Interview, 3/16/20)

Elle related this story to me as we sat in her classroom during one of our interviews. As she told this narrative, she pointed to the baskets of books the students read from, the green table where the reading specialist always sat, the schedule full of reading tasks posted on the wall, and a stack of informational texts stacked precariously on the edge of a long table in the back of the room. Elle thought back on that moment and said, "They cheered, Alison. They actually cheered" (Elle, Interview, 3/16/20). I asked Elle about this decision to eschew literature instruction in favor of a science lesson. She explained, "What these students really need are chances to explore the things they're learning. They can only learn so much science by reading books." (Elle, Interview, 3/16/20). It was at this moment that Elle looked around her room and sighed. With a half-smile, she continued, “I wish I could do this more. I mean, it’s what all my students need. But I can really only do a lesson like this with this one class [of three].” But why only one class? Elle clarified, “This is when I don’t have extra eyes watching my every instructional move. It’s the only time I can get science in” (Elle, Interview, 3/16/20).

Elle is a teacher who aspires to “teach against the grain” (Cochran-Smith, 1991, 2001). The simple fact that Elle works to integrate science into her daily instruction and gives it almost equal weight and priority as other subjects is a form of teaching against the status quo of traditional schooling. This vignette and Elle’s reflection relate just one of the many stories teachers narrated throughout this study as I explored the dilemmas teachers encountered, their responses, and the nature of their professional agency. These narratives underscore the challenges that arise for teachers who are committed to integrating and enacting science and engineering in their elementary classrooms and some of the accompanying threats to teachers’ autonomy and professionalism.

In fact, the vignette highlights a two-fold problem—a lack of science and engineering in elementary classrooms and teachers who feel de-professionalized to include it in their curriculum. Teachers do their best work in the classroom on behalf of all learners when their physical and sociopolitical workplaces are humanizing spaces that advance professionalization. The problem is that many elementary teachers working to teach science and engineering in high-needs school contexts face challenges to their professionalization every day. These challenges present themselves in the form of institutional, governmental, and local demands that promote adhering to standardized thought, practice, and curricula and which limit autonomy, stifle agency, and suppress creativity and innovation with regards to science and engineering instruction.

Focusing on elementary science education is important. Over the past 20 years, education reforms have called for quality, inquiry-based science instruction, particularly in the elementary grades (Duschl et al., 2007; National Research Council [NRC], 2012). Moreover, reform efforts in the United States, led by the Next Generation Science Standards (NGSS Lead States, 2013), indicate that quality science instruction should begin early. Evidence suggests that students with limited science instruction in their early years rarely make learning gains equal to students who had a solid science foundation in elementary school (Nelson & Landell, 2007) and often struggle to see that science is for them (Archer et al., 2012). These recommendations on the national level clash with teachers' local struggles to be positioned with professionalism, which would allow them to include science and engineering regularly in their curriculum and to teach it adequately.

Research Problem

These are challenging times for teachers; at times, it is hard to remain committed to one's vision and ideals. Teachers hold, and reform documents like the Next Generation Science Standards (NGSS Lead States, 2013; Reiser et al., 2017) portray a vision of "ideal" elementary science and engineering instruction. All too often, institutions demand another set of ideals—e.g., ideal curriculum practices, pedagogies, and schedules. In many cases, personal and professional visions are not recognized or accepted, and teachers are encouraged to "buy into" an institutional set of ideals. Teachers experience this conflict as a dilemma as they work to sustain their vision and practice. Autonomy enables teachers to make curricular and instructional decisions to meet the diverse needs of students in their classrooms (Freidson, 2001). But when institutions specify content and instructional methods for teachers, they diminish the autonomy and professionalism of teachers—taking away teachers' abilities to be independent, creative, thinkers.

The purpose of this study was to explore the elementary teachers' professional visions for science and engineering in high-needs schools, the dilemmas they encounter as they work to enact their professional visions, and the nature of their STEM-linked professional agency when doing so.

"Ideal" Elementary Science

Science and engineering permeate almost every facet of modern life. Every child has the capacity and propensity to observe, explore, and discover the world around them (NRC, 2012). As such, there are skills and abilities for science learning that can and should be nurtured, encouraged, and supported among children in the early years of their lives and the elementary grades of their educational experience. Learning science and engineering practices in the elementary years can foster children's curiosity and enjoyment in exploring the world around them and lay the foundation for a progression of science learning in middle school, high school, and throughout their entire lives (NRC, 2007).

All students deserve high-quality science instruction in the elementary grades as it is essential for establishing a solid foundation for learning, instilling a natural wonder and curiosity, and addressing the need for a well-formed citizenry (National Science Teachers

Association [NSTA], 2018). High-quality science and engineering instruction move students from curiosity to interest to reasoning (Moulding et al., 2015). Frequency and intentionality magnify the progression of learning that occurs with each science and engineering experience. Children, even at the elementary age, can engage in scientific practices and develop deep understanding at a conceptual level. Early in their science education, students need opportunities to observe phenomena, engage in problem-solving, and provide explanations of their thinking (NSTA, 2018).

Over time and through multiple and varied experiences, children develop skills in scientific discourse as they plan and carry out explorations, solve problems, create models, analyze and interpret data, construct explanations, and design solutions (NSTA, 2018). Students reason with others and seek shared understandings of complex phenomena. These opportunities allow them to deepen their understandings of fundamental concepts over time and positions students as collaborative constructors of knowledge early in their educational experiences (Cafarella et al., 2017). Elementary science education literature centers on what science should be taught, how it should be taught, and what the expertise of the teacher providing science instruction should be (Duschl et al., 2007). For many teachers, this comprises the foundation of "ideal" instruction and serves as the premise for their professional vision for science and engineering in their classrooms. The problem is that in our current climate of education, students do not always receive these opportunities, and teachers feel disempowered to provide them.

The Realities of Elementary Science

Despite calls to establish science as an important component of the elementary school curriculum (NRC 2007, 2012), science is almost completely ignored or approached through traditional teacher-centered instructional methods in many elementary schools today (NSTA, 2002; NRC, 2007). Many elementary classrooms find science lacking, deprioritized, or entirely missing from the curriculum (Banilower, 2019; Banilower et al., 2018). Even though there are calls for science in all early childhood and elementary grades, many elementary classes receive science instruction only a few days a week or a few weeks throughout the year. In grades K-3, only 17% of teachers teach science most days of the week; and while the percentage is higher in fourth and fifth grades—35%—this is still much, much less than other subjects such as mathematics and English language arts (ELA) (Banilower et al., 2018). Primary grades classes average less than 20 minutes of science instruction per day. It is only incrementally better in the elementary grades (3-5), where instructional time for science and engineering increases to 27 minutes per day. In terms of activities, instruction tends to rely primarily on whole-class discussion with the teacher explaining ideas to the class. Small group work is the third most common activity in elementary science, but it is a far distant third, with inquiry-based learning a distant fifth (Banilower et al., 2018).

Less time is being devoted to elementary science instruction (Kingsbury, 2007; Linn, 2008; McMurrer, 2007, 2008). In a comprehensive examination of all 50 states, Rentner et al. (2006) found that 71% of school districts reduced elementary instructional time in one or more content areas to have more time for English Language Arts (ELA) and mathematics, with science frequently most shortchanged. A survey of teachers by the National Science Teachers Association (NSTA) revealed that nearly half of those teachers reported that their allotted instructional time for science had decreased in the 2010-2011 school year as compared to the year before (Petrinjak, 2011). Studies continue to reveal that less time is devoted to science and engineering in elementary schools but provide few, if any, accounts of teachers who try to increase the time they dedicate to science and engineering and how they incorporate it into their curricula.

Understanding High-Needs School Contexts

It is difficult to know how to refer to the schools involved in this study. Some might say that these are *urban* schools. Others might say that they are *high-needs, under-resourced,* or simply *diverse.* Therefore, it is important to clarify the meaning and use of words such as *diverse*, *urban*, *under-resourced*, and *high-needs*. I recognize that *diversity* can be understood in many ways, that *high-needs* can be construed in varied ways, and that schools located in *urban* areas are neither necessarily “diverse” (i.e., usually meaning racially and ethnically diverse) nor “high-needs” (i.e., usually meaning resource-poor and low-performing). The No Child Left Behind Act of 2001 (NCLB) defines a high-needs school as

> within the top quartile of elementary and secondary schools statewide, as ranked by the number of unfilled, available teacher positions; or is located in an area where at least 30 percent of students come from families with incomes below the poverty line; or an area with a high percentage of out-of-field teachers, high teacher turnover rate, or a high percentage of teachers who are not certified or licensed. (USDoE, 2004, p. 254)

The Ready to Teach Act (2003-2004) defines high-needs schools as those in which at least 20% of the student population lives below the poverty line. No matter the definition, high-needs schools face many challenges, including higher teacher and administrator turnover, limited financial resources, substandard facilities, and a lack of material resources (Darling-Hammond, 2004; Reichardt, 2002). Most high-needs schools are located in rural or urban areas. Essentially, high-needs schools serve communities of higher poverty rates, where schools and classrooms function within the unique contexts of their students' lives and communities.

Teachers working in high-needs schools can find themselves between a "rock and a hard place" (Eslinger, 2014), navigating an already challenging school context with the additional pressure of reducing already present achievement gaps. Eslinger (2014) uses the metaphor of a "rock" to describe the dilemmas faced by teachers who work with students coming from different racial, socioeconomic, linguistic, and cultural backgrounds; while using the metaphor of the "hard place" to describe the increasing bureaucratic control of testing, content, and pedagogy that ends up limiting what teachers can and cannot do in their classrooms (Au, 2010). Many teachers in these contexts feel that they can no longer enact their professional knowledge, judgment, and creativity under these strenuous conditions. Elementary teachers in high-needs schools find themselves stuck between two different structures, with no or very limited agency to enact change in their professional work and in matters that positively affect their students' academic and personal well-being (Eslinger, 2014).

The Reality of Science in High-Needs Schools

High-needs schools across the United States are confronted by the same complex social and economic problems that materialize in the communities that they serve (Ladson-Billings, 2008). There is extensive research that provides evidence that these schools are under-resourced, underachieving on high-stakes assessments, and populated by minoritized students who live in disadvantageous economic circumstances (Darling-Hammond, 2007; Ladson-Billings, 2006; Seiler, 2001). In many high-needs schools targeted for improvement, or data-driven organizational improvements addressing school climate, instructional quality, and students' achievement (VanGronigen & Meyers, 2017), little to no time is spent teaching science as the demands on teachers' days push science instruction to the margins (Olson, 2009). In my own experience as a classroom teacher for 16 years in high-needs schools and as someone who has facilitated professional learning opportunities for teachers who teach in high-needs schools, I know all too well how difficult it is to work around the additional accountability pressures and school norms to integrate science and engineering into the instructional day.

High-needs schools are often labeled as low-performing due to lower student achievement on state and national standardized assessments and therefore experience numerous and often changing mandates, programs, and policies from federal, state, and municipal administrators (Anderson & Stillman, 2011). Under constant pressure to raise test scores and student achievement levels, high-needs schools, these schools face more institutional challenges than schools in very different contexts. The strong focus on student performance on standardized tests results in the severe narrowing of the school curriculum and instruction (Eslinger, 2014). The emphasis on the tested areas of reading and mathematics leads to the reallocation of time and resources to these content areas at the expense of other subjects, such as science (Blank, 2013; Sunderman & Kim, 2005). The stress on student test performance also results in school districts and individual schools developing and adopting curriculum guides that were aligned to tested topics and skills, providing teachers prescribed scripts and activities. Becoming what some feel is a “teacher-proof curriculum,” these guides give specific instructions and language for teaching, which stress direct instruction, lecture-based activities, and rote learning (Au, 2011; personal experience, 2018). The conditions in which high-needs schools operate exist, but missing from the scholarly literature are how teachers navigate these conditions—especially the voices and experiences of teachers who are motivated to teach science and engineering.

All of this contributes to a heightened culture of surveillance and control (Giroux, 2006). The high-stakes conditions, accountability pressures, and heightened culture of surveillance at these schools have dramatically affected teaching practices (Giroux, 2006). This climate has created a dehumanizing and deprofessionalized effect on the teacher workforce that stifles creativity and innovation, negatively affecting teachers’ professional self-concept (Wronokski & Urick, 2019). This often causes teachers to regulate and restrict their instructional practices to be more teacher-directed and traditional in their approach. Consequently, such actions place significant constraints on teacher autonomy and professionalism. Looking at the research on how high-stakes testing affects classroom practices in high-needs schools, it becomes quite clear that limiting teachers with scripted curriculum, a lack of autonomy, heightened surveillance, and constant accountability measures promote the standardization of teaching that disempowers and deskills teachers (Au, 2011). Some teachers resist such standardization and constraints on their professionalism, yet their narratives are missing from the overall picture. What meaning do these teachers make of their contexts? Why do they pursue more difficult paths? And, when they do, what are the ways they do so?

What is the Purpose?

Historically, high-needs schools contend with a disparity in resource allocation, a higher rate of teacher and administrator turnover, an always narrowing curriculum due to increased accountability measures, and a heightened culture of surveillance. These realities shape what has happened and what seems possible for teachers in high-needs schools. Increased accountability pressures heighten the culture of surveillance, narrow the curriculum, and reduce teacher autonomy. These realities impact science and engineering instruction by dictating how and what teachers teach. This study has its roots in my tenure as an elementary teacher in high-needs schools. As a teacher in such schools, I have struggled with these realities, especially when it came to creatively pushing the boundaries to keep science and engineering a prioritized part of the instructional day. Right now, the curriculum in high-needs elementary schools is becoming ever narrower. There are copious examples of science getting pushed to the margins in favor of tested subjects and institutional demands constraining teachers' practice. But, there are few, if any, accounts of teachers who exercise their agency to navigate these tensions productively.

The purpose of this study is to raise teachers' voices, their ideas, the dilemmas they face, and how they navigate those dilemmas. In this climate, teachers' voices are often silenced, and their decision-making squelched. Every day teachers face threats to their autonomy and professionalization, especially when it comes to their science and engineering instruction. Teachers in high-needs elementary schools who find ways to creatively manage and implement science and engineering instruction in their curriculum are seen as teachers who teach against the grain (Cochran-Smith, 1991, 2001). These teachers hold robust professional visions—sets of ideal images of how and what to teach the students they serve (Hammerness, 2006). But many times, teachers who teach against the grain find their personal ideals and visions in conflict with institutional ideals and demands. When this happens, teachers understand this conflict as dilemmas (Windschitl, 2002). Sometimes, these dilemmas can feel insurmountable, but many teachers respond to these dilemmas with professional agency, creatively pushing back and working through tensions to be change agents (Eteläpelto et al., 2013).

Research Questions

The literature lacks fully realized portraits of teachers' professional visions for science and engineering instruction in elementary classrooms, the dilemmas teachers encounter as they work to fully realize those visions, and the nature of elementary teachers' professional agency that enables them to push boundaries creatively and be innovative with science and engineering in high-needs schools. Exploring and understanding these teachers' lived experiences better enables the field to address the tensions currently faced in science and engineering instruction in high-needs, elementary schools, and support in *re-professionalizing* our teachers. Therefore, the research questions that inform my study include:

1. What is the nature of their elementary teachers' professional visions for science and engineering instruction in high-needs schools?
2. What facilitates and/or constrains the enactment of teachers' professional visions for science and engineering?
3. What dilemmas emerge for elementary teachers as they reconcile their professional vision with the ideals and demands of schools?
4. In what ways do teachers respond to those dilemmas?
5. How do teachers who work in high surveillance cultures and have strong commitments to their professional vision for science and engineering narrate the nature of their STEM-linked professional agency over a school year?

Definitions of Significant Terminology

Dilemmas are aspects of teachers' intellectual and lived experiences that prevent theoretical ideals of pedagogical practices from being realized in practice in school settings. These dilemmas, which become conceptual entities for researchers, often exist as concerns, conflicts, or implicit questions posed by teachers who attempt pedagogical change in their classroom (Windschitl, 2002).

Doability is when science and engineering instruction is *doable*; it is when a teacher's decision and actions are the expressions of a teacher influencing work-related matters to put into practice the pedagogical moves that they envision.

High-needs schools are schools

> within the top quartile of elementary and secondary schools statewide, as ranked by the number of unfilled, available teacher positions; or is located in an area where at least 30 percent of students come from families with incomes below the poverty line; or an area with a high percentage of out-of-field teachers, high teacher turnover rate, or a high percentage of teachers who are not certified or licensed. (USDoE, 2004, p. 254)

These schools are sometimes referred to as *urban*, *under-resourced*, *low-performing*, *schools of poverty*, or *diverse*, yet those terms do not always fully encompass the *high-needs schools* in this study. Essentially, high-needs schools serve usually rural and urban communities of higher poverty rates, where classrooms are influenced by the contextual realities of their students' lives and communities.

Professional agency exists when subjects' direct agency at work-related phenomena, and when those subjects influence, make choices, and take stances in ways that affect their work and their professional identities (Eteläpelto et al., 2013).

School Climate is the quality and character of school life; it includes the students', parents', and personnel's norms, beliefs, relationships, and teaching practices, as well as the organizational and structural features of the school.

School Culture refers to the way teachers and other staff members work together and the set of beliefs, values, and assumptions they share.

STEM-Linked Professional Agency refers to content-specific professional agency focused on science and engineering content and pedagogy.

Teacher professional vision is a teacher's personal stance on teaching that rises from deep within the teacher and drives independent thinking. A teacher's vision shapes the way they feel about their teaching, their students, and their school, and helps to explain the changes they make in their classroom (Duffy, 2002). A teacher's professional vision is more than a teaching philosophy; it is a set of vivid and concrete images of practice that shapes what teachers do in the classroom, how they interact with students, and what they and their students can achieve (Hammerness, 2006).

Thinkability occurs when science and engineering is *thinkable*; meaning it is a realistic, achievable aspiration that teachers can envision, articulate, and see playing out in their classrooms, despite obstacles and tensions that might arise or the dilemmas with which they might wrestle. If an idea or concept is thinkable, it is conceivable and achievable (Archer et al., 2012).

CHAPTER II

FRAMEWORK AND RELATED LITERATURE

Introduction

> I know what good science, real science, should look like. I know what my students need. There comes a time when you just have to be willing to shut the door, dig deep, and teach what you know you should teach. My students deserve that. I mean, really all students deserve that. (University STEM Program teacher, interview, 1/21/19)

This quote from a University STEM Program (a pseudonym) teacher, one of the participants in this study, begins to surface possible solutions to the persisting problem of the lack of quality science and engineering instruction in elementary classrooms. Though this teacher seems to imply otherwise, the answer is *not* simply to close the classroom door and block out the systemic problems facing teachers. Instead, it is about "digging deep" and finding ways to creatively push boundaries, making science and engineering instruction "thinkable" and "doable" for teachers in elementary classrooms.

Conceptual Framework

My framework (see Figure 2.1) shows the way that I conceptualized the deprofessionalization of teachers and the lack of science and engineering in elementary classrooms. Teachers who undertake the integration and enactment of science and engineering into their elementary curricula strive to make science and engineering "thinkable" and "doable" in their classrooms and schools. I saw the "doability" of science and engineering in elementary classrooms as connected to teachers' professional agency, or their willingness and capacity to make decisions and take actions regarding their pedagogical practices. Science and engineering instruction's "thinkability," or teachers' professional vision, and certain sociocultural factors of teachers' workplaces frame and shape the doability and professional agency of teachers. The dilemmas teachers wrestle with when they find their personal and professional ideals in conflict with those of their educational community underpin teachers' professional agency and the thinkability and doability of science and engineering.

I used this framework, which emerged from multiple constructs in the literature, to conceptualize what it takes to integrate and enact science and engineering into the elementary curriculum in light of the sociocultural conditions teachers encounter in high-needs schools. In this chapter, I unpack each of the constructs found within the framework. I begin by clarifying the notion of barriers, highlighting the idea that teachers face barriers to their instructional practices at every turn in their careers. Focusing specifically on elementary science and engineering instruction, I draw from reports and studies that outline some of these perceived barriers. I argue that, rather than frame perceived constraints on teachers' pedagogical reasoning as barriers, it is more productive to think of them as dilemmas (e.g., pedagogical, cultural, political, and conceptual). I further explain how teachers make sense of and respond to the dilemmas they confront when trying to integrate science and engineering into their curriculum.

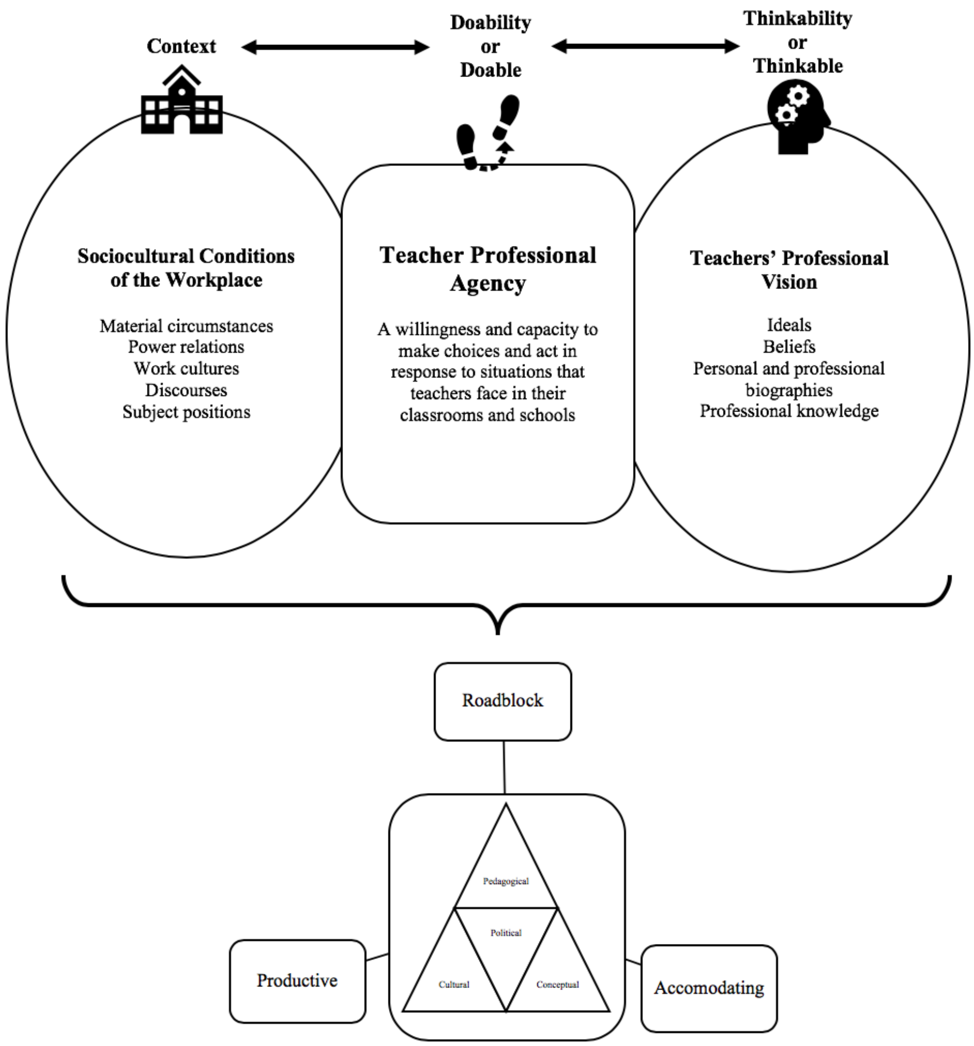


Figure 2.1. Conceptual Framework for Teachers' Professional Agency.

Next, I argue that when teachers make science and engineering "doable" in their elementary classrooms, they are exercising their professional agency, or their willingness and capacity to act and make decisions to be active change agents in their workplace. Framing and affecting this doability are the thinkability of science and engineering and the sociocultural conditions of the workplace. Pedagogical practices and science and engineering must be "thinkable" within certain sociocultural conditions to become "doable" in elementary classrooms. I then explain how science and engineering's thinkability is closely tied to teachers' professional vision.

Finally, one cannot separate the individual, or teacher, from their context, classroom, and school; instead, each one mutually influences the other. I explain why a subject-centered sociocultural perspective is an effective way in which to examine the nature of elementary teachers' professional agency. In doing so, I build an argument related to understanding the nature of teachers' STEM-linked professional agency in the wake of dilemmas that elementary teachers face as they integrate and enact science and engineering in high-needs schools.

Barriers to Teaching Science in Elementary Schools

Spend a day in an elementary classroom, ask that teacher about their science instruction, and begin to understand some of the many barriers that teachers face. Elementary teachers feel many constraints placed upon their teaching, especially in science and engineering instruction. Constraints commonly cited as reasons for decreased or non-existent science instruction include (a) elementary teachers feel underprepared to teach science (Banilower et al., 2018), (b) perceived lack of resources (Abell & Roth, 1992; Banilower et al., 2018; Smith & Nadelson, 2017), and (c) perceived lack of time for instruction (Abell & Roth, 1992; Appleton & Kindt, 1999; Banilower et al., 2018; Smith & Nadelson, 2017).

An abundance of research has chronicled the difficulties that science teachers encounter as they enact, or attempt to carry out, new science practices in their classrooms. Southerland et al. (2007) summarized these constraints as internal and external barriers for teachers. Internal barriers include teachers' beliefs about science and students, their understanding of content, and their experiences with authentic science. External barriers relate to school resources and systemic requirements for learning and assessment.

Crawford (2000) offered examples of internal barriers. For teachers to adequately engage in quality science and engineering with their students, they needed to engage in new roles that required a shift in mindset and beliefs, a certain amount of risk-taking, and mentoring, guiding, or collaborating (Crawford, 2000). Roehrig and Luft (2004) found five constraints that impacted teachers' implementation of science instruction in their curriculum: teachers' (a) understanding of inquiry and the nature of science, (b) strength of content knowledge, (c) pedagogical content knowledge, (d) beliefs about teaching in general, and (e) managements and student concerns.

Similarly, Hsu, Purzer, and Cardella (2011) noted that elementary teachers who infused engineering into their classrooms found their perceptions of, knowledge about, and confidence in elementary engineering impacted their ability to teach engineering curricula in their classrooms. Stereotypical views of engineers and engineering and a limited understanding of engineering design made it difficult for teachers to conceptualize ways to infuse engineering into their teaching. This negatively affected their efficacy, serving as a barrier to their instructional and pedagogical practices. These studies, taken together, mostly locate the difficulties with integrating science and engineering instruction into their curricula to a lack of beliefs, knowledge, or experiences—internal barriers—that support their successful implementation.

There are also examples of external barriers impacting teachers' instructional and pedagogical practices. Teachers find their science and engineering instruction constrained by many factors outside of themselves. For example, Lee and Houseal (2003) noted that science and engineering instruction suffered when teachers encountered factors that constrained their practice: (a) a lack of financial and material resources, (b) the curriculum standards imposed on science instruction and other content areas by schools, school districts, and the state, (c) the pressure from colleagues and administrators to teach in a specific manner, and (d) the isolating nature of teaching and lack of time for collaboration.

Teachers also feel constrained in their science and engineering instruction by accountability pressures that narrow the curriculum. Teachers at high-needs schools (often labeled as low-performing) are more likely to succumb to the pressure to change their practices due to accountability pressures because teachers and principals need to rapidly raise achievement scores in response to increased scrutiny or a heightened culture of surveillance (Blanchard et al., 2010; Jones et al., 2003). Many teachers indicate that the high stakes nature of assessments and the culture of testing and accountability that it creates impact the quality and quantity of their science teaching, resulting in science and engineering being left out of the curriculum altogether (Southerland et al., 2007).

Many of these studies suggest that teachers lack appropriate resources (i.e., personal, temporal, financial, material, political) to integrate science and engineering practices into their elementary curricula. This locates the problem with the teacher—with what the teacher does and does not possess and teachers' management of those barriers regarding their science and engineering instruction. Additionally, considering these constraints as barriers does not illustrate how individual teachers persist in including science and engineering in their elementary curricula, despite experiencing constraints on their practice. This calls for us to reconsider barriers that *affect* how and what teachers teach and explore how sociocultural conditions of a teacher's workplace *shape* teachers' decisions, choices, and actions.

Dilemmas as an Alternative to Barriers

In this section, I discuss the construct of *dilemmas* as an alternative to thinking of barriers to teachers' science and engineering instruction (see the highlighted portion of Figure 2.2). Barriers are static and intractable. Teachers must work around them or remove them. An alternative to looking at constraints to teachers' science and engineering instruction as siloed barriers, is to analyze the *dilemmas* (Windschitl, 2002) teachers encounter. Dilemmas denote an interaction between teachers and their environment. Unlike barriers, dilemmas are worked *with*, not around. They shape teachers' responses depending on context, experience, and vision. Windschitl (2002) theorizes that dilemmas are aspects of teachers' intellectual and lived experiences that prevent teachers from realizing ideal pedagogy in practice. In other words, teachers often experience moments of tension when they find their personal beliefs, vision, and ideals in competition and conflict with those of their workplace. In these moments of juxtaposition, teachers find themselves wrestling with dilemmas that complicate their attempts to teach science and engineering according to their professional beliefs, values, and knowledge (Braaten & Sheth, 2017).

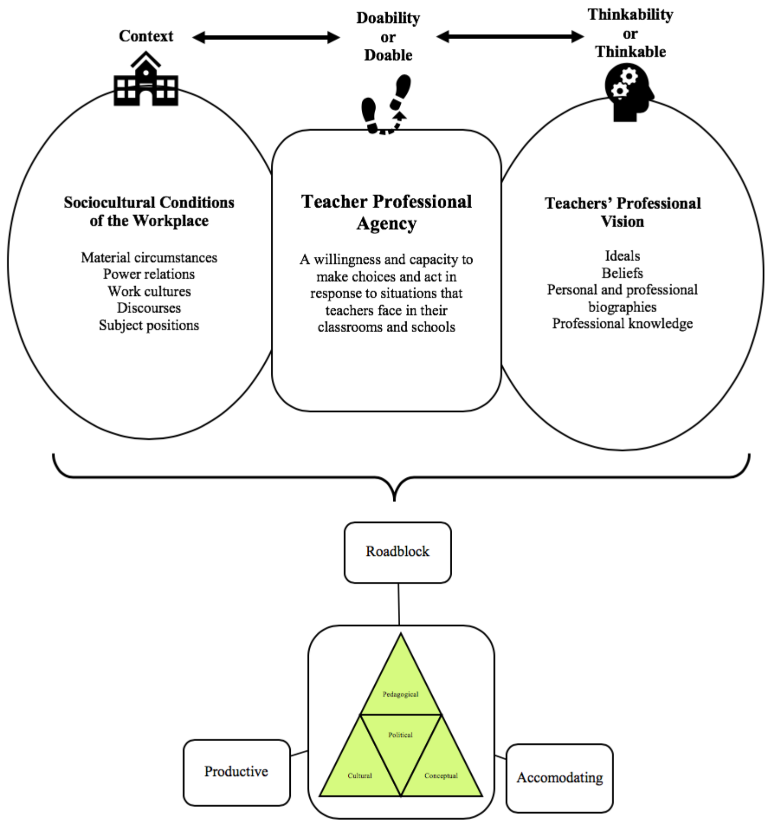


Figure 2.2. Dilemmas Positioned in the Conceptual Framework.

Windschitl (2002) argues that teachers seeking to enact quality science and engineering in their classrooms experience dilemmas with *conceptual, pedagogical, cultural,* and *political* dimensions (see Table 2.1). However, teachers' lived experiences do not fall neatly into one of the four dimensions of dilemmas. In teachers' day-to-day practice, they experience challenges and conflicts as products of an interplay between multiple dilemmas (Windschitl, 2002).

Table 2.1

Four Dimensions of Dilemmas

Dilemma	Description
Conceptual	These dilemmas are rooted in teachers' attempts to understand the philosophical, psychological, and epistemological foundations of the instruction teachers seek to implement.
Pedagogical	These dilemmas arise from designing curriculum and learning experiences aligned with the instructional approach teachers seek to implement.
Cultural	These dilemmas emerge between teachers and students during the reshaping of classroom roles and expectations to accommodate a new instructional philosophy.
Political	These dilemmas are associated with resistance from stakeholders in educational communities when teachers question institutional norms and disturb routines of privilege and authority.

Note. Adapted from Windschitl (2002).

Analyzing teachers' experiences within their context as they integrate and enact science and engineering instruction in their high-needs, elementary classrooms into these four categories or dimensions of dilemmas allows a better understanding of the multiple layers of concerns and tensions that teachers experience and must address in their working lives (Braaten & Sheth, 2017). Dilemmas are fluid concerning time, school context, leadership, pedagogy, and political environments, and offer a degree of teacher agency. These dilemmas, especially the political and pedagogical, might be heightened and magnified in the context of high-needs schools. With few, if any, studies focusing on these contexts, understanding the dilemmas elementary teachers face considering their high-needs school contexts gives us insight into the complexities of the reasoning, decisions, and choices that teachers make and the actions they take when attempting to integrate quality science and engineering instruction into their curriculum.

Characterizing Teachers' Responses to Dilemmas

In this section, I discuss the common tension metaphors used to describe how teachers typically respond to tensions and dilemmas (see the highlighted portion of Figure 2.3). Windschitl's (2002) framework serves as an important theoretical tool for characterizing teachers' pedagogical reasoning; it provides a structure to give name and meaning to the dilemmas teachers face and uncover what influence teachers' decisions and choices about if to teach, what to teach, and how to teach science and engineering. Three common tension metaphors describe how teachers respond to dilemmas: (1) dilemmas as *roadblocks*, (2) dilemmas as *accommodation*, and (3) dilemmas as *productive* (Braaten & Sheth, 2017) (see Figure 2.3).

Hammerness (2004) characterizes the dilemmas encountered by beginning science teachers as *roadblocks*. In a study of one teacher, Hammerness found that the externally imposed context of accountability created conflict between the teacher's vision of a student-centered classroom and the reality seen in the culture of the school. This intersection of political, cultural, and pedagogical dilemmas affected her efficacy and beliefs, ultimately seeing these dilemmas as a *roadblock*, abandoning the vision to which she aspired.

Some teachers manage dilemmas rather than seeing them as complete roadblocks. Smagorinsky, Cook, et al. (2004) explain this as a form of coping, or as *accommodation.* In their case study, the authors describe a teacher candidate who wrestled with decisions about her pedagogical and instructional practices, gravitating towards a middle ground that accommodated beliefs from both sides of the dilemma. In this case, the teacher candidate who, while experiencing frustrating tensions between conceptions of good teaching between her university and student teaching site, used a form of compromise between personal expectations and those of her supervising teacher. Teachers accommodated for or coped with manageable dilemmas, requiring a kind of negotiation with and deference to more powerful forces in the environment (Smagorinsky, Cook, et al., 2004).

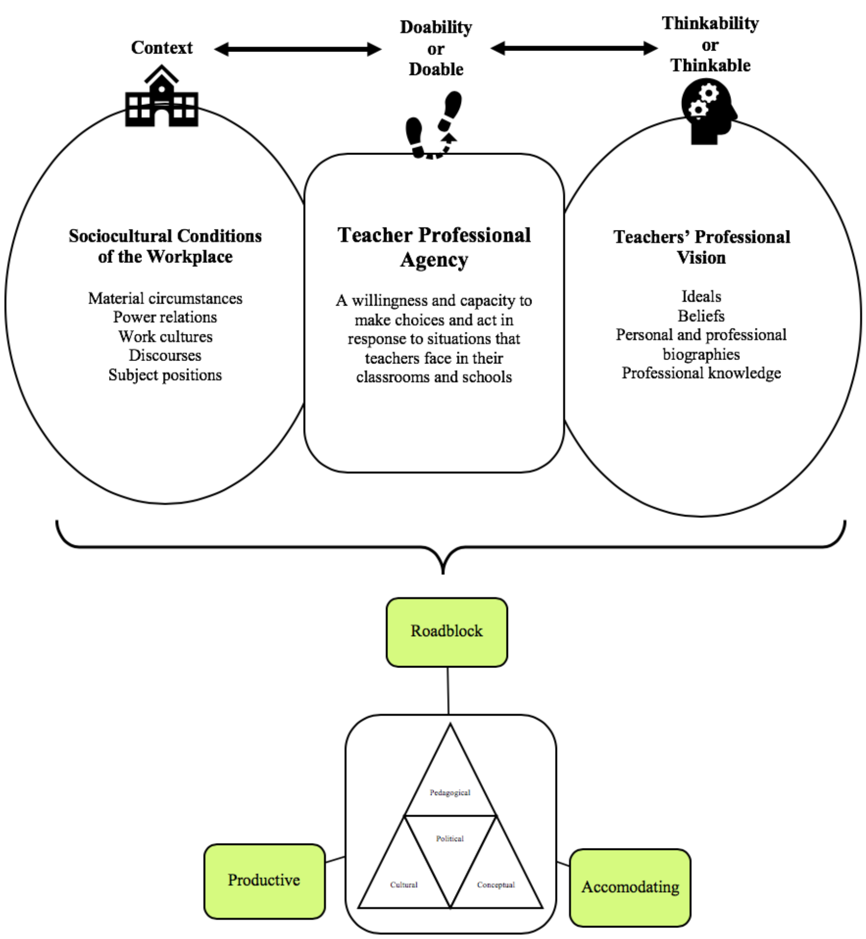


Figure 2.3. Responses to Dilemmas Positioned in the Conceptual Framework.

Finally, other literature considers that certain dilemmas are *productive* (Stillman, 2011). In a study of upper-elementary teachers in "underperforming" schools who navigated accountability demands within a tightly controlled context, Stillman (2011) highlighted how teachers experienced *productive tension* when administrators provided them with opportunities to grapple with reforms which conflicted with their beliefs and vision. Here, teachers still found dilemmas challenging, but analyzed their practice, engaged in professional learning, and ultimately sought ways to creatively work through the dilemma and improve the quality of their instruction.

Studies often explore dilemmas when teachers attempt to restructure or enact new pedagogies, i.e., constructivist pedagogies (Windschitl, 2002), teaching science for equity (Braaten & Sheth, 2017), and reform-based inquiry practices (Lotter et al., 2013). In these studies, the status quo of traditional schooling that teachers creatively push against centers on what and how teachers are teaching. When considering the teachers in this study, teaching against the status quo is not *just* about changing pedagogical practices. Instead, it is about challenging the norms and ideals of schooling in high-needs elementary schools from its core by working to integrate science and engineering into the curriculum as a whole. I expect that teachers will still encounter a combination of dilemmas, but that differences in the intermingling of dilemmas may arise as I explore a different "status quo." This is not just about one pedagogical method versus another; this is about the overall norms and structure of schooling and education in high-needs schools—educational contexts that often squeeze science and engineering out of the picture altogether or ask for it to be taught in a technicist manner.

The dilemmas that teachers experience as they try to teach quality science and engineering instruction in their elementary classrooms rarely fit into neat categories. They are layered and multi-faceted. The interplay between dilemmas and how teachers wrestle and respond to them gives us insight into the decisions and choices teachers make, the stances they take, and the influence they have within their workplaces. Simply put, the pedagogical reasoning involved in wrestling with and responding to multiple dilemmas can be seen as teachers making everyday pedagogical and practical decisions and actions based on their goals, interests, and motivations—or exercising professional agency (Heikonen et al., 2017).

Professional Agency as Thinkability and Doability

When teachers creatively work through dilemmas, no matter how they frame them, they exercise their professional agency. In these moments, teachers wrestle with the dissonance between personal and institutional ideals to make choices and decisions and take action that they believe is professionally sound and can make a meaningful difference in their classrooms. In this section, I unpack how I have conceptualized professional for this study. In short, professional agency is a teachers' capacity to make choices, take stances, and influence their educational community in ways that affect their work and in keeping with their professional sense of self (Eteläpelto et al., 2013). To fully understand the construct of teachers, I first consider "doability" and then I explain "thinkability."

Science and Engineering Instruction as Doable: Teachers' Professional Agency

In this section, I discuss the construct of *doability,* which includes teachers' professional agency (see the highlighted portion of Figure 2.4). The word "do" means to perform or to execute (Do, n.d.). It is an action verb, the intent of which is to express the physical or mental action of a subject.

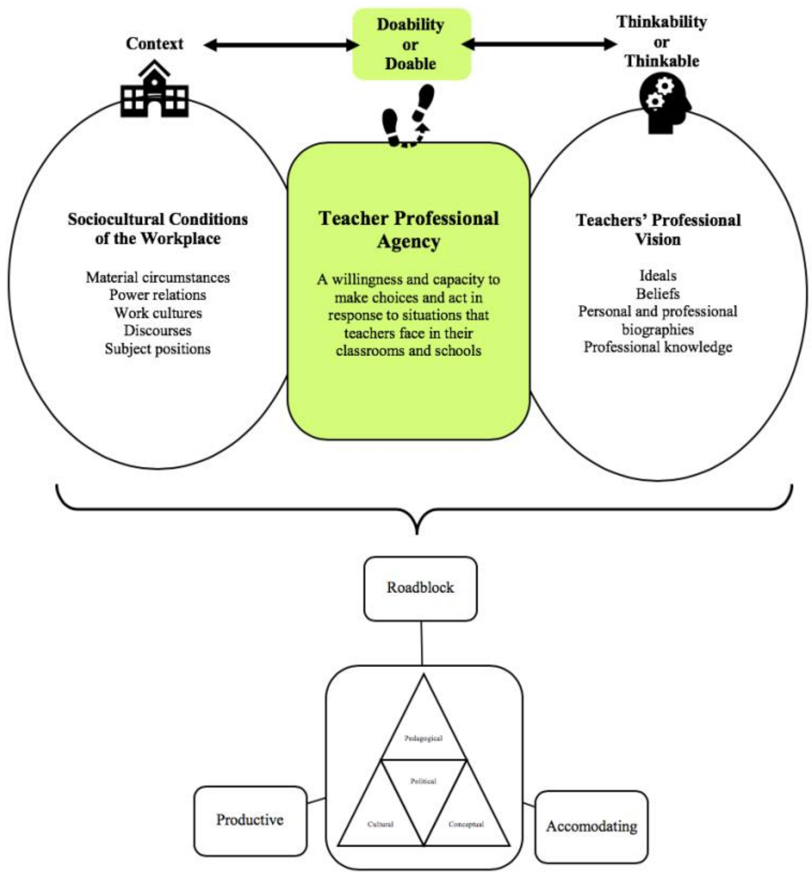


Figure 2.4. Professional Agency as Doability Positioned in the Conceptual Framework.

When a teacher says that science and engineering instruction are *doable,* they imply that they take action or make decisions about their pedagogy. When I designed this study, I initially saw this as professional agency. As will become clear throughout the dissertation, this framework evolved with data analysis, but here I highlight my initial thoughts about professional agency, doability, and thinkability.

Professional agency. Recent studies across various professions frame professional agency as pivotal to the development of the work community and the practices within those communities (Collin et al., 2015). This research positions workers' agency and actions as strategic, revealing that workers make conscious choices regarding when and how to act (Mrozowicki et al., 2010; Vähäsantanen, 2015; Vähäsantanen & Eteläpelto, 2009). I draw on this literature to establish that professional agency includes opportunities for individuals to influence their own work (Ketelaar et al., 2012; Priestley et al., 2012).

Conceptualized as transformative and linked to certain phenomena, such as the power to transform objects of activity, professional agency can also include breaking away from a given frame of action or traditional taken-for-granted practices or courses of action and the taking of initiatives to transform them (Engeström, 2005; Virkkunen, 2006). Professional agency does not always mean positive participation in and contribution to a shared activity in the workplace; instead, it can also manifest via resistance, opposition, withdrawal, omission, and the violation of power relations (Lipponen & Kumpulainen, 2011; Raino, 2008).

Teachers' professional agency. While the literature addressing and exploring teachers' professional agency is now more prevalent, the prevailing empirical studies are wrought with different interpretations about what counts as professional agency for teachers in their workplace. Table 2.2 gives a broad picture of the literature and the themes embedded in its conceptualizations of teachers' professional agency. I further unpack the ideas from Table 2.2 throughout this chapter.

Table 2.2

Definitions of Professional Agency and Key Concepts

Definition of Teachers' Professional Agency	Key Concepts and Understandings
Subjects' creative initiatives and suggestions for developing existing work practices (Vähäsantanen et al., 2009)	Developing practices Active and passive agents
Taking a critical stance, or entering into a struggle against reforms suggested from outside (Vähäsantanen & Eteläpelto, 2009)	Critical stance Struggle Reform
Choices and intentional actions of a teacher regarding her/his involvement in educational reform during its implementation (Wei & Chen, 2019)	Making choices Intentional actions Reform Positive and negative agency
Teachers' active efforts to make choices and intentional action in a way that makes a significant difference; Teachers' ability to act in new and creative ways, and even to resist external norms and regulations when they contrast or conflict with professionally justifiable action (Toom et al., 2015)	Active efforts Making choices Intentional actions Making a difference Ability to act Resistance
Willingness and capacity to act according to professional values, beliefs, goals, and knowledge in the different contexts and situation that teachers face in their work both in classrooms and outside of them (Lasky, 2005; Toom et al., 2015)	Capacity to act Professional values, beliefs, goals, and knowledge

Table 2.2

Cont.

Definition of Teachers' Professional Agency	Key Concepts and Understandings
Practiced when professional subjects and communities exert influence, make choices, and take stances in ways that affect their work and their professional sense of self (Eteläpelto et al., 2013)	Exert influence Influence Make choices Take a stance Affect their work Professional sense of self Subject centered Collective agency
When teachers perceive themselves as being in control of their everyday pedagogical and practical decisions and actions based on their goals, interests, and motivations (Heikonen et al., 2017)	Controlling decisions Controlling actions Goals, interests, motivations Individual agency
The notion that professionals such as teachers have the power to act, to affect matters, to make decisions and choices, and take stances, for example, concerning their work and professional identities (Vähäsantanen, 2015)	Power to act Affect matters Make decisions Make choices Take stances Professional identity Individual capacity Within systemic pressures
Involves practitioners taking a stance and being able to influence their work and professional identity (Edwards, 2015)	Taking a stance Influencing work Professional identity
An ability to make a difference or to intervene in the world, to act otherwise, to exercise some sort of power (Pantić, 2015)	Making a difference Intervening in the world Exercising power Acting as a change agent
The power of teachers (both individually and collectively) to actively and purposefully direct their own working lives within structurally determined limits (Hilferty, 2008)	Power to act Direct working lives Individual and collective agency Constrained by limits

Table 2.2

Cont.

Definition of Teachers' Professional Agency	Key Concepts and Understandings
Actively influencing, making choices, and taking stances at work (Pappa et al., 2017)	Making choices Taking a stance Actively influencing Resistance
Intentional efforts to affect and to make a difference in the transformation of workplace practices and cultures (Hökkä et al., 2017)	Affect work Make a difference Acting as a change agent Intentionality
A capacity that prepares the way for intentional and responsible management of new learning, at both an individual and community level (Pyhältö et al., 2015)	Intentional acts New learning Capacity Individual and collective
When a person can influence one's work, including influencing and negotiating the objective contents and conditions of one's work, including educational reform practices, and making choices and decisions about one's ways of working and acting accordingly (Vähäsantanen, 2015)	Influence work Reform Making choices Making decisions Individual Mental activity Practical activity Social resource
Interrelated elements of a teacher's motivation to continuously learn about teaching, their efficacy beliefs about their learning as teachers, and intentional activities for facilitating and managing learning in everyday pedagogical practices in various professional contexts of their work (Soini et al., 2015)	Motivation Continuous learning Efficacy Intentional activity
The condition required for teachers to remain focused, to hold the line, and to engage with the authorities where necessary in the interests of good education (Long et al., 2017)	Hold the line Remain focused Engage authorities Cultural identity Collective agency

Table 2.2

Cont.

Definition of Teachers' Professional Agency	Key Concepts and Understandings
Professional agency gives teachers the capacity to either adapt or think and do differently while understanding the space of schooling as s a site of contestation, resistance, and possibility (Dovemark, 2010)	Resistance Capacity Decisions and actions Changes
Agency theorized and explored specifically within the context of teachers' workplaces and their engagement with the temporal-relational contexts-for action of their workplace (Biesta et al., 2015)	Not a capacity Achieved Decisions and actions Based on biographies Goal/future-oriented

Most interpretations of teachers' professional agency generally describe it as teachers' active efforts to make choices and take intentional action in ways that make a significant difference in their workplace (e.g., Toom et al., 2015). Teachers, as professionals, engage in innovative learning, adapt themselves to diverse requirements in their working environment, navigate possibilities set forth by policies and mandates, make independent choices, and find a balance between their personal and professional ideals and the shared cultural understandings of their workplace.

Teachers' professional agency can refer to teachers' abilities to act in new and creative ways, and even to resist external norms and regulations which conflict with professionally justifiable ideals and action (Dovemark, 2010). For example, in a study of Swedish secondary teachers, Dovemark (2010) explored teachers' professional agency as they attempted to utilize "consciousness-raising work" in their classrooms. The teachers' views of education stood in sharp contrast to the strong dominant ideology of education, characterized by student individualism, self-regulation, and self-governance. Acting out of a notion of what they believed to be professionally and pedagogically "right," the teachers' actions became symbols of resistance, displaying how the structure of a workplace affected the workers, but that professional agency gave the teachers capacity to think and do differently.

Teachers' professional agency is, however, more than just coping with challenging professional situations. In contrast to defining professional agency as moral resistance, Pyhältö et al. (2015) focused on teachers' active efforts to learn in their professional community to promote personal and school development. While Pyhältö et al. (2015) did not spotlight teachers actively opposing and resisting reform or policies and ideals they think of as professionally unsound, they illustrated how teachers actively sought to make decisions and take action that affects their workplace. Teachers used professional learning to transform their learning practices, which in turn impacted and transformed how they interacted with students in the classroom and their larger professional community.

These are just two of the varying stories of teachers' professional agency in the literature. Through both examples mentioned above, along with the extensive literature summarized in Table 2.2, a few key ideas begin to emerge about how to think about teachers' professional agency—it involves teachers (or groups of teachers) making decisions that affect their instruction, their classrooms, and their broader educational community; it is active and, most often, involves teachers taking action in ways that affect their work. Eteläpelto et al. (2015) add to these assumptions by unpacking types of action, integrating ethics and vision, and taking into account context-specific influences on professional agency. Their conceptualization of teachers' professional agency includes: (a) being practiced and seen when teachers exert influence, make choices, and take stances in ways that affect their work and who they see themselves as in their educational community, (b) being closely entangled with teachers' professional and ethical commitments, ideals, motivations, beliefs, interests, and vision, (c) having teachers' unique professional experiences, knowledge, and competences work as resources, (d) being drawn upon for certain purposes, (e) being supported and constrained by certain historically formed sociocultural and material factors, and (f) being needed for developing pedagogical practice and for enacting creative plans in the workplace. Eteläpelto et al. (2013) provide a powerful definition of teachers' professional agency, and I draw heavily on their framework to define professional agency in this study. However, while they applied the construct of professional agency to understand both outside of education and of preservice teachers, I apply it to understand how elementary teachers in high-needs schools navigate social, cultural, and political dilemmas to incorporate science and engineering in their classrooms.

Conceptualizing professional decisions, choices, and actions. Professional agency is something that people do in practice; it is active (Toom et al., 2015). Professional agency encompasses the choices and decisions made, but also the actions taken by teachers concerning the instructional and pedagogical practices in their educational context. The literature that examines teachers' decisions, choices, and actions related to their professional agency, does so almost exclusively focused on teachers' response to education reform (Heikonen et al., 2017; Ryder et al., 2018; Toom et al., 2015; Vähäsantanen, 2015; Vähäsantanen & Eteläpelto, 2009; Wei & Chen, 2019). However, just like the characterizations of teachers' professional agency, the views of professional decisions, choices, and actions vary in the literature as well. The remainder of this section explores how teachers' professional decisions, choices, and actions are conceptualized in professional agency literature to help clarify what is meant by *decisions, choices*, and *actions*.

In an exploration of two physics teachers in China and the interplay of their professional identities, professional agency, and high school context, Wei and Chen (2019) described and characterized the teachers' decisions, choices and actions as *consistent (with reform), critical*, *resistant, passive,* and *creative*. One teacher pursued a focus on practical work counter to the expectations and desires of the students and institution. The authors categorized this teacher's choices and subsequent actions as *creative* and noted this as an example of *positive agency,* acknowledging that all teachers have a capacity for professional agency, but there are both positive and negative manifestations. In contrast to the positive agency of the first teacher, *negative agency* and *passive* choices and actions illuminate the case of the second physics teacher. This teacher disagreed with her school's policy of only following the lessons outlined in the mandated textbook. She felt that as a beginning teacher, it was not her place to take a stance against the normative practices of her institution, nor did she have the confidence to do so, choosing instead to "follow the crowd" (Wei & Chen, 2019, p. 1297). Though the authors characterized this as a passive decision and passive action, the decision not to take action was still an enactment of professional agency. Here, the characterization of teachers' professional decisions, choices, and actions seem static and dichotomous; teachers showcase either *positive agency* or *negative agency* through their actions. However, not all authors consider teachers' actions to be so siloed and straightforward.

Vähäsantanen (2015) explored the professional agency of vocational teachers, elaborating on teachers' decisions and actions when their professional agency was *restricted* and *extensive*. When teachers' professional agency was restricted, Vähäsantanen conceptualized teachers' decisions and actions to be *humble, uncritical,* and *non-intervening*. When teachers had extensive professional agency, their decisions and actions were *active*, *critical*, and *initiating*. However, the more illustrative categorization and description of teachers' decisions and actions as part of their professional agency is Vähäsantanen's spectrum of teacher reactions as somewhere between *passive accommodation* and *active participation* in response to educational reforms. When teachers simply adjusted to and tolerated social demands and the educational reform without question, it was described as passive accommodation. In these cases, teachers, without action, chose to adjust their beliefs and practices to follow the status quo and social demands of their institution.

In contrast, teachers seen as using refined innovations within their classrooms exhibited active participation in the face of educational reform. Some teachers were critical of the reform, and some were enthusiastic supporters, but these teachers chose to involve themselves in a personal decision-making process to alter or innovate the reforms instead of being passive travelers on the sea of change. Similar to Wei and Chen (2019), Vähäsantanen (2015) presents positive and negative aspects of teachers' professional agency through their decisions and actions. However, in contrast to Wei and Chen's (2019) framing of decisions and actions, these conceptualizations of professional agency appear on a spectrum leading one to believe that there are flexible graduations of teachers' professional decisions and actions. This approach to viewing and perceiving the decisions and actions of teachers may not be siloed into categories, but it is still a fixed, linear spectrum.

In contrast to the dichotomous or fixed frameworks described above, Eteläpelto et al. (2015) characterize all the decisions, choices, and actions of teachers within the scope of professional agency as *renegotiations*. In their study of novice teachers' personal perceptions and understandings of their professional agency, choices, and decisions by the novice teachers expressed feelings of complete and total autonomy within their classrooms. This perception of autonomy led the novice teachers to develop and use pedagogical practices aligned with their professional and personal beliefs of student learning and vision for quality instruction. Here, when the teachers sensed their autonomy, they made decisions about the instructional approaches in their classrooms and took action to realize this fully. In another example of teachers' professional decisions, choices, and actions as a renegotiation, the authors found that beyond this feeling of autonomy for instructional approaches in their classrooms, these same novice teachers worked to utilize other reform-minded approaches, both in the classroom and school-wide. They chose to persevere and try new approaches but found themselves having to adjust their actions, the approach, and the enactment of their strategies, based on the contextual realities of the school. There were times when teachers decided to use these approaches and strategies but had to put aside their endeavors, at least for the moment, in favor of more traditional methods, renegotiating their decisions, choices, and actions.

Whether called *taking control*, *passive accommodation*, *renegotiations*, *passive choices*, or by other terminology, when examining teachers' professional agency, the literature points to definite conceptualizations of the professional decisions and choices teachers make in the influence of their context. Though the literature is wrought with ways to understand and depict the decisions, choices, and actions that are part of teachers' professional agency, Eteläpelto et al.'s (2015) characterization as *renegotiations* best informs my framework and study. Teachers' professional agency, their decisions and actions, their professional sense of self, and the context in which they are situated are all intertwined. Teachers who are committed to teaching science and engineering make and remake themselves by drawing on their current self-conceptions and then acting in ways that seek to match those self-conceptions in the context of high-needs elementary schools.

Summary. There is a profusion of thought surrounding teachers' professional agency. It is defined in terms of professional learning (Eteläpelto et al., 2013; Pyhältö et al., 2015), resistance (Dovemark, 2010; Edwards, 2015; Toom et al., 2015), and intentional influence and action (Eteläpelto et al., 2013; Vähäsantanen, 2015; Wei & Chen, 2019). The literature is clear that teachers' professional agency focuses on decisions, choices, and actions, but those, too, have varied conceptualizations throughout the literature. In examining the nature of elementary teachers' professional agency as they try to enact science and engineering in their curriculum, I define teachers' professional agency as a willingness and capacity to make choices and take action in response to situations that teachers face in their classrooms and schools (Eteläpelto et al., 2013; Lasky, 2005; Toom et al., 2015). I conceptualize teachers' enactment of professional agency as moments when teachers willingly tap into their capacity for action to make decisions, choices, and changes to their educational environment or their practices to align those practices with their professional vision—creating a workplace where science and engineering instruction are "doable" in their elementary classrooms.

Science and Engineering Instruction as Thinkable: Teachers' Professional Vision

In this section, I discuss the construct of *thinkability*, which includes teachers' professional vision (see the highlighted portion of Figure 2.5). Teachers' actions and pedagogical decisions connect with seeing science and engineering instruction as *thinkable*. When science is *thinkable*, it is a realistic, achievable aspiration that teachers can articulate and see playing out in their classrooms, despite obstacles and tensions that might arise or the dilemmas with which they might wrestle (Archer et al., 2012). To render science thinkable is to consider it to be a conceivable aspiration, where aspirations are complex and socially embedded and constructed views, goals, and beliefs (Archer et al., 2012).

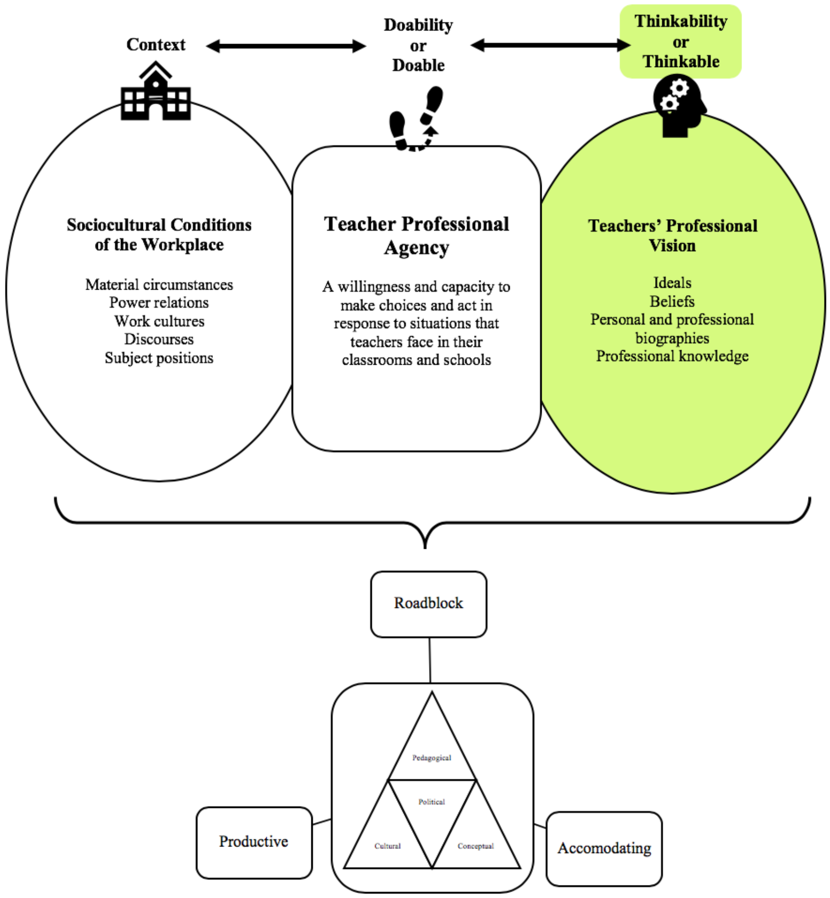


Figure 2.5. Teachers' Professional Vision as Thinkability in the Conceptual Framework.

Archer et al. (2012) theorize that a combination of habitus (deeply ingrained dispositions) and capital (Bourdieu, 1986) provides a fertile ground which renders science more thinkable for students. Therefore, I suggest that, in the case of teachers, certain dispositions, practices, and resources enable them to capitalize on interests, goals, ambitions, and visions that render science a realistic and potentially robust aspiration in their classrooms. The professional agency literature uses teachers' personal characteristics (i.e., teachers' professional beliefs, vision, commitments, goals, and ideals) to frame teachers' willingness and capacity to act and make decisions in their classrooms (e.g., Biesta et al., 2015). The problem is that the professional agency literature abounds with multiple, differing interpretations of what constitutes these personal characteristics and how they interact with agency. The literature explores these personal qualities and their relationship to professional agency as professional identity (Eteläpelto et al., 2015; Wei & Chen, 2019), as professional beliefs and vision (Biesta et al., 2015; Van der Heijden, 2015), as a personal calling (Long et al., 2017) and as a professional sense of self (Buchanan, 2015; Eteläpelto et al., 2015).

The multiple ways of defining personal characteristics leave little clarity about this important piece of teachers' professional agency. In line with what Archer et al. (2012) say about rendering science thinkable—that thinkable implies that something is a realistic, conceivable aspiration—I see a teacher's professional vision to be indicative of what they know, believe, and envision as thinkable in their classrooms. I choose to consider teachers' personal characteristics contributing to science and engineering's thinkability as a teacher's professional vision. A teacher's vision is aspirational, as it includes future-oriented goals and ideals of what could be (Hammerness, 2001, 2006).

Teachers' professional vision. A teacher's vision is a personal commitment to seek results beyond the usual status quo. Teachers' vision has its roots in professional beliefs. It is what teachers envision for their students, but also what they believe is pedagogically just and right (Biesta et al., 2015; Fairbanks et al., 2010). Hammerness (2006) defined professional vision as a set of ideal images that teachers hold of what the environment could be, what their students will be doing, and her or his role in the scene.

Duffy (2005) described a teacher's vision as an ultimate goal for what their students might become as adults.

I prefer to think of a teacher's professional vision as consisting of images of what teachers hope *could* or *might* be in their classrooms, their schools, and their educational community (Hammerness, 2001, 2006). A teacher's professional vision comes from within; it gives meaning to their work (Fullan, 1993). Teachers with a clear vision possess vivid ideals regarding how and what to teach, developed, in part, through experiences, interests, and moral convictions (Vaughn & Faircloth, 2011). Teachers' visions are a component of how and why some teachers have a sense of purpose that guides them through restrictive climates. They serve as a foundation for change and action because they represent a "reach," or a set of images of ideal classroom practice for which teachers strive (Hammerness, 2001). For many teachers, this vision, and reach, inspires and motivates them, and invites them to reflect upon their work and who they are concerning this work.

A personal and professional vision serves as both a guide and a measuring stick for teachers (Hammerness, 2006). A teacher's vision can drive what and how they teach, but it can also indicate how far a teacher's current practice is from where they desire to be. In this way, it not only serves as a touchstone for past practice but also as a projective moment of goal-setting and aspiration. However, a teacher's professional vision cannot be isolated from the contexts in which these teachers imagine and work. Whether teachers feel their contexts provide support is critically important to their ability to carry out their visions.

Factors, Sociocultural Conditions, and Professional Agency

In this section, I discuss the factors that support and constrain professional agency and make an argument for why it is important to reconsider these factors as *sociocultural conditions* of teachers' workplaces (see the highlighted portion of Figure 2.6). Teachers enact professional agency in the middle of dilemmas and uncertainties of professional pedagogical activities (Labaree, 2000; Munthe, 2001).

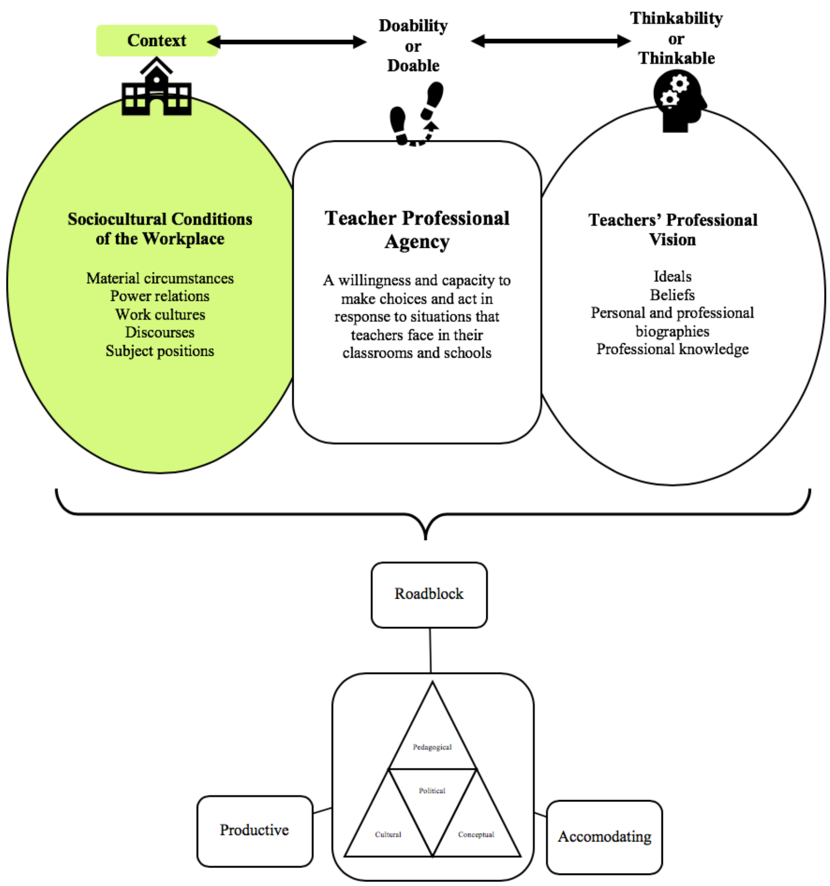


Figure 2.6. Sociocultural Conditions of the Workplace in the Conceptual Framework.

It is seen as their willingness and capacity to act according to professional vision. Not just a personal attribute attached to teachers in their professional work, professional agency is shaped by the different contexts and situations that teachers face in their work (Lasky, 2005; Toom et al., 2015; Turnbull, 2005). Teachers shape and are shaped by the contexts in which they teach every day, as institutional norms, educational policy practices, workplace cultures, and human and material resources influence teachers' enactment of professional agency.

Supporting and constraining factors. When seen as professionals, teachers are active and self-creative with their professional visions; their enactment of professional agency is bound up in the sociocultural conditions of the workplace, including its practices, power relations, discourses, and subject positions. Teachers' professional agency is bound up in an interplay of the individual and their context; they have multifaceted jobs and work in complex educational and social environments. Many studies focusing on teachers' professional agency examine this interplay between the teacher, their professional vision, their decisions, and their actions. However, very few studies, some of which are unpacked in the remainder of this section, have thoroughly explored the nature of teachers' professional agency and give attention to factors that support and constrain it (Eteläpelto et al., 2015; Long et al., 2017; Pappa et al., 2017).

In an exploration of student teachers' perceptions of their professional agency, Eteläpelto et al. (2015) found that teachers exhibited both strong and weak senses of professional agency and that these perceptions were often bound up with personal and contextual factors that both bolstered and constrained their agency. Within the classroom context, factors perceived as positive resources affecting professional agency included such things as collaboration, school culture, and support from a multi-professional team and stakeholders outside of the school. In contrast, perceived constraints included such factors as difficult students, prescribed curriculum, time and energy, and division of subjects into disciplinary silos. The findings further indicated that the school administration represented both a main constraint and a main resource affecting professional agency. While providing a clearer picture of what supports and constraints perceptions of professional agency, these factors are described as structural elements of education put in place and acting upon teachers' professional agency. As of yet, this fails to capture the idea that teachers are both shaped and do the shaping of their educational context.

Similarly, Long et al. (2017) discussed enabling and constraining factors affecting teachers' professional agency in a study of South African teachers' struggle with systemic educational planning. The factors in question were structures put in place by authorities charged with the responsibility of planning and managing the education system. Three phases of educational planning enabled and constrained teachers' professional agency: (1) authorization and implementation of curriculum, (2) monitoring the implementation of curriculum, and (3) monitoring the attainment of curriculum or assessing instruction and student outcomes. The systemic focus on monitoring and compliance interfered with the core identities of teachers who believed the purpose of assessment was to enhance the well-being of their "local" learners. Teachers found this national, standardized assessment constrained their professional agency as they were no longer seen as autonomous professionals; these teachers felt unable to make decisions in the best interest of their learners.

Sociocultural conditions of the workplace. The literature paints a picture of how factors both support and constrain teachers' professional agency. However, considering these as *factors* can be troublesome. *Factors* imply immovable elements that are static and must be "dealt with." Instead, I choose to consider *factors* in terms of the *sociocultural conditions* of teachers' workplaces. Teachers and their sociocultural environment are inextricably linked, as teachers are continually shaped by and shaping their context. Therefore, considering factors not as structural elements that *happen to* teachers, but instead as sociocultural conditions of the workplace that *influence* and *are influenced* by teachers' professional agency is an important view missing from some of the scholarly literature. The capacity for professional agency varies across contexts and time. It is dependent on both sociocultural conditions of possibility and constraint, and also a teachers' ability to utilize their beliefs, values, and visions in response to those (Priestley et al., 2012). Table 2.3 consolidates the examples of supporting and constraining factors into categories explaining them as sociocultural conditions of a teacher's workplace.

As professional agency is a situated activity, the sociocultural conditions of a teacher's workplace facilitate and constrain professional agency and vary by context and even time of year. I began this study by viewing these sociocultural conditions of a teacher's workplace as possibly facilitating or constraining teachers' professional agency; thus, I worked these into my conceptual framework (see Figure 2.6). The literature outlines these factors from the experiences of student teachers in Finland, rural South African teachers, and Finnish language-education teachers, with little to no empirical research exploring the factors that support teachers' professional agency within U.S. elementary high-needs school contexts. I anticipate that as contexts vary, so too will the sociocultural facets of an educational workplace facilitate and constrain teachers' professional agency.

Table 2.3

Factors and Sociocultural Conditions and Impact on Professional Agency

Factors	Impact on Professional Agency	Sociocultural Condition
Material and physical resources available to teachers Curriculum Teacher's time and energy	Both supports/facilitates and constrains	Material circumstances
School culture School climate Mandated assessments Local culture	Both supports/facilitates and constrains	Work culture and climate
Administration Labor relations Clear regulations Policy	Both supports/facilitates and constrains	Power relations
Collaboration Network of support Multiprofessional mentoring	Supports/facilitates (when present)	Discourses
Autonomy Administration Labor relations Policy	Both supports/facilitates and constrains	Subject positions

Sociocultural Approach to Agency

Teachers' professional agency can be exercised in their teaching practices, which includes influencing and negotiating pedagogical and instructional practices to apply new ideas within the classroom and making decisions about one's way of teaching (Priestley et al., 2012; Vähäsantanen et al., 2009). Teachers' professional vision frames and shapes professional agency (e.g., Vähäsantanen et al., 2009). However, certain social and contextual aspects are also intertwined with these practices of agency. These aspects, which influence and frame teachers' professional agency, can include the curriculum, the professional tasks, school culture and norms, and the material resources available (Lasky, 2005; Vähäsantanen et al., 2009).

Eteläpelto et al. (2013) provide a review of different conceptualizations of professional agency in studies of workplace learning. Their analysis identifies four broad approaches to viewing agency: (a) social science, (b) post-structural, (c) sociocultural, and (d) life course/identity. These perspectives differ in how they frame an individual's choices, or intentionality, how agency in the present is related to the past and future, or the temporality, and the relationship between the individual and their broader social context. A sociocultural approach to exploring professional agency requires the researcher to look closely at the individual teacher in such a way that gives priority to both social contexts and cultural tools that shape the teacher's beliefs, values, and ways of acting (Lasky, 2005). Cultural, historical, and social structures reflected in the context of teachers' workplace shape what teachers believe, how they think, and how and why they act. If I wish to explore professional agency in the working life contexts of elementary teachers in high-needs schools, I need to understand how the practice of agency and how it is resourced, constrained, and bounded by individual, social, and institutional factors, including power relations and discourses, and further by the material conditions and culture of social interaction in teachers' work conditions. A sociocultural approach is appropriate to do this since it views learning as socially and culturally imbued.

Subject-Centered Sociocultural Approach to Professional Agency

Eteläpelto et al. (2013) make the case for a subject-centered sociocultural perspective as the most appropriate for capturing the ongoing complexities of workplace practices. In this perspective, professional agency centers on the individual, with an acknowledgement of the interplay between the teacher and her/his context. The teacher is strongly participative in choices and decisions—they have intentionality. Therefore, their decisions are not solely the outcome of external forces or an outside structure. Furthermore, personal biographies (the past) and forward-looking vision (the future) frame teachers' actions in the present (Biesta et al., 2015). Through this view, professional agency is a long-term, developmental practice, rather than a set of actions at a specific point in time. Though a subject-centered sociocultural approach to exploring teachers' professional agency is inherently focused on the teacher, teachers' professional agency is still supported or constrained by the broader social and institutional contexts, but with personal goals and biographies as fundamental resources for action. In other words, the sociocultural conditions of the workplace (e.g., material resources, power relations, work culture, dominant discourses) have a mutual relationship with a teacher's professional agency.

If professional agency includes teachers exerting influence, making choices, and taking stances in ways that affect their practice and their workplace (Eteläpelto et al., 2013), then it is almost impossible to separate teachers, their professional agency, and the context in which the work takes place. A subject-centered sociocultural approach and perspective examines the nature of teachers' professional agency as they enact science and engineering instruction in their elementary classrooms in the following ways (see Figure 1). First, as the name implies, this approach is "subject-centered," which means that the focus is on how teachers negotiate and renegotiate certain senses of self (i.e., professional beliefs, visions, commitments, goals, and values). Second, professional agency is situationally and contextually related, that is, supported and constrained by cultural, social, and historical factors. Therefore, an analysis of professional agency at work, or professional agency in an educational context, should take into account material conditions, workplace culture, power relations, or support structures (Biesta et al., 2015; Goller, 2017).

Summary

To conclude this chapter, I, again, provide my conceptual framework for studying the dilemmas teachers wrestle with when undertaking the integration and enactment of science and engineering in their elementary curriculum and the nature of their professional agency as they do so. Many resilient teachers strive to use quality, rigorous science and engineering instruction in their elementary classrooms. To do this, teachers actively and willingly tap into their capacity for professional agency. But, what counts as professional agency in the context of a high-needs elementary school?

When teachers find their personal and professional ideals and vision in conflict with that of their workplace and educational community, they wrestle with dilemmas (Windschitl, 2002). Teachers who grapple with overlapping, and often, multiple dilemmas do so in various ways. The most common tension and dilemma metaphors that explain how teachers respond to these as dilemmas as roadblocks (Hammerness, 2006), accommodations (Smagorinsky, Cook, et al., 2004), or as productive tensions (Stillman, 2011). These dilemmas and teachers' responses underpin science and engineering's thinkability and doability for elementary teachers. Before science and engineering instruction can be doable in certain contexts, it must be thinkable (Archer et al., 2012). When something is thinkable, it is a realistic, conceivable aspiration; with aspirations being complex and socially embedded views, goals, and beliefs. I consider the construct of thinkability to be most closely associated with teachers' professional vision, as teacher vision includes a set of ideals and a reach to which teachers aspire in their pedagogical practices (Hammerness, 2001, 2006). Teachers' vision drives what and how they teach, allowing teachers to reflect on past practice and envision how they desire to teach in the present and future. Thinkability frames the doability of science and engineering, or the actions that teachers take and the choices they make regarding their instructional practices.

When teachers make decisions and take action to align their current pedagogical practices with their aspirations and vision, they are making the science and engineering instruction they consider thinkable, doable. The “doability” of science and engineering in elementary classrooms is connected to teachers’ professional agency, or their willingness and capacity to make decisions and take actions regarding their pedagogical practices. The practice of professional agency, or those moments when teachers make choices and take action to make science and engineering doable, is bound up in the sociocultural conditions of the workplace, including its practices, culture and climate, power relations, discourse, and subject positions (Eteläpelto et al., 2013). The sociocultural context of high-needs elementary school shapes the professional agency of teachers and, in part, frame what is doable and thinkable in these classrooms.

Using a subject-centered sociocultural approach provides me with an opportunity to explore how elementary teachers narrate the nature of their professional agency, the decisions and choices they make, and the actions they take to effect change in their classrooms and schools as they integrate and enact science and engineering into their curriculum. This framework and approach allow me to carefully focus on the professional agency of teachers through an examination of their decisions and actions as framed by their professional vision, experiences, and knowledge, and the broader social, cultural, and institutional contexts in which these teachers work. Careful attention to these aspects will provide me with a clearer understanding of how teachers narrate the nature of their professional agency within the unique context of a high-needs elementary school setting.

CHAPTER III

METHODOLOGY

Introduction

In this study, I used narrative inquiry (Clandinin & Connelly, 2000) to explore the nature of the teachers' professional agency. I explored the professional visions and experiences of elementary teachers teaching in high-needs school contexts as they responded to dilemmas they confronted when integrating science and engineering into their curriculum and the nature of their STEM-linked professional agency in those responses over time.

I chose a narrative inquiry approach because I was interested in providing a space for the voice of elementary, public school teachers as they shared stories of their lived experiences in understanding and negotiating their professional agency. In drawing from Dewey's (2015) understanding of experience as individual and social, yet continuous, I understand that although the teachers may work within this shared context of high-needs schools, they understand and narrate the dilemmas they confront and the nature of their professional agency in diverse ways. Teachers' understandings within this shared context are situated within and influenced by their personal experiences within the contexts of different social and personal spaces. Thus, my use of a narrative design was appropriate because narrative methods assist researchers in understanding "how people structure the flow of experience to make sense of events and actions in their lives" (Schram, 2006, p. 104).

Researcher Positionality: My Story

Saving the world through public education is my passion. It is a rather idealistic one (or at least the part about saving the world is), but it has been the primary driving force in my professional and personal life for a long time. I believe that public education should be a priority; it is worth the fight. I believe that *all* students deserve the right to a quality, free, and public education. My second passion is science, now science education. Science builds our knowledge and understanding of the world and allows us to create new technology and innovation. It drives positive change and conversation. Science is a way of thinking and a platform through which we can understand the world around us.

This is my 17th year in education. My experiences have spanned two states, North Carolina and Maryland, and a variety of positions (i.e., beginning teacher, classroom teacher, reading teacher, mentor teacher, facilitator, researcher, STEM coach), all in high-needs public schools. I have taught through the No Child Left Behind policy mandates and watched the culture of my schools shift from a student-centered, teacher-driven culture of collaboration, trust, and professionalism to a culture of surveillance, outcomes-driven instruction, mistrust, and privatization of classrooms. The loss of autonomy over our own classrooms was a very real experience. There was a time when we mapped out our collaboratively planned, integrated curricula to meet the unique needs of our learners aligned with district and state expectations. But now, no longer trusted to use their professional expertise to meet the needs of their students, schools and districts ask teachers to implement scripted curricula focused on tested subject areas pushing science to the back burner—and sometimes even to the backsplash.

Teaching at a high-needs school can often be synonymous with teaching at a low-performing school. Low-performing schools that struggle to improve scores on standardized, state assessments function under increased accountability pressures, a higher culture of surveillance, and a narrower curriculum. In my last 8 years as a classroom teacher in a traditional public elementary school, I experienced the effects of policy mandates and accountability pressures, which affected my practice and my students' learning. Dedicating almost all our scheduled instructional time (a schedule over which teachers had no control) to mathematics and reading with scripted or semi-scripted programs, there was no time for pursuing students' interests, there was no room for science and other subjects, and there was no avenue for teacher input or expertise.

I was never unaware of the inequities in our schools and the exclusion of teachers from the decisions made by bureaucrats, legislators, and administrators, but I often felt as if I had little power to address them. However, at some point, I refused to be a collaborator in the oppression of teachers and students. I refused to see the tensions and constraints of traditional schooling, as defined by those above me, as roadblocks.

Someone once gave me a life-changing compliment—they told me I was a *tempered radical*. Until that moment, I never had a name for the constant struggle that I felt. Tempered radicals work to introduce and make a difference in their workplace (Meyerson, 2001). Often done in small and unassuming ways, their struggle to make and maintain a difference can have a lasting impact on a place's culture, traditions, and prevailing ideas of what it means to do work there. As a tempered radical, I found ways to work the system to teach in ways that were consistent with my personal, pedagogical, and professional beliefs, vision, and goals (Carlone et al., 2010). I found ways to integrate and incorporate science and engineering into my elementary classroom. I did so both publicly and privately as I navigated my accountability-driven context and the demands and tensions associated with it to work towards ambitious, quality science and engineering practices and learning in my classroom.

My position at University STEM Program afforded me the opportunity to collaborate with and hear from teachers in our area. Even the teachers, who, like me, see hope for quality, balanced, equitable education, are frustrated. They complain of lack of teaching time for science, the constant focus on data, their evaluations and pay tied to irrelevant test scores, and the suffering of their students. The teachers in high-needs schools complain that they lack the support, trust, funds, resources, technology, and infrastructure to truly meet the needs of their students in science and other academic content areas. Teachers wrestle with tensions every day. Sometimes these tensions and dilemmas manifest themselves as insurmountable roadblocks. But, often, teachers find creative ways to push boundaries and teach science and engineering in ways that align with their personal, pedagogical, and professional vision for their students. Understanding teachers' tensions and how they wrestle with those affords insight into the complexities of their professional and pedagogical reasoning and teachers' professional agency.

My experiences as a classroom teacher in high-needs schools and my vision for the science and engineering I know is possible in an elementary classroom, has both enabling and constraining aspects regarding the research. My personal biography helped me to understand teachers' situations, establish trusting relationships, and, at times, know when and how to push teachers to narrate their lived experiences more deeply. However, there was always a lurking tension regarding my passion for public education and science and engineering in elementary classrooms. I had to set aside my own lived experiences, ensuring that I told the teachers' narratives centering their experiences and perceptions and not my own.

Research Goals

In qualitative research, and specifically narrative inquiry, it is necessary to understand one's personal goals for undertaking a research project (Clandinin et al., 2007). Additionally, Strauss and Corbin (1990) affirm that "the touchstone of a potential researcher's experience may be a valuable indicator of a potentially successful research endeavor" (p. 23). Who I am and who I see myself as, both as an educator and a researcher, allow me to reflect upon my personal, practical, and intellectual goals for doing this study (Maxwell, 2012). Personally, my motivation to explore teachers' dilemmas and professional agency as they strive to implement science and engineering in their elementary curriculum stems from my experience as a classroom teacher where I worked to make similar agentic moves. We do not have nearly enough examples of teachers who do so, serving as exemplars and beacons of hope for other teachers. Practically, I wanted to understand other teachers' experiences as they confronted dilemmas and the creative ways in which these teachers pushed boundaries and work through these dilemmas, enacting their professional agency. Intellectually, I wanted to understand what it meant for teachers to contend with the sociocultural realities of high-needs schools, but also how their professional agency enabled them to think and do differently with regards to science and engineering instruction.

Research Design

Why Qualitative Research?

Exploring and understanding the nature of teachers' professional agency as they seek to implement science and engineering into their curriculum requires a research design approach that gathers insights into teachers' experiences and the meanings created within high-needs, elementary schools. Through a qualitative approach, I collected, analyzed, and interpreted data to understand teachers' "richly textured experiences and reflection about those experiences" (Jackson et al., 2007, p. 21).

Qualitative research is the inquiry into social phenomena in natural settings (Shank, 2002), including how people experience parts of their lives, how individuals and groups behave, how organizations function, and how interactions shape relationships. A qualitative approach was best for this study because I examined events that occurred, why they occurred, and what those meant to participants. In this case, I explored teachers' professional visions for science and engineering, the dilemmas they encountered as they worked to do that, how teachers responded to those dilemmas, and the nature of teachers' professional agency in those moments. In this qualitative study, I drew on constructivist beliefs. I assumed there was no single reality for all teachers, and instead assumed that this study elicited participants' views of their reality. Merriam (1998) comments "that reality is not an objective entity; rather, there are multiple interpretations of reality" (p. 22). In this vein, my primary interest as a qualitative researcher was to understand the meaning or knowledge constructed by people as they made sense of their world and their lived experiences in it.

Narrative Inquiry

Narrative inquiry is based on the view that humans, both individually and socially, live storied lives—lives that are experiential and narrative in nature, reflecting the interplay of personal (a person's life history) and contextual (the milieu in which they live) (Clandinin & Connelly, 1998). Telling those stories is an essential way of characterizing human experience (Clandinin 2006; Clandinin & Connelly, 2000; Connelly & Clandinin, 2006). A narrative researcher portrays individuals' experiences from different perspectives and brings meaning to the experiences lived by the participants (Clandinin, 2006; Creswell, 2013).

Connelly and Clandinin (1990) initially established the significance of narrative inquiry to bring "theoretical ideas about the nature of human life as lived to bear on educational experience as lived" (p. 3). Narrative inquiry is both a phenomenon and method in that "narrative names the structure quality of experience to be studied, and it names the inquiry for its study" (Connelly & Clandinin, 1990, p. 2). Narrative inquiry is contextualized and grounded in experience. As a phenomenon, a narrative is the story that makes sense of otherwise disconnected events. As Connelly and Clandinin (2006) put it, story is “a portal through which a person enters the world and by which his or her experience of the world is interpreted and made personally meaningful” (p. 477).

As a narrative inquiry, the main component of this study was the narrative discourse—the teachers’ stories recounting their lived experiences of working to integrate science and engineering in high-needs schools. Narrative discourse requires meaning-making through the shaping and ordering of participants’ experiences. This is a way of understanding a person’s actions, organizing those events into a meaningful whole, and connecting and seeing the outcomes of the actions and events over time (Chase, 2011). The belief that a person’s experiences are storied is based on a three-dimensional space, which includes notions of temporality, sociality, and place, and allows for an analysis of teachers’ experience that may have accounted for context and cultural impacts (Clandinin, 2006).

Three-dimensional space of narrative. Connelly and Clandinin (2006) elaborated on how to narratively understand experiences by identifying three common dimensions of an inquiry space: (a) continuity or temporality, (b) interaction or sociality, and (c) situation or place. Every story has a past, present, and future. A story viewed through a temporality dimension represents Dewey’s “continuity of experience” (Dewey, 2015, p. 35). To inquire into narratives, the stories must be situated as constant, ongoing processes with a past, present, and future. Sociality refers to the relationship between participants and their social world and participants and the researcher. This involves a balance of personal (e.g., feelings, desires, dispositions) and social conditions (e.g., environment, contextual forces). This social dimension includes participants looking inward (self or personal) and outward (social conditions) and considering both as they narrate their experience. Situation or place is “the specific concrete, physical and topological boundaries of place or sequence of places where the inquiry and events take place” (Connelly & Clandinin, 2006, p. 480). It includes any physical characteristics of the teaching environment and the physical positioning of people within that space. While it was possible to see each of the three dimensions separately in teachers’ words, participants’ narratives and the sense they make of their lived experiences interconnect and intermingle these dimensions (Connelly & Clandinin, 2006).

Design principles of narrative inquiry. Clandinin and Connelly (2000) describe the characteristics of narrative inquiry as “a way of understanding experience” (p. 20). Many design principles set narrative inquiry apart from other qualitative methodologies (see Figure 3.1). Narrative inquiry differs from other forms of inquiry, as it involves “a collaboration between the researcher and the participant, over time, in a place or series of places, and in social interactions with milieus” (p. 20). Narrative inquiry “is an approach to the study of human lives conceived as a way of honoring lived experiences as a source of important knowledge and understanding” (Clandinin, 2006, p. 17). It was these design principles and these unique tenets of narrative inquiry that allowed me to listen to and understand teachers’ everyday experiences. This made narrative inquiry an appropriate qualitative approach for exploring the nature of teachers’ professional agency when confronted with dilemmas while integrating science and engineering into their elementary curriculum

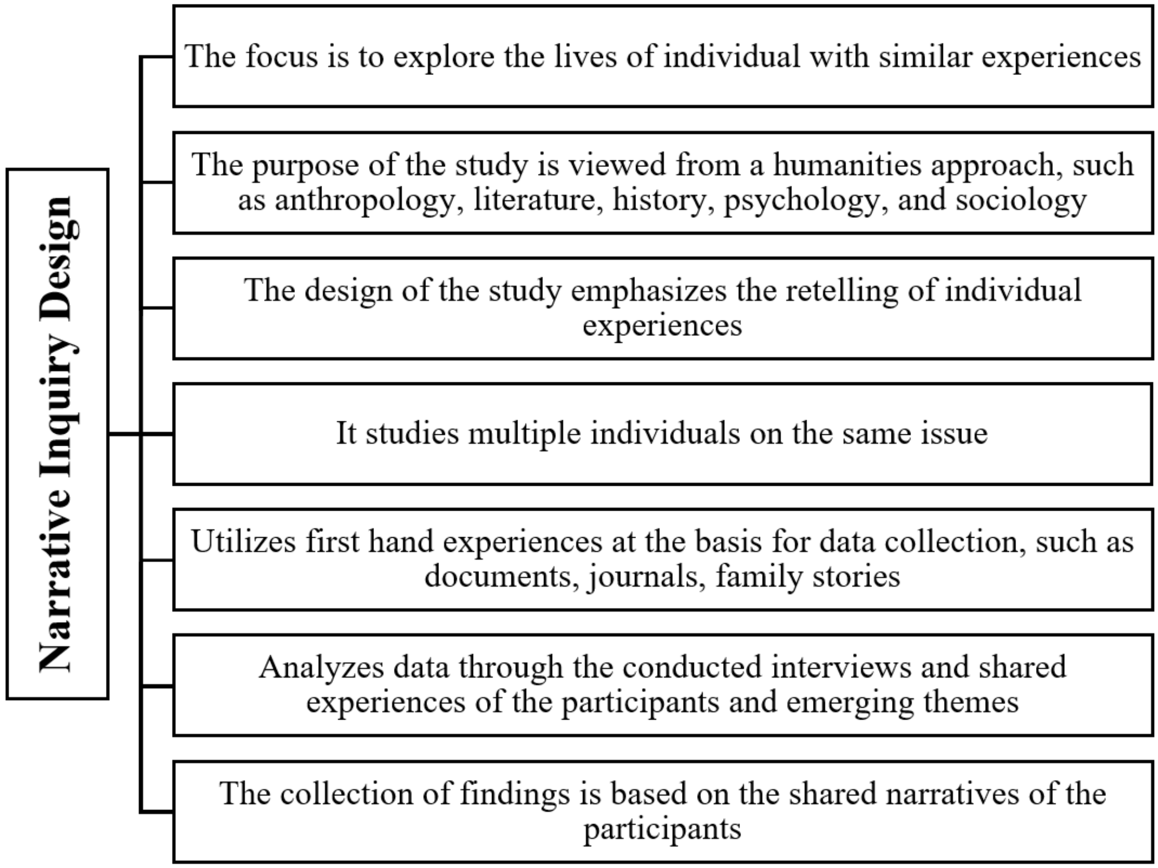


Figure 3.1. Narrative Inquiry Elements. Adapted from (Clandinin & Connelly, 2000; Connelly & Clandinin, 2006; Creswell, 2013).

I looked to narrative inquiry to connect to teachers' experiences. It informed the understanding of elementary teachers committed to teaching science and engineering in high-needs, the dilemmas they encountered, and the professional agency they enacted. Narrative inquiry allowed me to amplify voices that may have otherwise remained silent and utilized storytelling as a way of communicating teachers' realities, struggles, and agency to a larger audience.

The Story of My Study: Data Collection, Data Analysis, and Sampling

The teachers involved in this study are part of the University STEM Program (a pseudonym). A community of approximately 200 teachers, administrators, and university faculty, the STEM Program strives towards a sustainable support network of educators enacting science, technology, and engineering (STEM, for ease of description) in high-needs elementary schools. The STEM Program's goals include nurturing STEM equity by making rigorous and responsive STEM a regular part of the elementary curriculum in high needs schools, empowering teachers to include STEM regularly despite pressures to do otherwise, providing teachers with leadership opportunities while remaining in the classroom, and growing the community's STEM education network. Teachers choose to be involved with the STEM Program. Usually, through word of mouth and on the recommendation of colleagues, teachers select into the STEM Program network, their involvement varying from teacher to teacher.

STEM Program offers a variety of supports for teachers; two of these supports figure prominently in this study. Each summer STEM Program holds the Summer Institute, a three-day professional learning opportunity that brings together K-5 teachers from across the geographic area to learn about the role engineering and the engineering design process could play in the science instruction in teachers' classrooms. The STEM Program focuses the Summer Institute on engineering instruction because it provides teachers with unique learning opportunities that nudge them out of comfortable, traditional, teacher-driven instructional practices, instead emphasizing student talk, teacher talk moves, discourse around data, student sensemaking, and collaboration. All but two teachers in this study attended the STEM Program Summer Institute, either as a participant or in the role of a Teacher Leader. Another way of empowering teachers with leadership opportunities, Teacher Leaders help facilitate the Summer Institute and mentor teachers new to the STEM Program network. Many teachers, especially many of those featured in Phase II of the study, also participated in the University STEM Program Community of Inquiry (COI) groups. COI brings together same-grade-level teachers in a professional learning community to collaboratively plan science lessons, observe group members' science instruction, and then reflect on classroom practices. Using a Lesson Study model, teachers come together for professional learning with a shared commitment to professional growth and inquiry into their own pedagogical practices (Dotger, 2015) for a combination of collaborative planning and "Studio Days," or opportunities to share and reflect on practice (Jessica's work that I can't find to cite, XXXX Thompson et al., 2019).

I served many roles within the STEM Program, including serving as coordinator of programming, newsletter writer, co-designer of the Summer Institutes, and facilitator of Communities of Inquiry groups. I collaborated with teachers to design and implement responsive professional learning opportunities and to support teachers in their classrooms as a STEM coach. STEM Program professional learning opportunities allow teachers to first be learners before integrating and implementing these science and engineering teaching practices in their own classroom. Additionally, I support the teachers of the STEM Program by providing the social and material resources teachers feel they need to be successful elementary science teachers. While this is not a study of the effectiveness of the professional learning offered by the STEM Program, it is important to consider the STEM Program as a potential source of agency and a part of teachers' contexts.

Study Outline

I conducted this study in two narrative phases. Phase I of the study addressed Research Questions 1, 2, 3, and 4, while Phase II of the study addressed Research Question 5. The research questions that inform my study were:

Phase I: A narrative inquiry of 47 teachers

1. What is the nature of elementary teachers' professional visions for teaching science and engineering in high-needs schools?
2. What facilitates and/or constrains the enactment of teachers' professional visions for science and engineering?
3. What dilemmas emerge for elementary teachers as they reconcile their professional vision with the ideals and demands of schools?
4. In what ways do teachers respond to those dilemmas?

Phase II: A narrative inquiry of a select sample of 18 teachers

5. How do teachers who work in high surveillance cultures and have strong commitments to their professional vision for science and engineering narrate the nature of their STEM-linked professional agency over a school year?

I describe each of these phases in turn below.

Phase I: A narrative inquiry of 47 teachers. In Phase I of this study, I gathered teachers' stories and experiences about themselves, their instruction, the institutional realities in which they work, and their perceptions of professional learning and available supports to determine how elementary teachers respond to the dilemmas they confront when integrating science and engineering into their curriculum. This first phase of the study included a semi-structured interview of 47 teachers, followed by qualitative analysis in keeping with narrative inquiry analysis methodology.

Phase I participants. Following the three-day STEM Program Summer Institute, a total of 45 teachers initially agreed to participate in the study. Two teachers joined the study a few months later due to their participation in STEM Program COI groups, bringing the participant count to 47 teachers. All 47 teachers taught in high-needs school contexts, though their contexts varied between traditional public schools and public magnet schools. As is characteristic of most elementary schools, only two of the teachers were male. The average years of experience was nine years, although the participants ranged from a first-year teacher to a teacher who had been teaching for 28 years. Thirty-nine percent of the teachers were African American, 50% White, 6% Latinx, and 5% Asian. Table 3.1 provides demographic information for all 47 teachers from Phase I of this study.

Table 3.1

Demographic Information for 47 Phase I Teachers

Participant (Pseudonyms)	School Type	Male or Female	Years Teaching	Grade Level	Ethnicity	Years Associated with STEM Program
Adeena	T	F	5	2	African American	4
Alanza	MS	F	5	3	African American	1
Alice	T	F	7	1	White	5
Alina	T	F	27	2	White	1
Amelia	T	F	3	5	African American	1

Table 3.1

Cont.

Participant (Pseudonyms)	School Type	Male or Female	Years Teaching	Grade Level	Ethnicity	Years Associated with STEM Program
Arabella	MS	F	13	1/2	Asian	7
Ava	T	F	7	5	White	3
Avery	MS	F	5	2	White	3
Becca	MSU	F	13	3	African American	1
Bridget	MSU	F	7	4	White	1
Chloe	MSU	F	28	5	Latinx	8
Collette	MS	F	6	K-5	White	5
Dawn	MS	F	12	5	African American	7
Deanna	MSU	F	4	K	White	1
Easton	MSU	M	5	K-5	White	1
Elle	T	F	8	4	African American	1
Elliot	T	M	3	4	African American	1
Emma	MS	F	8	5	Latinx	1
Holly	T	F	1	3	White	1
Janice	MS	F	9	3	African American	1
Jayleen	MS	F	7	3	African American	3
Jemma	T	F	11	2	White	1
Jessie	MS	F	11	2	White	1
Karleigh	MSU	F	4	4	White	1
Kate	T	F	13	2	African American	1
Kayla	T	F	12	2/3	White	1
Keira	MSU	F	9	4	White	1
Kendall	MS	F	4	3	Latinx	1
Laura	T	F	12	4	White	5
Lucy	MSU	F	11	1/2	White	1
Maggie	MSU	F	5	1/2	White	1
Marlene	MS	F	22	5	African American	1
Megan	T	F	8	3	White	1
Neisha	MSU	F	10	K	African American	1

Table 3.1

Cont.

Participant (Pseudonyms)	School Type	Male or Female	Years Teaching	Grade Level	Ethnicity	Years Associated with STEM Program
Nichelle	MSU	F	11	1/2	African American	1
Rhea	MSU	F	10	K	African American	1
Sadie	T	F	4	2	White	1
Susie	MSU	F	14	5	White	1
Samara	T	F	12	5	Asian	4
Sophie	T	F	3	1	African American	1
Susan	T	F	5	4	White	1
Sylvie	T	F	8	5	White	1
Tana	T	F	9	4	African American	2
Teonna	MSU	F	8	3	African American	1
Tibby	MSU	F	6	K-5	African American	1
Willa	T	F	14	1	White	1
Zoie	T	F	4	1	White	1

Note. T= traditional public school; MS=magnet school; MSU=magnet school with history of university support and collaboration.

Phase I data collection. In keeping with a narrative tradition (Clandinin & Connelly, 2000), a fellow doctoral student[2] and I conducted interviews with 47 teachers using the STEM Program Post-Institute Interview protocol (see Appendix A) during Phase I of this study to elicit teachers' stories and experiences. The purpose of an interview is to allow the researcher access to another person's perspective. A qualitative interview begins with the assumption that the perspective of others is meaningful, knowable, and that the interviewer can make that explicit (Patton, 2002). The STEM

[2] This fellow doctoral student was an experienced teacher who served in a similar role for STEM Program and who had developed close relationships with teachers. She helped collect 42% of the interview data during Phase I of this study—something for which I am eternally grateful.

Program Post-Institute Interview was a semi-structured interview protocol that combined conversational and guided interview strategies (Patton, 2002). Since the purpose of a narrative interview is neither to simply get answers nor to test a hypothesis, but instead to understand human experience (Clandinin & Connelly, 2000; Shkedi, 2005), this interview protocol helped me gain insight into teachers' conceptions and interpretations of the educational context in which they worked and any dilemmas they might confront during their day-to-day science and engineering instruction. To do so, I included a variety of question types in this interview protocol (see Table 3.2) (Patton, 2002).

In keeping with a three-dimensional narrative space, we asked teachers to move backward and forward in time (continuity), to examine feelings and experiences (interaction), and to think about the space in which they found themselves (situation) (Clandinin & Connelly, 2000). We asked teachers about their perceptions of previous STEM Program professional learning, their current views on professional development, their professional visions for teaching in general and for teaching science and engineering, perceived social, historical, cultural, and institutional influences on their instructional and pedagogical practices. These interview questions provided an opportunity for teachers to explore the temporal and spatial boundaries suggested by Clandinin and Connelly (2000). This interview protocol provided teachers with an opportunity to explore their own experiences. It informed their understanding of their professional sense of self within their unique context. Additionally, it assisted me in understanding how teachers perceive their schools and their own responses to the sometimes-competing ideals and demands of their schools.

Table 3.2

Types of Questions in the STEM Program Post-Institute Interview Protocol (Patton, 2002)

Question Type	Description	Example
Experience and behavior questions	Questions about what a person does or has done and aimed at eliciting behaviors, experiences, actions, and activities that would have been observable if the researcher had been present	So, given this context, do you speak truth to power? If so, how? If not, why not? How, if at all, do you speak up?
Opinion and Value Questions	Questions aimed at understanding the cognitive and interpretive processes of people. This is about the “head stuff” as opposed to actions and behaviors.	It can be hard to teach science and engineering in elementary school. What’s your opinion on this?
Feeling Questions	Questions aimed at eliciting emotions and how people feel about their experiences	Why do you teach science and engineering?
Knowledge Questions	These questions inquire about the respondent’s factual information or what the participant actually knows (not opinions or feelings)	Elementary teachers are often seen as dutiful, loyal, and people-pleasers. Who are the powerful stakeholders, and what are the policies or norms **at your school** that influence your teaching?
Sensory Questions	Questions that ask about what a participant saw, heard, touched, tasted, smelled, and experienced. Questions that ask participants to recreate the experience.	Now let me ask you about your experiences with STEM Program this past summer. I’d like to start with you thinking back to one experience or activity that was meaningful or enjoyable to you. Tell me about that experience.

Phase I data analysis. I primarily used thematic coding for analyzing interviews while still preserving the narrative elements of the data (Charmaz, 2006). I conducted the data analysis in multiple stages. In the initial stage of data analysis, I closely examined the data for the sole purpose of naming and categorizing phenomena. Strauss and Corbin

(1990) portray this initial phase of coding, like beginning work on a puzzle. During this stage, I read the interview transcripts to begin to come up with a few conceptual labels. Instead of applying a line-by-line or sentence-by-sentence analysis, I worked with an entire interview breaking the data down into discrete parts to scrutinize, but not lose the larger picture painted by the data. “This form of coding helps us to remain attuned to our subjects’ views of their realities, rather than assume that we share the same views and world” (Charmaz, 2006, p. 515).

I based the categorization of data on the teachers’ descriptions of experiences, perceptions, and personal viewpoints. When beginning the process of categorization, I looked for in-vivo category names, or terms used by the participants (Saldaña, 2015). I categorized each case narrative separately and, to the best of my ability, with an equally open mind. The intention was not to force the categorization of the first few case narratives on the subsequent ones. However, since all the cases generally dealt with similar phenomena, I often had a general idea of probable categories as they emerged (Shkedi, 2005).

In the next stage of data analysis, a mapping stage (Shkedi, 2005), I developed a new system of categories based on the previous stage of data analysis. Here, I worked intensively with the in-vivo codes identified in each case narrative to seek and find connections and relationships between them. In the initial stage of data analysis, I regarded all the categories at the same level. In this second stage, the mapping stage, I divided the categories into separate levels. Here, I considered the initial categories, read the data included in each category carefully, compared each to the other, and visually mapped categorizations into levels of categories and sub-categories (see Figure 3.2). This specific mapping revealed a deeper characterization of my data.

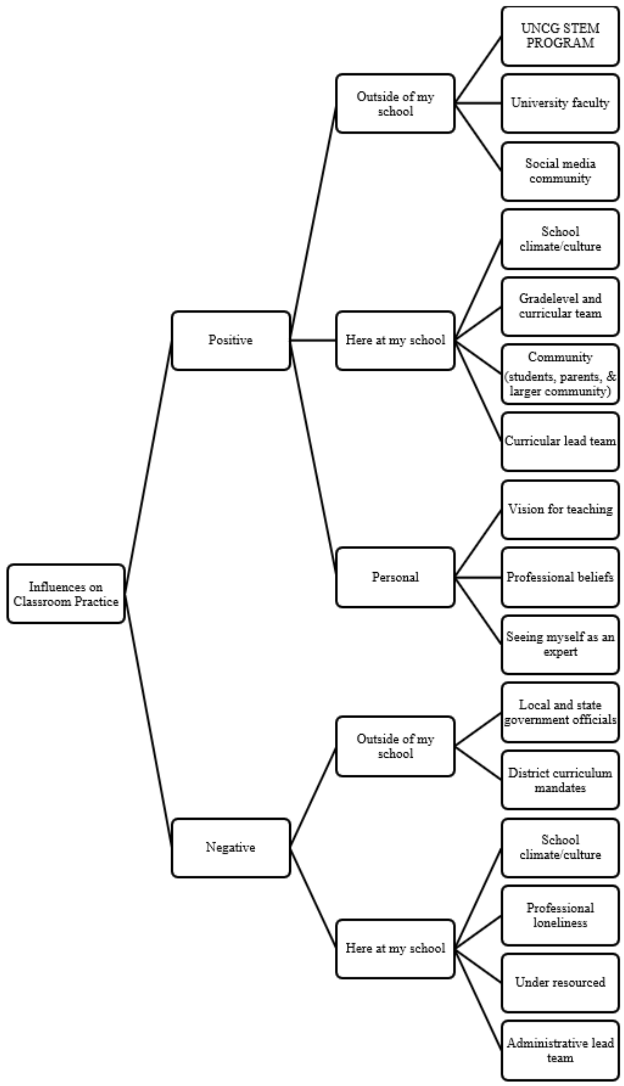


Figure 3.2. Multiple Levels of Categorization Across Narratives.

I worked to find patterns within the core categories and themes. As patterns and themes emerged within the core categories and themes, I completed a taxonomic analysis by developing a hierarchy of terms associated with each category and theme (Spradley,

1980) to make better sense of the data and collapse repetitive sub-themes and sub-categories as needed.

Phase II: A narrative inquiry of a select sample of 18 teachers. For the second phase of this study, I continued to employ narrative inquiry to explore the nature of teachers' professional agency over a year and what actions and beliefs that professional agency enabled. A purposeful sample of teachers from Phase I of the study narrated certain ways in which they made sense of the dilemmas they confronted when trying to integrate science and engineering into their curriculum. Therefore, I interviewed a smaller sample of 18 teachers using a narrative visual elicitation device and interview protocol.

Purposeful sampling for Phase II. Purposeful sampling (Patton, 2002) allowed me to determine which teachers to interview in Phase II. These teachers gave me a deeper insight into the nature of teachers' professional agency as they worked to integrate and enact science and engineering in their elementary curricula. I searched for teachers who fit four sampling criteria: (a) a robust professional vision for science and engineering, (b) responding to tensions and dilemmas by speaking up and, sometimes, with action, (c) teaching in what they perceived to be a culture of high surveillance, and (d) despite the context in which they taught, enacting instructional and pedagogical change (see Appendix B for a detailed explanation of the process). Twenty-four (24) teachers fit the selection criteria, and the sample of teachers for Phase II included 18 of these 24 teachers. I did not intentionally exclude the other six teachers; one teacher left the teaching profession mid-year (Alanza), four teachers declined to continue with Phase II of the study (Arabella, Jayleen, Laura, and Zoie), and one teacher was not a classroom teacher (Tibby). Tibby was an Exceptional Children's teacher (special education teacher), spending her instructional time facilitating subject-specific interventions with no expectations of consistently teaching science or engineering throughout her schoolyear.

Phase II participant demographics. Selected from the original pool of participants, these teachers worked in high-needs, elementary school contexts. While these teachers were selected based on the selection criteria and were not specifically selected to be a representative sample of the original demographics; the sample was indeed representative of the original pool of 47 teachers as one was male, 44% was White, 28% was African American, 22% was Latinx, and 6% was Asian. This sample also continued to contain the range of teaching experience from a first-year teacher to the teacher with 28 years of experience. See Table 3.3 for a detailed description of the demographic makeup of the participating teachers in Phase II of this study.

Table 3.3

Participant Demographics for 18 Phase II Teachers

Name	Gender	Race/ Ethnicity	Years of Experience	School Type	Grade
Alice	Female	White	7	Traditional	1
Alina	Female	White	27	Traditional	2
Ava	Female	White	7	Traditional	5
Chloe	Female	Latinx	28	Magnet	5
Collete	Female	White	6	Magnet	K-5
Dawn	Female	African American	14	Magnet	5
Elle	Female	African American	8	Traditional	4
Elliot	Male	African American	3	Traditional	4

Table 3.3

Cont.

Name	Gender	Race/ Ethnicity	Years of Experience	School Type	Grade
Emma	Female	Latinx	8	Magnet	5
Holly	Female	White	1	Traditional	3
Janice	Female	African American	9	Magnet	3
Jessie	Female	Latinx	11	Magnet	2
Kayla	Female	White	12	Traditional	2
Kendall	Female	Latinx	4	Magnet	3
Marlene	Female	African American	22	Magnet	5
Samara	Female	Asian	12	Traditional	5
Susan	Female	White	5	Traditional	4
Willa	Female	White	14	Traditional	1

Phase II data collection. I developed an interview protocol to explore how teachers narrated the nature of their professional agency and how professional agency enables teachers' beliefs and actions (see Appendix C). The interview protocol was comprised of two parts—a STEM journey map elicitation device (see Figure 3.3), where I asked teachers to describe the thinkability and doability of science and engineering in their classrooms over the previous year, and open-ended, narrative interview questions, where I asked teachers to narrate the visual they created using the elicitation device.

From personal experience as a classroom teacher and experience working with teachers associated with a STEM Program, teachers' perceptions about whether they feel able to implement science and engineering in their elementary classrooms and their professional agency are not fixed or linear. These ebb and flow. One moment pedagogical and instructional choices seem possible and achievable; then a few days, weeks, and even months later, their perception changes completely. Throughout the design of this study, I affectionately thought of this as a roller coaster. There were highs and lows, and along each point, teachers had a story to tell of that experience.

I designed the interview protocol for Phase II of this study to have two parts. I first used an elicitation device called a STEM journey map so that teachers could look backward and forward throughout their year and reflect on how thinkable and doable science and engineering instruction was in their space—their classroom. Most often used in research on marketing design and healthcare, journey maps evolved out of the service design field (Stickdorn et al., 2011). I adapted a journey map to depict a system from the perspective of the individual participating and experiencing that system (Howard, 2014). As such, the STEM journey map mapped a series of "touch points" (McCarthy et al., 2016) between the teacher and the thinkability and doability of science and engineering instruction in their classroom over the previous school year. The resulting visual tool, the STEM journey map (see Figure 3.3), incorporated both the physical (functional aspect of the teacher's experience) and emotional (rational aspect of the teacher's experience) journey to capture the teacher's behavior, feelings, motivations, and attitudes across the touch points of the school year. In this way, I was able to focus on multiple aspects of the nature of teachers' professional agency as parts of their lived experience.

To begin, I defined the terms "thinkability" and "doability" for teachers and left color-coded definition cards with the teacher (thinkability on a blue card and doability on a yellow card). I defined "thinkability" as the teacher's STEM mindset or, in other words, their feelings as to whether they thought STEM was possible in their classroom. I then went on to define "doability" as the actions that teachers took to implement and teach their vision of STEM. The teacher used blue and yellow stickers to describe the thinkability and doability of science and engineering in their classroom at certain time points throughout the previous school year (see Figure 3.3).

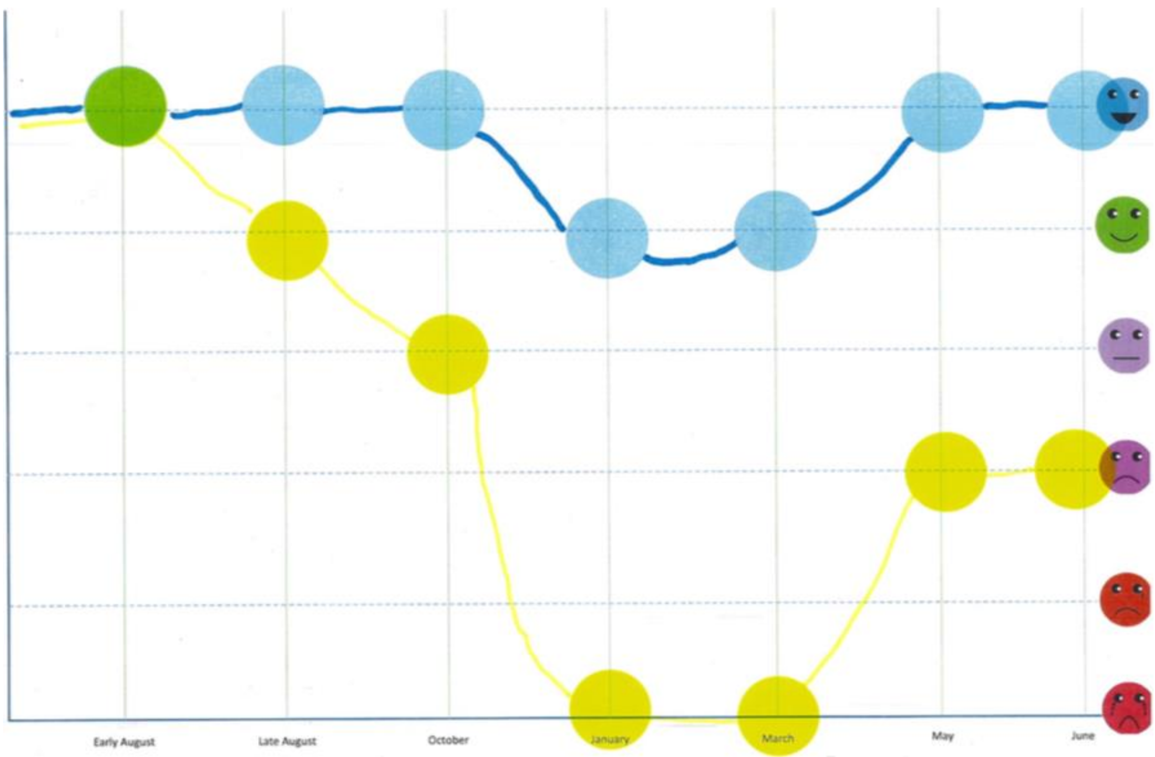


Figure 3.3. STEM Journey Map with Touch Points and Color-Coded Stickers. Blue stickers=thinkability; yellow stickers=doability.

I chose the timepoints along the horizontal axis to be benchmarks of the year. *Early August* referred to the point in time after teachers completed the STEM Program Summer Institute. *Late August* referred to the very beginning of the school year. *October, January,* and *March* referenced the end of grading periods. *May* represented the time of year when teachers traditionally bring an end to their instruction, with *June* serving as an almost projective moment with teachers beginning to think through the summer to the next school year. The faces along the vertical axis served as a representation of teachers' descriptions of the "thinkability" and "doability," ranging from the lowest, reddest face (a frowning face and tears), to the highest, bluest face (sporting a wide, open smile).

Through intentional design, I framed this elicitation device and protocol as a three-dimensional narrative inquiry space (Clandinin & Connelly, 2000). It encouraged teachers to look forward and backward, and inward and outward at their lived experiences while considering the space where these experiences occurred. I immediately followed the STEM journey map with an open-ended, narrative interview so the teachers could narrate the threads of these lived experiences that occurred over time, in a place or series of places, and in social interactions (Clandinin & Connelly, 2000).

Teachers used their STEM journey map as a visual reference from which to begin their reflections and narration of their perceptions of the thinkability and doability of science and engineering instruction, and therefore the nature of their professional agency. Using the STEM Program Journey Map Interview Protocol (see Appendix C), I asked teachers to move backwards and forwards in time, to examine feelings and experience, and think about the space in which they found themselves (Clandinin & Connelly, 2000). I asked the teachers open-ended questions which referenced the STEM journey map. I crafted these minimal questions (e.g. "Tell me the story of this part." and "What was happening here?") to encourage and stimulate the teachers to tell the story of the significant events and experiences in their instructional lives and social context (Clandinin, 2006; Jovchelovitch & Bauer, 2000).

Phase II data analysis. I conducted the next phase of data analysis in multiple, iterative stages. Figure 3.4 gives an overview of the decisions I made and steps I took in analyzing the data from Phase II. I began by reading the transcripts to come up with conceptual labels, looking at discrete parts of the data to not lose the whole picture of the data. As I began the process of categorization, I looked for in-vivo category names or terms within each quote (Charmaz, 2006; Shkedi, 2005). As I began developing new systems of categories and themes to incorporate and explain the in-vivo codes, my system of data analysis became problematic; I felt as if I was losing the narrative threads of the teachers' lived experiences.

For this reason, I added a holistic-content analysis to my analytic approach. Holistic-content is a narrative approach for understanding the meaning of an individual's story (Clandinin & Connelly, 2000; Ollerenshaw & Creswell, 2002). The holistic-content analysis of narrative interviews included more than the description and thematic development (Riessman, 1993). It involved a complex set of analytic steps based on "restorying" a story from the original, raw data so that one can understand a person's lived experiences (Clandinin & Connelly, 2000; Ollerenshaw & Creswell, 2002). For me, the process of restorying included reading and rereading the interview transcripts, analyzing teachers' individual stories, and then telling that teacher's story by extracting powerful and meaning-laden quotes from transcripts and physically placing them on teachers' STEM journey maps to re-story and re-order their narratives. Figure 3.5 is an example of a re-storied STEM journey map, illustrating this component of my data analysis.

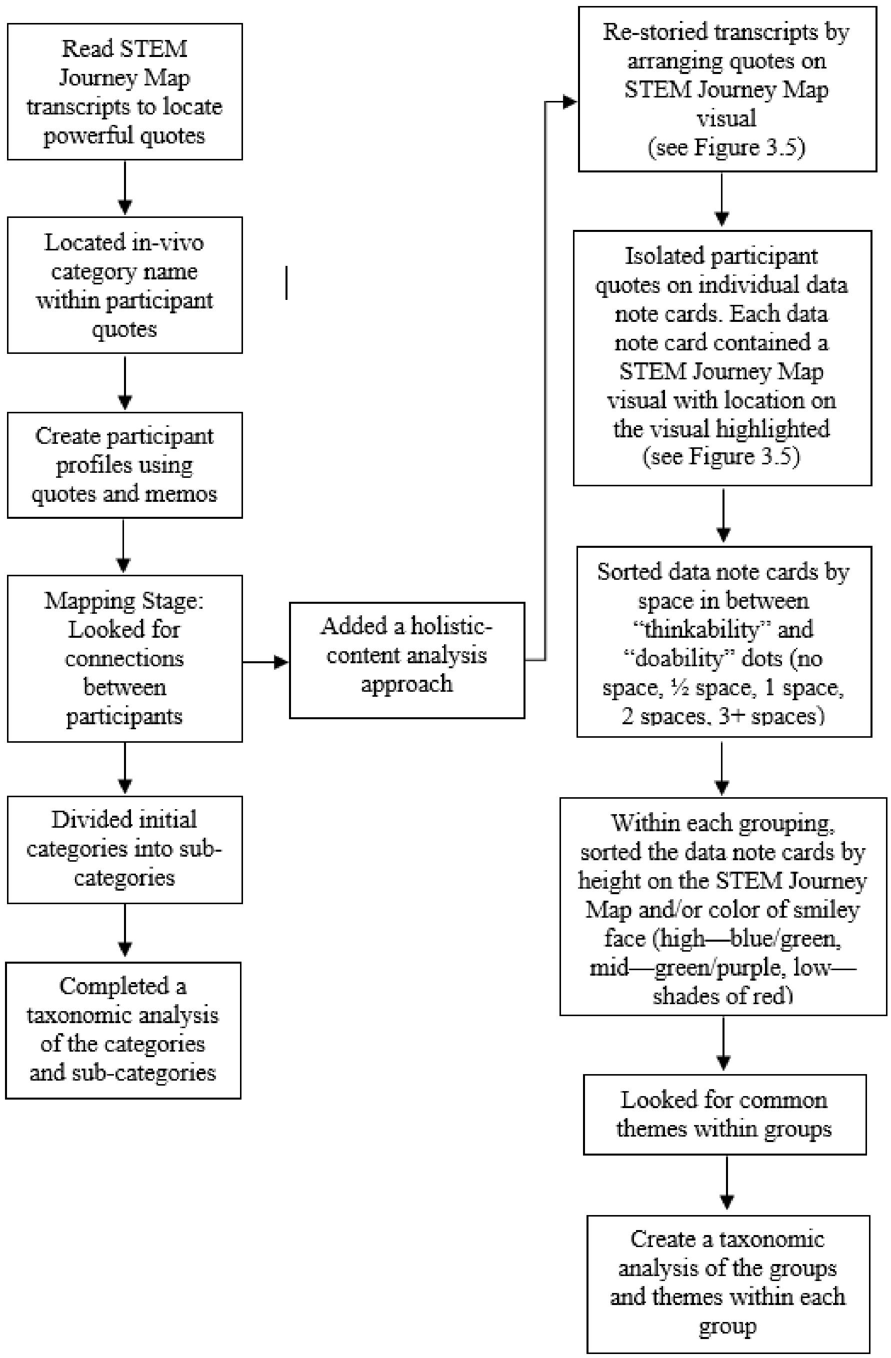


Figure 3.4. Phase II Data Analysis Decisions.

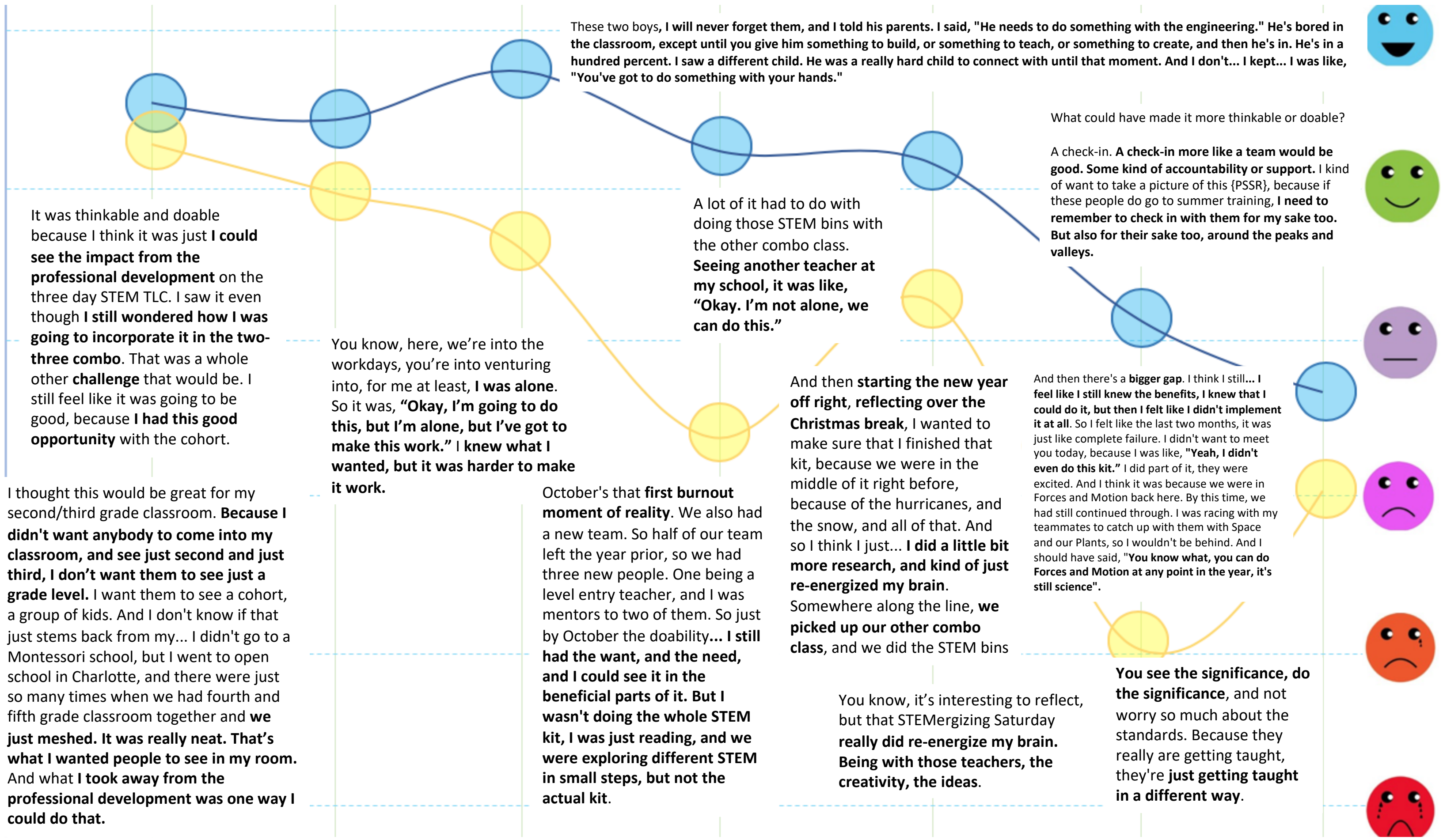


Figure 3.5. Kayla's Re-Storied STEM Journey Map.

Even though the organization, reading, and analysis of the data appeared to have followed one another sequentially, it is important to note the iterative nature of the analysis of the data. I utilized an iterative process of data analysis where I “dove in” to the data to understand its content, dimensions, and properties, then “stepped back” to assess preliminary understandings and to determine the next steps (Flick, 2018; Glaser, 1965; Maietta, 2006). I repeated this process of “diving in” and “stepping back” throughout the analytic process. This allowed me to move from establishing an understanding of what was in the data to exploring my relationship to the data and finally to arrive at an evidence-based, hybrid story of data content and researcher knowledge and interpretation.

With this holistic-content analysis, I used Clandinin and Connelly’s (2000) three-dimensional space as a lens for thinking about the data. As described earlier in this chapter, there are three aspects of this narrative approach: interaction, continuity, and situation. To analyze the data for interaction (which involves both the personal and social), I analyzed the transcripts for the personal experiences of the teacher as well as for the interactions that teacher had with others. To analyze the data for continuity, or temporality, I listened for stories of past experiences as well as present or future actions that might have occurred. And finally, to analyze the data for situation, or place, I looked for and listened for specific situations and locations in the teacher’s storied landscape, which involved both the physical places and sequences of those places. This was the lens through which I viewed the data analysis process.

In this phase, my analysis of the data was a process of reading, rereading, and considering interactions, continuity, and situation through the personal practical knowledge and the professional landscape of the teacher. Practical knowledge can be described as individualized and pointing inward (e.g., affects, feelings, beliefs, attitudes, values, assumptions). A teacher's professional landscape is contextual and points outward to conditions in the environment, which can include other individuals' actions, reactions, intentions, purposes, and assumptions (Connelly & Clandindin, 2000; Ollerenshaw & Creswell, 2002). Keeping in mind the three-dimensional space lens, I began the data analysis (again) with quotation identification and data inventory of just a few teacher narratives. I found powerful quotations in the data and created an inventory of impactful data, re-storied, or rearranged, on a digital recreation of the STEM journey map of each data collection episode, or each teachers' interview. I based the decision of which segments of data to select on three, self-imposed guidelines: (a) the data spoke to one of the three dimensions, (b) I could articulate my reasons for selecting it, and (c) there was a sufficient amount of data to preserve the context. At this point, I created quotation memos which involved writing my reasons for selecting quotations and any connections and themes I noticed emerging. Together, the selection of quotations, memos, and visual diagrams of those first few narratives allowed me to create episode profiles for each teacher.

In creating episode profiles for each teacher, I was able to more closely examine instances that particularly stood out as significant for individual teachers. After analyzing all transcripts and completing episode profiles for each teacher, I looked across teachers' personal narratives and episode profiles, paying close attention to interaction, continuity, and situation, while also focusing on common and exceptional themes. I then created a table to examine how each teacher narrated the nature of their professional agency, the individual, social, and institutional realities that influenced that agency, and commonalities of stories shared between teachers.

In the final stage of data analysis, I took each participant quote and placed each on separate notecards with a visual of the STEM journey map on the back of the notecard. For each quote, I highlighted the point on the STEM journey map that the quote referenced. This allowed me to sort the notecards by thinkability and doability dots. I first sorted all notecards from all teachers into groups determined by how closely related the thinkability and doability dots were. This resulted in four groupings—overlapping or close together, one space apart, two spaces apart, and three or more spaces apart. I then divided each of those four groups into three additional groups based on their height on the STEM journey map—high, mid, and low. I was then able to reread all the quotes in each of the 12 groups to look for commonalities and themes. I created a taxonomic analysis of the new themes that emerged across teachers' quotes based on how closely associated thinkability and doability were and how high or low their descriptions were.

Validity

Connelly and Clandinin (2006) describe narrative inquiry as the telling of a story. A marker of the validity of a narrative inquiry is the credibility of the story. Maxwell (2012) uses the term validity to refer to "the correctness or credibility of a description, conclusion, explanation, interpretation or other sort of account" (p. 106). In this study, it was important for my accounts and interpretations of teachers' narratives to align with their intended meanings. I used the following validity strategies to minimize validity threats—interrogating my own researcher bias, investigating my own reflexivity on the study (Maxwell, 2012), collecting a rich set of data in the interviews, and member checking with the participants (Merriam, 1998).

It is important to consider potential threats to validity when conducting qualitative research due to the possibility of alternative explanations or interpretations of phenomena (Maxwell, 2012). Research involves (a) the collection of evidence, and (b) the analysis or interpretation of that evidence. Narrative researchers frequently move between these two enactments choosing further sources of evidence-based interpretations of the already-gathered evidence. Narrative researchers pay attention to the validity of the collected evidence and the offered interpretation (Polkinghorne, 2007). In narrative research, the main concern is clarifying the intention of the storied text, because for the intended audience to make an informed judgment about claims being advanced, narrative researchers need to spell out their understandings of their collected evidence coherently.

Validity threats arise in narrative research because the narrated descriptions of lived experiences given by participants are the researcher's reflection of participants' meanings (Polkinghorne, 2007). Participants' stories may leave out or obscure parts of what they are telling. In narrative inquiry, validity issues focus on how well the audience understands the assembled texts to express the actual meaning of the participants. Polkinghorne (2007) says that there are four areas of possible disconnect between a participant's actual experienced meaning and their storied description, or four main threats to validity:

> (1) the limits of language to capture the complexity and depth of experienced meaning, (2) the limits of reflection to bring notice to the layers of meaning that are present outside of awareness, (3) the resistance of people because of social desirability to reveal fully the entire complexities of the felt meanings of which they are aware, and (4) the complexity caused by the fact that texts are often a co-creation of the interviewer and participant. (Polkinghorne, 2007, p. 480)

Language-imposed structure and over-simplification limit the complexity and depth of the participant's description (Polkinghorne, 2007). To address the first threat to validity, I encouraged the teachers to elaborate and explain in greater detail. I often repeated the phrase, "Can you say that again? I want to make sure I capture what you *mean* and not just what I *think* I heard." I constantly asked teachers to expand on their experiences as if we didn't hold shared meanings for parts of their experiences.

Participants can only articulate that portion of meaning that they can access through reflection (Polkinghorne, 2007). I addressed the second validity threat through use of the STEM Journey Map elicitation device and careful, focused listening, and exploration. Participants were more in touch with the meaning of their lived experiences upon repeated, deeper reflection. Asking teachers to reflect on their year using the STEM Journey Map elicitation device and then go back and narrate their lived experiences allowed time for participants to explore reflectively their deeply felt meanings.

People are often resistant to revealing self-explorations of their feelings and understandings to others, especially strangers (Polkinghorne, 2007). Participants are more open to sharing their lived experiences if they trust that the interviewer is open to accept their meanings without judgement. Seidman (2006) recommends that in order to overcome the hesitancy of participants to reveal themselves in an interview, that participants be interviewed at least three times so that the researcher and participant can establish a trusting relationship. Through my work with STEM Program and in the local schools, the trusting relationship was already well-established with most teachers. However, this relationship had its pros and cons. My personal and historical connection to the culture and climate of the schools the teachers worked in, the close and trusting relationships with the teachers, and my connection with the University STEM Program may have influenced the participants in my study. Our shared relationships with organizations such as a STEM Program or local school districts may have skewed participant perspectives and responses to questions. This meant the teachers might have been hesitant to include experiences that negatively affected them or that they may have more heavily weighed their recollection of experiences in their professional life to include STEM Program supports while failing to include other experiences that influenced their teaching. Conversely, few teachers were hesitant to be open and honest. An overwhelming number of participants showed a range of emotions, many shedding tears, demonstrating their willingness to be vulnerable. My established relationships with the teachers and close connections with teachers through shared experiences meant that teachers were comfortable speaking candidly and thoughtfully about their experiences.

Narrative texts generated by interviews are not simply productions of participants; they are co-creations of interactions between interviewers and participants (Polkinghorne, 2007). As for the fourth validity threat, Mishler (1991) outlined the many ways in which interviewers affect participants' responses. Participants attend to the interviewer's clothing, speech pattern, gender, and other attributes—but especially to established relationships, body movement and voice intonations for indications of whether their responses are acceptable. As an interviewer, I attempted to minimize these by separating myself from my own lived experiences as a teacher in high-needs schools and by conveying a neutral affect while conducting an interview. My unique perspective as both an outsider (as the researcher), and an insider (as a recent former teacher), was a perspective that I constantly navigated. During interviews, I attempted to encourage the participants to describe their lived experiences as if I did not have an intimate understanding of most of the organizations and to disregard my relationship with them. The reality was that in their minds, it proved difficult to sever these connections. Therefore, I was careful to remain true to the teachers' experiences and not my own as I re-storied their narratives. I worked to accomplish this by constantly asking participants to expand on their experiences and to explicitly describe the parts of their narratives that I might implicitly understand so that I captured their experiences in their words and not only my interpretation.

Subjectivity is also something I needed to consider throughout this study. As is the case for many narrative researchers, the time spent with the participants and the depth of the conversations during the interview resulted in the formation of relationships. Although the relationships were beneficial as I constructed narratives of the nature of teachers' professional agency, I had to be cautious to ensure I represented the voices of the participants as they told their stories and not color their lived experiences in a skewed light. The use of member checking and the actual words of the participants helped me tell their story and not my own.

Ethics

Ethical considerations are not just a means by which a researcher conducts their research but should also constitute an end goal of a quality study (Tracy, 2010). Ethical dilemmas are likely in qualitative research. For that reason, it is important for researchers to conduct studies ethically (Merriam, 1998) and that they anticipate ethical considerations when collecting, analyzing, and sharing the data (Creswell, 2002).

In anticipation of and to ensure ethical considerations, I established trusting relationships with the participants and communicated an overview of the study, its purpose, data collection, and any risks and benefits. I assured the teachers of their anonymity and explained the method and audience for reporting the data and results. I found the need to reaffirm the confidentiality of teachers' experiences, statements, and stories while stressing that at no time would I share the data directly with their administers or the school system in which they worked.

While ethical considerations are part of all educational research, there are certain relational ethical considerations come into play in narrative research (Clandinin et al., 2007; Connelly & Clandinin, 2006).

> In narrative inquiry, inquirers must deepen the sense of what it means to undertake a life study and to live in relation in an ethical way. . . . Ethical considerations permeate narrative inquiries from start to finish: at the outset as ends-in-view are imagined; as inquirer-participant relationships unfold, and as participants are represented in research texts. (Connelly & Clandinin, 2006, p. 483)

When it comes to the understanding, writing, and sharing of collected stories, ethics are part of the foundation of a narrative relationship between the researcher and participants (Clandinin, 2006). Ultimately, these teachers entrusted me with their stories, and each story was theirs to tell. To ensure that I accurately represented the meaning of the teachers' narratives, I returned to my participants so they could read and reread field texts and how I interpreted and wrote of their lived experiences. I understood that reading and rereading their words was a vulnerable activity and that their way of seeing a story might align with or differ from the final story.

Finally, just as important as the procedural and relational ethics is the consideration of existing ethics (Tracy, 2010). Just as I interpreted and re-storied teachers' narratives, others reading these narratives in the future may have their own understandings. I took into consideration how I portrayed my participants and how future audiences might come to understand their narratives by taking steps to represent the teachers in just and non-deficit ways.

CHAPTER IV

FINDINGS PHASE I

This study explored how elementary teachers teaching in high-needs schools responded to the dilemmas they confronted when trying to integrate science and engineering into their curriculum and the nature of their professional agency in those moments. This chapter, which I call Phase I of the findings, speaks to the findings that address the first four research questions, which included:

1. What is the nature of elementary teachers' professional visions for science and engineering in high-needs schools?
2. What facilitates or constrains the enactment of teachers' professional visions for science and engineering?
3. What dilemmas emerge for elementary teachers as they reconcile their professional vision with the ideals and demands of schools?
4. In what ways do teachers respond to those dilemmas?

As outlined in Chapter III, the participants for Phase I of this study included 47 elementary teachers (see Table 3.1 in Chapter III for teacher demographics), all teaching in high-needs schools. I defined high-needs schools as those serving a large percentage of students living below the poverty line with higher rates of teacher turnover. Table D-1 in Appendix D describes the demographic information of the teachers' schools. Data collection for this phase included interviews with each teacher. The interview protocol allowed me to explore the nature of their professional visions and identify dilemmas that teachers confronted in their day-to-day quest to enact science and engineering in their classrooms.

A few months before this interview, most teachers (45/47) participated in the STEM Program Summer Institute—a three-day-long summer professional learning opportunity focused on integrating engineering into their elementary curricula. I played a significant role in this professional learning opportunity, both in planning and facilitation. My role in the STEM Program helped me get to know the teachers before asking them to participate in the study. I had established a nascent, trusting relationship with many of them. I should also note that I worked closely with seven of the teachers as a fellow teacher in their school, a consultant, or a cooperating teacher.

Figure 4.1 shows the conceptual framework for the findings explained in this chapter. Teachers' ideals and professional vision for science and engineering instruction included images of an engaged classroom, instruction that connected learning to other content areas and real-world contexts, and broadened STEM pathways and students' opportunities. Schools' and school districts' demands placed upon teachers encompassed different degrees of narrowed, scripted curricula, increased accountability pressures, pressure to conform to certain teaching practices, reduced time and resources for science and engineering, and compliance with schedules, methods, and content. When teachers worked to integrate and enact science and engineering into their day-to-day instruction, they experienced this tension between their ideals and professional vision and institutional demands as dilemmas localized to their contexts of high-needs schools.

When asked how they spoke truth to power (American Friends Service Committee, 1955), teachers described three responses to power and authority—responses of compliance, deferential resistance, and tempered radicalism. The ways in which teachers felt comfortable with speaking up and back to conflict and tensions underpinned their responses to localized dilemmas.

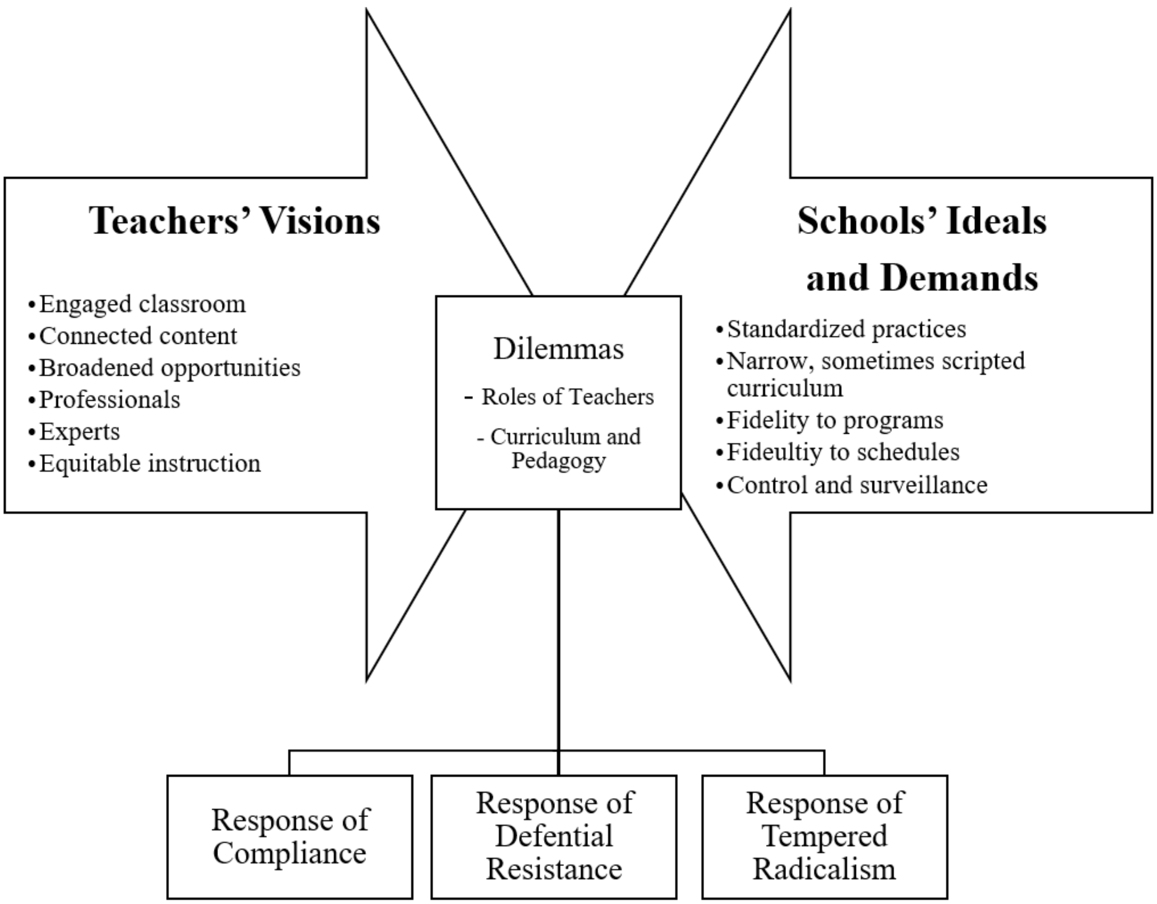


Figure 4.1. Framework for Teachers' Dilemmas and Responses.

The Nature of Teachers' Professional Vision

Arabella, a teacher committed to enacting science and engineering instruction in high-needs elementary school, began to depict her vision:

> I think it's all in your experience and your perspective and how you think about it. So, for me, for these children, I just envision what I want it to be like. I think about it being student-focused with the kids exploring and learning and getting up close and personal with science. (Arabella, Interview, 1/14/19)

Hammerness (2006) defined vision as "images of ideal classroom practice" (p. 3). Arabella's vision for science and engineering contained what Hammerness would consider *focus* and *range*. *Focus* represents the specific areas of interest of the teacher's practice as well as the clarity or detail of the vision, and *range* refers to what teachers include in their vision (Hammerness, 2001). Teachers' professional visions for both teaching in general and for science and engineering instruction were quite specific. The research question guiding this section of this chapter, as highlighted in the framework in Figure 4.2, was: For teachers committed to teaching science and engineering in high-needs elementary schools, what is the nature of their professional visions for science and engineering?

Adding to Hammerness's (2006) view of teachers' visions, Gess-Newsome et al. (2003) argued that a teacher's vision would "include images of teaching and learning, the role of teachers and students, and the purposes of and methods for content instruction" (p. 758). These professional visions are grounded in teachers' experience, their beliefs about curriculum and pedagogy, and their commitment to teaching and learning. In keeping with Gess-Newsome et al.'s (2003) depiction, teachers' visions were more nuanced than a description of the ideal classroom with ideal practices; they were hopes and dreams of possible instructional and pedagogical practices which included details about teachers' beliefs, motivations, and reasons for teaching in the manner they did. Aspects of teachers' visions overlapped as their vision for what, how, and why to teach were multifaceted.

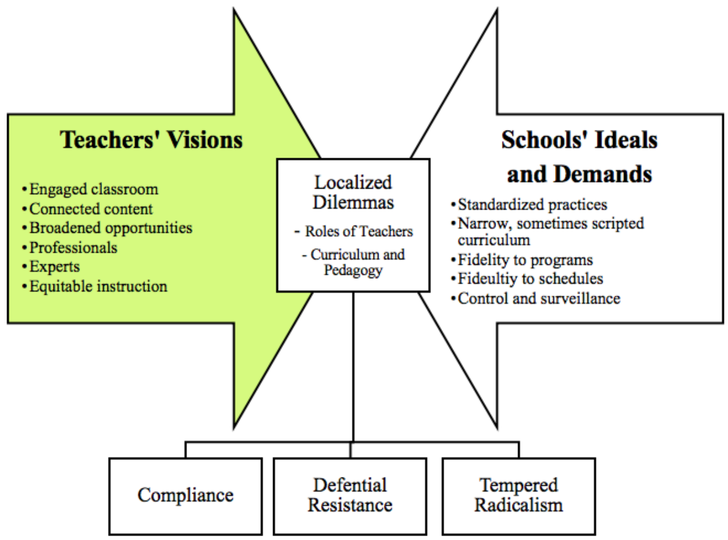


Figure 4.2. Teachers' Visions in the Framework.

Upon further analysis (see Table 4.1), the teachers expressed four broad professional visions for teaching science and engineering in elementary classrooms: (a) an engaged classroom, (b) practices that foster meaningful and relevant connections, (c) instruction that broadens student pathways, and (d) teaching for altruistic reasons.

Table 4.1

Aspects of Teachers' Professional Vision

Teacher Visions for Science and Engineering Instruction	Engaging Instruction	It's Fun (13)	"For most of them, it's just something that's fun. That makes a difference." (Avery, Interview, 1/14/19)
		Hands-on (8)	"Why? Because it's hands-on, and they remember more when they're doing things or experimenting with things." (Becca, Interview, 1/11/19)
		Students are Involved (17)	"In science, they're totally involved. They're totally engaged. Their minds, their hands, their conversations, everything is engaged." (Jayleen, Interview, 1/14/19)
		It's Enjoyable (17)	"It's just enjoyable for the kids. They're into it because they like it. That's why I'm into it." (Maggie, Interview, 1/10/19)
	Instruction that Broadens Possibilities	Allow for New Possibilities (18)	"My kids have never had these experiences. They're so successful now because it's my job to provide these experiences and opportunities that they didn't even know they could do." (Willa, Interview, 1/9/19)
		Opens Up Opportunities (16)	"Teaching like this just opens up a lot of opportunities for them to explore and learn and be curious. I love that I am opening that door for them, and I hope they keep that door open as they grow older." (Alice, Interview, 3/6/19)
		Students Grow Socially and Emotionally (12)	"Science and engineering help people to understand themselves and grow. As they grow into the world around them, they grow as thinkers and teammates and as people who can handle failure." (Sophie, Interview, 1/17/19)
		They See They Can Do Anything (11)	"I want my classroom to be a place where students don't just see themselves as students, but where they think 'I could be a leader' or 'I could be an advocate in my community' and even 'I am a problem solver.' There's just all these different things they can be, it's more than being just a student, it's about seeing that you can be a well-rounded person. I want to teach in a way that they understand that." (Kendall, Interview, 1/2/19)

Table 4.1

Cont.

Teacher Visions for Science and Engineering Instruction	Instruction That Creates Connections	Connected to Other Subjects (16)	"It's a building block for other subjects." (Kendall, Interview, 1/2/19)
		Real-World Connections (6)	"Science helps them [students] make connections between them and the world, about how things work and things they encounter on a day-to-day basis." (Jemma, interview, 2/19/19)
		Students Realize the Connections (8)	"Science and engineering are most powerful when students see the connections to other things. That's when they come up with those questions and start seeking answers in places outside of science." (Samara, interview, 2/22/19)
		You See It Everywhere (6)	"It's important because we're around it all the time. We live in an age where you're around some type of engineering or some type of science all the time, and my students need to know about it." (Zoie, Interview, 1/2/19)
	Instruction Driven by Altruistic Reasons	I Struggled Too (5)	"You know I struggled a lot in elementary school. I want to make sure no one else has to struggle like I did." (Karleigh, Interview, 1/7/19)
		Experiences Shape the Way I Teach (8)	"I didn't have a lot of chances like this growing up. I will make sure that my students get the chances I didn't get." (Willa, Interview, 1/9/19)
		Make a Difference in Kids' Lives (9)	"I teach to make a difference. I teach science to make a difference in their lives." (Elle, Interview, 12/7/18)
		Equity (5)	"I do science for all children." (Adeena, Interview, 1/9/19)
		Be an Inspiration (5)	"I had a first-grade teacher who told me that I could be a scientist. I want to be that inspiration for someone." (Adeena, Interview, 1/9/19)

Note. Numbers in parentheses are frequency counts of mentions.

An Engaged Classroom

"It's never a dull moment. It's always fun. It's very fluid with lots of activities, hands-on stuff. That's what gets them interested and gets their minds being creative" (Tibby, Interview, 1/16/19). Tibby, like other teachers, described ideals of their science and engineering practices with words and phrases such as *fun*, *hands-on*, *active*, *enjoyable,* and *interesting*. In these cases, they described professional visions of an engaged classroom.

> I like to think of a classroom with science where it's fun. I think fun is important for kids. We do that with games and experiments and hands-on things. It's important because with these kids we can lecture so much into their brains, not really lecturing, but pouring facts into their brains. I see science as that time when we don't do that. We make it fun and the learning happens. (Megan, Interview, 1/11/19)

Less didactic teaching styles, inquiry-based activities, and increased motivation due to student interest lead to student engagement in science and engineering. "You know science, it's fun, and the kids learn a lot and, and they remember it because they're so very engaged. That's what I always want my science teaching to look like" (Jayleen, Interview, 1/14/19). Jayleen, like many additional teachers, held professional visions of science and engineering instruction of engaged classrooms. These teachers narrated an ideal image of science and engineering instruction with content, practices, and pedagogies chosen and oriented toward fostering student engagement and creating an engaging learning environment.

Instruction that Creates Connections

Another broad theme was a vision of practices that created meaningful and relevant connections, meaning connections that were *real-world*, between *subject areas, realized by students*, and understood because *you see science and engineering everywhere*. Kendall, a third-grade teacher, described aspects of her ideal instruction as including science because of its value. “It’s [science] a building block for other subjects. And when students start to see those connections, that’s when the learning happens” (Kendall, Interview, 1/2/19). Like Kendall, other teachers highlighted the idea that their vision of ideal science and engineering instruction included practices to promote and value creating meaningful connections—for students, between content areas, and with the real-world. Instructional practices that encourage students to make connections between their learning, subject matter, and the world around them create meaningful instruction.

> For me, just knowing how it bridges between more than just science. I mean knowing that STEM goes so far beyond a science standard. It even goes beyond science. It goes into how do kids succeed in reading? How do they use math to be successful? How do they think beyond what is success? Just the way it challenges and changes their brains is what gets me excited for them personally. (Elliot, Interview, 2/11/19)

Elliot’s professional vision of science instruction in his classroom bridges content areas for students with connections. Elliot taught what and how he did because it now only challenged his students, but excited him personally. Jemma was also personally motivated by her professional vision of instruction that creates connection.

> Because it’s life. It’s, and it’s interesting to students and it can help. I mean, if they find an interest in the science topic, then I see kids checking out books to

> learn about it. So I think it can spark an interest. The way I teach science should connect them to the real world. (Jemma, interview, 2/19/19)

Several teachers echoed this sentiment, including Dawn, a fifth-grade teacher. She related a story about how instruction that fosters connection was influential for one of her fifth-grade students:

> It was a lightbulb moment. Suddenly he saw it. He saw the connection. I mean, we had covered it in reading and math and he had seen it happen in his neighborhood. That's why I do the engineering the way I do. For those lightbulb moments. (Dawn, Interview, 12/20/18)

Teachers' professional visions consisted of ideal images of teaching and learning. Teachers envisioned science and engineering instruction that created connections both in their practice and for their students.

Instruction that Broadens Student Pathways

Teachers also held professional visions that included instruction that broadened student pathways and provided students with new opportunities. Teachers expressed this in several ways; their pedagogical "choices" *allowed for new possibilities*, *opened up opportunities*, *fostered students' social and emotional growth*, and helped students *see that they could do anything*.

Alice, a first-grade teacher, explained why this was the instructional focus of her vision when she said, "Teaching like this just opens up a lot of opportunities for them to explore and learn and be curious. I love that I am opening that door for them, and I hope they keep that door open as they grow older" (Alice, Interview, 3/6/19). Alice's vision, like many other teachers' vision, included science and engineering learning that would provide opportunities for students to grow and see new possibilities.

"I want them to know that they can be risk-takers and problem solvers. If they can just see themselves as risk-takers, it could take them so far. In that sense, engineering opens doors for them" (Willa, Interview, 1/9/19). Willa envisioned facilitating engineering instruction with iterative activities to encourage risk-taking. She believed that teaching engineering in the way she did "opened doors" for students.

> My view is that I think science and engineering are so important for these kids. One, you know, so many of our kids come in and they think they hear, you can't, you can't, you can't. Wanting them to know that they can, and especially in something so broad and so seemingly frightening, you know, to some of them that's what engineering is. My vision is a place where students stop thinking "I can never be an engineer" or "I can never be a scientist." I want my teaching to be something that gets them to realize that they can. I think it's important to teach science and engineering and in ways that tell students that they can, because you may not be great at reading and you may not be great at social studies. But the way I think about engineering and science gives them an opportunity, another opportunity, and just another avenue to express themselves. (Avery, Interview, 1/14/19)

Avery's vision of ideal classroom practices for science and engineering instruction also included teaching in a way that provided expansive opportunities for students to see themselves in new ways. Professional visions of science and engineering instruction that broadened pathways and expanded opportunities for students were teachers' visions of their role within the classroom and the part their pedagogical practices played in students' experiences.

Altruistic Reasons and Personal Motivations

Finally, many of the teachers' visions for the instruction and opportunities in their classroom emanated from personal biographies and an altruistic foundation for teaching. "I didn't have a lot of chances like this growing up. I will make sure that my students get the chances I didn't get" (Willa, Interview, 1/9/19). Willa's quote illustrated what many teachers referenced. Their instructional vision and specific reasons for working to teach science and engineering in their elementary classrooms were shaped by very personal and altruistic motivations. Teachers were motivated because they *struggled like their students*, their personal *experiences shaped the way they taught*, they wanted to *make a difference* in students' lives, they were propelled by issues of *equity*, and they wanted to *be an inspiration* to children. Adeena explained it in this way; she was intent on teaching science and engineering every day, in any way possible, so that students always had a chance to see "that science is for them" (Adeena, Interview, 1/9/19). Her own personal experiences in school shaped Adeena's vision for her science teaching. "I had a first-grade teacher who told me that I could be a scientist. I want to be that inspiration for someone" (Adeena, Interview, 1/9/19).

Interpretations

Teachers' professional visions link the inner teacher with independent and creative thinking (Duffy, 2002). As such, teachers' visions have focus (distinctness and clarity) and range (specificity, i.e., narrowness or broadness) and vary across these dimensions (Hammerness, 2001). Most teachers narrated a professional vision focused on science and engineering instruction in high-needs schools. The data showed teachers had professional visions that were substantial and concrete, vivid and powerful, and distinctly focused on content and pedagogy for science and engineering. Though teachers were focused in their descriptions (i.e., almost entirely focused on science and engineering), their professional visions were not singular or narrow in their range. Teachers' visions can be narrow and specific or panoramic and broad in the scope of their focus. For analysis and writing, I have separated the different components and facets of the professional visions teachers narrated (e.g., engagement, connections, broadening opportunities, altruistic reasons). In reality, teachers' professional visions for science and engineering were never that narrow in their range (Hammerness, 2001). It was rarely the case that teachers' professional vision for science and engineering was one of only "fun, hands-on, engagement." Nearly all teachers in this study narrated *robust professional visions*, meaning that their professional visions were not narrow in their range and were comprised of multiple components narrated by teachers. The scope of teachers' visions was multifaceted, encompassing ideal images of practice that fostered engagement and connections in science and engineering and content and pedagogy that might provide expansive opportunities for students. A focused, yet broad professional vision helps guide teachers through more restrictive environments, the associated complexities of teaching, and persist in the face of obstacles (Vaughn & Faircloth, 2011).

What Facilitated and Constrained the Enactment of Teachers' Visions?

> You know, it's hard. I have this vision. But there's my vision and my administrator's vision. They don't always match. And then there's also these non-negotiables within the district. Like you have to teach science for at least this many minutes a week and you have to teach reading and you have to teach math for at least this many minutes. And then there's also resources, not everyone has

> the same resources or even has the same knowledge. I just feel like there are so many things that influence my teaching. (Colette, Interview, 1/28/19)
>
> STEM Program is a major influence. No, seriously, it was a major step forward. It opened my eyes to different things and the, the community that's built around it and the people that I've met from it, um, that is definitely a big stakeholder in my life and my teaching because I met so many different people just through the network who support me and lift me up as a teacher. (Alanza, Interview, 12/20/18)

Both Colette and Alanza are teachers committed to teaching science and engineering in high-needs elementary schools. Both teachers narrated stakeholders, issues, norms, or policies that influenced their teaching and their vision. However, Colette cited constraining influences, while Alanza alluded to influences that facilitated her science and engineering instruction. The following research question guided this part of the chapter and part of this framework in Figure 4.3: What facilitates or constrains the enactment of teachers' professional visions for science and engineering?

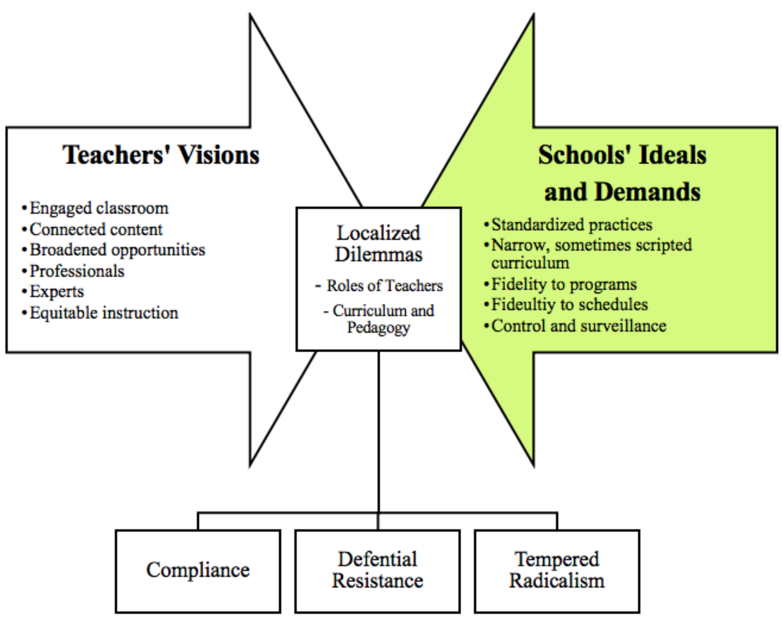


Figure 4.3. Schools' Ideals and Demands in the Framework.

Teachers described facilitating and constraining influences on the enactment of their profession for science and engineering (see Table 4.2). In order of strength (determined by frequency counts), facilitating influences included (a) teachers' students and their community, (b) teachers' colleagues, (c) the vision, structure, or philosophy of teachers' schools, and (d) support from outside of teachers' school community. Influences that teachers cited as constraining their practice included (a) schools' priorities and programs (including testing and curriculum); (b) school, district, and state policies; (c) teachers' colleagues (fellow teachers, coaches, and administrators); (d) constant surveillance of programs and policies; and (e) the vision and philosophy of teachers' schools.

Table 4.2

Facilitating and Constraining Influences

Influences on Enactment of Teachers' Professional Vision	Facilitating	Colleagues (19)	"She was not my official mentor, but she was kind of like the one who just, you know, put me under her wings. And then one day she released me and she did all that. But she, she pushes me, she encourages me. As a colleague, she's very honest with me and very open with me and that support really pushes me and the way I teach." (Jayleen, Interview, 1/14/19)
		Administration or Coaches (4)	"Our administration, our instructional coach is phenomenal. She helps guide us in the right direction. There's assistance if we need it, there's their support if we need it. There's praise when we need it. And I think she's fantastic." (Ava, Interview, 1/16/19)
		School Vision or Philosophy (18)	"[School's] mission, I believe, is learning to serve, serving to learn. And that resonates very strongly with my person. Um, because if the end of the day we are all learning from our surroundings and as scientists, you know, if you think about it from the science perspective, we are all about learning about the world around us." (Samara, Interview, 2/22/19)
		Students (18)	"They are what drive me and knowing who they are and what they need to be successful affects every decision I make about how I teach in my classroom every day." (Elle, Interview, 12/5/18)
		Community (12)	"What influences me is the community. These kids are part of the bigger community, and I teach to help make that stronger." (Neisha, Interview, 1/16/19)
		Support from Outside the School (10)	"The support from [University] is indispensable. [Professor] is like a mentor to me and whenever I'm teaching, his voice is in the back of my head and telling me what I should be doing and how it could be better. He's a huge influence on me in the way I teach and what I do." (Easton, Interview, 1/11/19)

Table 4.2

Cont.

Influences on Enactment of Teachers' Professional Vision	Constraining	Colleagues (4)	"I wish there was more of a community with the other teachers here. I'm professionally lonely and I don't get to have those good conversations. Supportive colleagues would be a real asset." (Willa, Interview, 1/9/19)
		Administration or Coaches (9)	"I just feel like we have [Administrator] and all the coaches coming in and saying do this, teach this, don't teach this, just telling us what to do and how to do it." (Janice, Interview, 1/7/19)
		School Priorities (20)	"It's like the school has different priorities than I do when it comes to teaching the kids." (Colette, Interview, 1/28/19)
		Surveillance (4)	"The more success I had with my students, the more people I had coming in to check up on what I was doing. It was like teams of people coming in to judge how I was teaching." (Susan, Interview, 1/2/19)
		Policies (School, District, or State) (18)	"But I mean [District] says this is the policy and this is what we have to do, we have to do the pacing. We have to do the programs. Is it the best thing for some of our kids? No, but we have to do it, you know. It's the policy." (Sadie, Interview, 12/17/18)

Note. Numbers in parentheses are frequency counts of mentions.

Facilitating Enactment of Professional Vision

Students. When asked about what stakeholders influenced the way they taught, their "students" figured prominently. "It's a calling. I do this for the students. I am who I am and do what I do for those students," said Tibby, a fifth-grade teacher (Tibby, Interview, 1/16/19). Like many of the other teachers who responded that their students were some of their most important stakeholders, Tibby said that her students influenced her teaching. When I pushed Tibby to consider how her students influenced her teaching, she explained,

> For children, I think learning is like this dark room and you can't see where you're going. As a teacher, you want to help them find their way so then you start lighting a candle every day and the room starts getting brighter and brighter. And lo and behold, the room brightens up and they are seeing more and know more than when they first began. But, I am still that person who helps them find their way. If everything I do is for the students, then they tell me what to do and that's how I help them find their understanding. (Tibby, Interview, 1/16/19)

Tibby demonstrated more than just gentle care and concern for her students; her comments showed that she deeply cared about her students, their diversity, and their achievement. This placed her teaching in an ethical, emotional, and academic partnership with her students. Tibby drew on her cultural experiences from Zambia and the influence of her students when designing learning experiences. Tibby went on to explain how her students influenced her science instruction:

> You know I am from Zambia. Also, the demographic of children I teach it's a socially, low-income area and I have found myself drawn to the African American male children, because it dawned on me that I could apply my cultural experience, especially the American African American boys, because I grew up with five brothers and they were very expressive. And when you're expressive, it

> looks like you're out of turn. So, I make learning expressive and no one is out of turn. Science might be the one place where these boys, these students, find their place in learning, so it makes it a place and way for them to learn and feel smart. (Tibby, Interview, 1/16/19)

This sense of caring obligation to her students and seeing students as influencers of instructional and pedagogical practice indicated a partnership rooted in respect, social responsibility, and pedagogical necessity. Tibby, like many other teachers, designated students as main stakeholders and the influencers of her instructional practices. This required Tibby to use knowledge and strategic thinking in deciding how to act in the best interest of others.

Community. Students were not the only entity cited as influencers of teachers' practice; a sense of duty to the community figured prominently for teachers as well, because, as one teacher put it, "Communities are shaped by children, and we are responsible for shaping those children" (Elliot, Interview, 2/11/19). "What influences me is the community. These kids are part of the bigger community, and I teach to help make that stronger" (Interview, Neisha, 1/16/19). Some teachers looked beyond the four walls of their classrooms and the confines of their school buildings, seeing their students as not only stakeholders who influenced their teaching, but also as pieces of a larger community puzzle.

These teachers spoke of their students' communities, outside of the immediate school community, as something that influenced and drove their instructional practices and pedagogical choices.

> Our school is predominantly African American and our students come from a predominantly African American community. Looking at society right now, just with all of the racial tensions and everything, thinking of the community that these students are part of just inspires me to keep going. I'm not just teaching these kids, because they'll leave me and they'll leave our school, but they'll still be part of their community. And I don't want these kids to leave fifth grade and go to middle school or high school and even on to careers and colleges and just not be ready, not be ready to live their best life and be a functional part of their community. So, I see my teaching as a way to invest in them, to invest in their community. I guess you could say that that's a really big stakeholder that influences how I teach. (Jayleen, Interview, 1/14/19)

Students' community drove how and what Jayleen taught. She understood her students' communities, and she also understood the political and cultural tensions coming from inequitable structures of society that give rise to predominantly African American communities.

Jayleen's thoughts were echoed by Elliot, a fourth-grade teacher at an urban elementary school.

> Lots of things influence how I teach. Hands down the most influential is the community. When I say I think the community influences how I teach, I realize, you know, thinking about the parents that drop our students off, thinking about who I meet at Walmart, all of that, I remember that our society, our communities are shaped by the children. We do, you know, bring them up with how we teach them. And I always think what I really mean is, when I'm thinking about how I'm going to reach a child, when I'm writing out my lesson, when we're having discussions about teacher pay, when we were having discussions about what's best to do for a child, I think about how does that influence what I'm going to do, but then also how will this child turn around and take that into their community. (Elliot, Interview, 2/11/19)

Elliot, Jayleen, and many of the other teachers spoke about how holding students' communities in mind influenced their instructional choices. Teachers understood that when their students left them, left their schools, even after they graduated from high school, these students would continue to be part of the larger community. Rhea, a Kindergarten teacher, said, “I mean it changes the way I teach because those kids, their parents, the community are such a driving force. You teach to make sure that you’re doing right by them” (Rhea, Interview, 1/16/19).

Purposes of schooling well beyond the ideals and vision of their school drove justice-centered teachers such as Rhea, Elliot, and Jayleen, all African American teachers teaching in Kindergarten, fourth-grade, and third-grade, respectively. They focused beyond students and saw their students’ communities as primary stakeholders, and as such, they used curricula that reflected students’ personal and cultural identities. Elliott talked about how he taught in a way that embraced multiple perspectives and emphasized critical thinking and inquiry. Jayleen described how she raised students’ awareness of inequity and injustice, but also scaffolded student learning experiences to give students a voice and prepare them to contribute to their communities.

Colleagues. Beyond their students and their students’ communities outside of school, teachers indicated that coworkers and fellow educators in their workplace also influenced their practice. “I feel like I can do anything because I know [Principal] supports me 110%” (Susan, Interview, 1/2/19). Samara also explained how influential administrative support was to her instructional practices. “My principal is part of the conversation about what happens in our classrooms, but so are we. To have a say makes all the difference” (Samara, Interview, 2/22/19). Like Susan, Samara spoke to the influence of her administrator’s support. Perceptions of administrative trust and support increased job satisfaction among teachers and supported teachers in believing they could implement science and engineering in their classrooms.

Colleagues beyond administrators influenced and shaped science and engineering instruction. Chloe, a fifth-grade teacher, put it this way: “Well, you know, I couldn’t have done this without [Teammate]. We bounced ideas off each other, and it just worked. She was really my biggest support when it came to science, we were in it together” (Chloe, Interview, 1/2/19). Jayleen held similar sentiments for one of her colleagues. “Having her on my team is like having my own personal mentor. She’s like the yin to my yang. She shows me what’s possible, keeps me motivated, and I keep her moving” (Jayleen, Interview, 1/14/19). Connections with supportive, collaborative colleagues facilitated the implementation of rigorous science and engineering instruction.

School vision and philosophy. Many teachers indicated that the structure, vision, and philosophy of their school influenced how and what they taught. These teachers came exclusively from two schools, Weaver Elementary School, or Clayton Collaborative, a magnet school with university connections (see Appendix D). Other schools in this study had strong, cohesive visions and school philosophies, but all of the teachers from Weaver Elementary School described their school’s vision, “The Weaver Way,” as being held in such common esteem that it penetrated teachers’ instructional and pedagogical practices. The school’s saying loosely translated to a “whatever it takes” stance on teaching and learning. Students, teachers, families, administrators, and community members all had an understanding that the school’s mission was to reach every student, every day through authentic learning opportunities, guided by reflective professionals who are committed to preparing students to succeed by placing students as the primary focus for all decisions—the basic premise of The Weaver Way. The school's motto and vision had staying power. Developed over 3 decades and three principals ago, The Weaver Way had always been at the heart of instruction, professional learning, school communications, community projects, and relationships.

Every teacher I interviewed from Weaver Elementary School, an urban elementary school serving a mostly minoritized population, talked about how The Weaver Way influenced them personally and their teaching. "Weaver is focused on making sure that we are always doing what's best for kids" (Interview, 1/10/19), said Amelia, a fifth-grade teacher at Weaver Elementary School. When I pushed Amelia to say more about what she meant by "doing what's best for kids," Amelia continued:

> It's about The Weaver Way. That's our school mission and vision. We all believe in it and do it. [Principal] reminds us all the time that our kids learn best when we give them real-world, hands-on learning that's right for each student, you know differentiated and thoughtful. It's our job to teach in a way that connects with students so that they're the main focus. Everyone at Weaver shares in that and our teaching all kind of revolves around that (Amelia, Interview, 1/10/19)

Zoie, a second-grade teacher at Weaver, echoed Amelia's sentiments. "Give every kid a chance," Zoie said, "that's what it all boils down to" (Zoie, Interview, 1/2/19). I asked Zoie how that translated to her classroom. Zoie, along with Weaver Elementary teachers Jemma and Susan, indicated that the school's focus on "giving every kid a chance" meant that the students were the primary focus regarding how to use instructional time, curricula, and resources in their classrooms. Jemma put it this way: "I think there's just a common high expectation that our kids can learn, *all of them* [her emphasis], and will learn if we're teaching them what they need and deserve" (Jemma, Interview, 2/19/19). When I pushed Jemma to explain what she meant by "teaching them what they need and deserve," Jemma explained that common, high expectations that every child can learn complex science concepts charged her with the responsibility for designing learning experiences that were both grounded in sound pedagogical practices and strategies that would advance the learning of every student.

Jemma's use of the word "common" indicated that this mission, vision, and philosophy at Weaver Elementary School was a universally held vision of what classroom instruction should look like and why it should look that way. More than a commonly held belief and philosophy that was an integral part of the school culture, The Weaver Way was a commonly held ethos. While The Weaver Way was held in esteem by many people within the Weaver Elementary School community, teachers invoked it unevenly and for different purposes for different people in different contexts. As I previously said, The Weaver Way influenced teachers *personally* and the enactment of their professional vision and instructional practices *in their classrooms*. On a teacher-level, buying into The Weaver Way shaped how teachers pursued their professional vision in their own classrooms. It enabled teachers to focus the enactment of their professional vision on their students. But at the same time, these teachers struggled to "do the right thing" for their students amidst testing narratives and suffocating accountability pressures. On a school-level, Weaver Elementary School seemed to consider The Weaver Way as a primary layer of school improvement, uniting curricula, practice, and mindset, and encouraging or expecting commitment and compliance to a shared vision. These collective principles and shared vision guided the thoughts and actions of the Weaver Elementary staff, often facilitating teachers' enactment of their professional visions in their classrooms.

Constraining Enactment of Professional Vision

Influences that teachers cited as constraining their practice included (a) schools' priorities and programs (including testing and curriculum), (b) school, district, and state policies, (c) teachers' colleagues (fellow teachers, coaches, and administrators), (d) constant surveillance of programs and policies, and (e) the vision and philosophy of teachers' schools.

> We just don't let teachers be valued, we're not letting teachers be at the forefront and be creative and do the things that they need to do because of testing. It's such a priority that it's part of our culture now. It's like it influences everything I do in my classroom. (Alanza, 12/20/18)

Programs, policies, and priorities. Like Alanza, many teachers said their schools' programs, policies, and priorities constrained how and what they taught. A seemingly endless focus on high stakes testing and student achievement data permeated and shifted the culture of many schools. Roughly half of the teachers who talked about these programs, policies, and priorities as constraining influences described mandated curricula and test preparation programs usurping their instructional time for science and engineering and limiting the content they could teach.

> I've just been hoping so badly to include more STEM activities into my science lessons. I mean, it's not like my schedule has any leeway for science, anyway. If I do get to teach science, it's all integration into reading.

> And I've argued about that quite a bit. They're always asking about reading interventions or asking about benchmark data. I mean they're always saying that it's math this and reading that and a lot of times it's at the deficit of other subjects. There's one teacher who wanted to do the Jumpstart [pseudonym] book starting in October instead of the science passages we were doing. Can you imagine? In October? (Tana, Interview, 1/16/19)

When Tana referred to "they," she referred to her school's Curriculum Lead Team—a team of support staff and administration charged with shaping and supervising the curriculum and instruction at her school. The "Jumpstart" book Tana referred to is a test preparation book filled with informational passages and multiple-choice questions. The school's focus on standardized testing and student achievement ultimately limited Tana's autonomy, making it nearly impossible to fit science, beyond informational, text-based passages, into her instructional routines.

Colleagues. Colleagues, coaches, and administrators, though sometimes described as positive influences, were also sometimes perceived as constraining influences. This is not meant to paint these teachers' colleagues in a deficit or negative light. Teachers indicated that it was not the *person* who constrained their practices, but rather the *actions* of those colleagues. For instance, when Alice described how her team functioned, she did not describe her personal feelings for her colleagues. "You know what would help? A supportive team that actually functioned as a team. It would help so much just to have someone to plan science with" (Alice, Interview, 3/6/19). Alice felt "alone" because she lacked the support of the other teachers on her grade level team. "It's just hard without the support of other teachers that I work with. I'm not saying that they need to hold my hand and do everything for me, but it would be nice to just collaborate"

(Alice, Interview, 3/6/19). Alice explained how a lack of collaboration and support from her colleagues made science integration and implementation difficult. Alice was capable of teaching science and engineering on her own but felt as if her colleagues constrained the possibilities for her instruction.

While some teachers defined colleagues constraining their science and engineering instruction as “fellow teachers,” some teachers identified “instructional coaches” and “administrators” as constraining their integration and implementation of science and engineering. It should be noted that teachers did not indicate that these coaches and administrators were actively attempting to keep them from teaching science and engineering. Teachers indicated that instructional coaches and administrators contributed to an underlying narrative about a loss of autonomy and an increased culture of surveillance (Giroux, 2006), which, in turn, constrained how and what they taught.

> Our schools are governed by people not necessarily in our profession, you know, officials who’ve never been classroom teachers. I feel like most of the time [Principal] has no other choice than to do what those people think we should be doing and what they say. It’s not completely her fault, but this pressure trickles down through our principal and just changes everything about my classroom. (Dawn, Interview, 12/20/18)

Administrators and instructional coaches took certain actions that shaped the way teachers felt they were able to teach science and engineering. “Fidelity is the new buzzword. Everything should be done with fidelity, and our principal and coaches are always checking up on us. Are we teaching the way they want? With fidelity?” (Sophie, Interview, 1/17/19).

Summary

Teachers' professional visions integrate their "passions, their hopes, cares, and dream with their knowledge about how and what children should be learning" (Duffy, 2002, p. 24). Many sociocultural aspects of high-needs elementary schools both facilitated and constrained teachers' enactment of their professional visions for science and engineering for how and what their students should be learning. Teachers indicated that their students and their students' communities outside of school influenced both the way and what they taught. This lessened or narrowed the gap between professional vision and practice that most teachers experience (Hammerness, 2001; Vaughn & Faircloth, 2011). Administrative support both facilitated and constrained teachers' enactment of their vision and instructional practices, while support from principals and instructional coaches shaped how much instructional time teachers spent on science and engineering and to what extent they used reform-based, inquiry-based strategies (Banilower et al., 2007). Collaboration among teachers and collegial support also influenced the instructional practices as these relationships supported or reduced teachers' confidence in integrating and implementing science and engineering into elementary curricula (Apple, 1999; Franke et al., 2001).

These contextual influences facilitated and constrained teachers' ability to enact their professional vision to integrate and implement instructional practices for science and engineering in their elementary classrooms. When the enactment of teachers' professional vision is enabled and assisted, the gap between vision and practice is lessened. Shulman and Shulman (2009) would argue that teachers in these circumstances are more likely to reflect on their practice and evaluate their instruction based on the needs of their students or the educational community. Conversely, when teachers found their professional vision for science and engineering constrained and difficult to turn into practice, the gap between vision and practice is widened. These teachers found it more difficult to take effective action to enact their professional vision and persist in the face of dilemmas of practice (Vaughn & Faircloth, 2011). Teachers' professional vision gave them a particular standpoint or stance from which they embodied their commitment and passion for teaching when both facilitated and constrained by the sociocultural conditions of their high-needs school contexts.

Dilemmas and Responses

When teachers worked to integrate and enact science and engineering into their elementary curricula, their vision, at times, disrupted the status quo of schooling in high-needs school contexts. This caused teachers to confront competing ideals and demands—their vision for science and engineering instruction versus that of the institution. This surfaced deep dilemmas. Dilemmas are defined as "aspects of teachers' intellectual and lived experiences that prevent theoretical ideals from being realized in practice in school settings" (Windschitl, 2002, p. 132).

The research questions guiding this section of the chapter and the framework (see Figure 4.4) were: What dilemmas emerge for elementary teachers as they reconcile their professional vision with the ideal and demands of their school? (Figure 4.4a); and In what ways do teachers respond to those dilemmas? (Figure 4.4b).

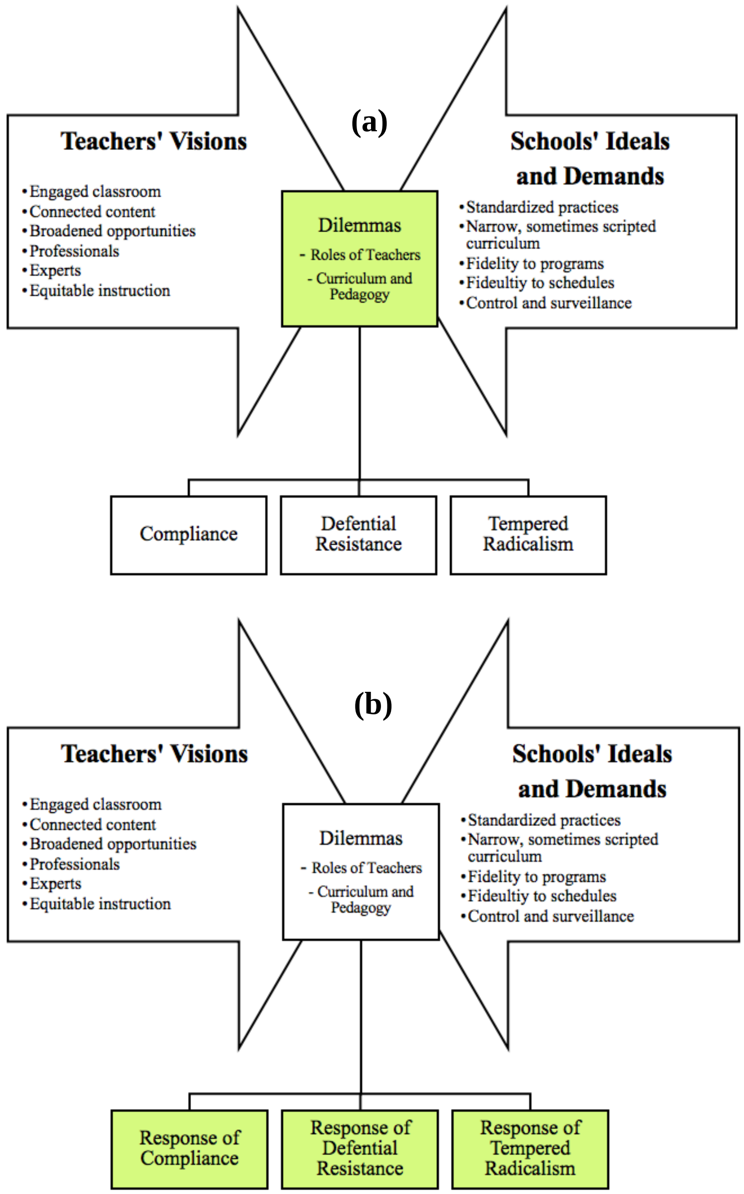


Figure 4.4. Dilemmas (a) and Responses (b) in the Framework.

Dilemmas

Teachers held distinctive, robust visions for science and engineering instruction, consisting of ideal images of teaching and learning, curriculum and pedagogy, and their role as a teacher. They envisioned teaching for engagement and connection, saw themselves as facilitators of experiences that opened up opportunities and broadened pathways for their students, and envisioned instruction responsive to students' interests, innate curiosities, needs, and prior experiences. These same teachers, however, often found their professional vision for science and engineering instruction at odds with the ideals and demands of their school, school district, and even sometimes their state educational system. This dilemma—a conflict between teachers' professional visions and the ideals and demands of "the institution"—permeated teachers' experiences and involved conflicting visions of teaching and learning, curricular goals, pedagogical practices, and conceptualizations of positions within the educational community.

When professional visions for teaching and learning competed with institutional ideals and demands, teachers experienced this as a deep dilemma. Teachers experienced that dilemma—the disconnect between their ideal set of images for teaching and learning and what their schools were demanding of them—as two sub-dilemmas narrated as:

- Dilemma #1—The Role of Teachers
- Dilemma #2—Curriculum and Pedagogy

Teachers felt pulled in opposite directions by their professional vision for science and engineering instruction and the vision of teaching and learning emphasized by institutions. Teachers found that images they held for their role as a teacher competed with schools' conceptualization of what teachers were meant to do. Additionally, teachers envisioned curricular and pedagogical decisions to be possible in their classrooms and found their schools often making those choices in their stead. As teachers wrestled with and responded to these, the construct of dilemmas became a useful way to frame the complexity of teaching in high-needs schools, the multiple layered issues teachers confronted when implanting change, and the diverse ways in which teachers responded to dilemmas of practice (Windschitl, 2002).

Responses to Dilemmas: How Teachers Spoke Truth to Power

To respond means to answer in some way with words or actions. As part of understanding the dilemmas teachers faced, I wanted to know how teachers spoke up, spoke back, and pushed back on those in positions of authority when they encountered a dilemma. In analyzing story after story, I came to conceptualize teachers' responses to dilemmas as ways that teachers spoke truth to power. First attributed to the American Religious Society of Friends Church, the phrase *speak truth to power* means to confront those who hold important positions as a way to demand a right and moral response to a problem, not just an expedient or easy solution (American Friends Service Committee, 1955). With time, the phrase has come to be associated with speaking out to those in authority or responding to authoritative actions taken against you or others (Speak truth to power, n.d.).

Teachers' responses to dilemmas were multifaceted. To gain a better understanding of how teachers narrated structural realities, the tensions and dilemmas these created, and how teachers responded to these dilemmas, I asked teachers about the people, stakeholders, policies, norms, and resources that influenced how and what they taught. I then followed that question with "given those influences, how, if at all, do you speak truth to power?" (Interview Protocol). Teachers described speaking truth to power and responding to dilemmas with three forms of responses: (a) compliance, (b) deferential resistance, and (c) tempered radicalism. These three responses are explained in more detail in Table 4.3.

Table 4.3

Teachers' Responses to Dilemmas

Response	Explanation
Compliance	Teachers cooperated, conformed, or yielded to other's requirements, demands, or ideals. This did not, however, imply agreement or alignment of vision and beliefs.
Deferential resistance	Teachers voicing opinions and ideas in respectful in-line ways to advocate for students or make small contributions. Teachers added their voice to the professional conversation but spoke up respectfully and courteously. Multiple viewpoints were regarded, and resistance occurred within institutional and cultural parameters.
Tempered radicalism	Teacher action mixed with strength and resistance. Speaking up in critical and creative ways. Respectfully pushing back against prevailing norms and laying the groundwork for organizational, cultural, and social change.

Teachers described speaking truth to power and their responses of compliance, deferential resistance, and tempered radicalism in various ways (see Table 4.4). Below, I provide examples of data that gave rise to the different response categories described in Table 4.3.

Table 4.4

Examples of Teachers' Responses to Dilemmas (Numbers in Parentheses are Frequency Counts of Mentions)

Teachers' Perceptions of Speaking Truth to Power and Responses to Dilemmas	Compliant Responses	Rule follower (5)	"Luckily, I'm a rule follower" (Kayla, Interview, 2/19/19).
		I'm not heard (4)	"Sometimes I don't feel like I should push back because I feel like no one ever hears my voice" (Holly, 5/20/19).
		Dutiful (1)	"Yeah, I'd say I'm pretty dutiful. That describes me" (Nichelle, Interview, 1/16/19).
		I do what I'm told to do (8)	"I teach science because I'm told to. I work on their [district] directives. I make sure I implement those in the classroom and I follow their rules and procedures." (Kate, Interview, 1/23/19)
		I stay to myself (6)	"I kind of keep to myself, stay in my lane, and just do what I'm supposed to do" (Karleigh, Interview, 1/7/19).
		Speaking up is considered negative (4)	"I don't push back on a lot of things a whole lot because it's something that's not looked on very favorably" (Adeena, Interview, 1/9/19).
	Deferential Resistance Responses	I work to help people understand (8)	"I try to work with the collective voice of teachers to try and explain why I do certain things" (Jemma, Interview, 2/19/19).
		I speak up respectfully (21)	"I never rule anything out and I'll definitely speak my mind and advocate for change, but I do it respectfully. That's the way to be heard" (Avery, Interview, 1/14/19).
		I *just* advocate for students (22)	"I think the biggest thing that I do is advocate for my students. I make sure that I advocate on behalf of them" (Laura, Interview, 12/21/18).

Table 4.4

Cont.

Teachers' Perceptions of Speaking Truth to Power and Responses to Dilemmas	Deferential Resistance Responses	I adjust what I do, but within limits (11)	"I'll put my own spin on it because it's doing what's best for the kids, but still making sure we're covering what it is that they're *supposed* to learn" (Amelia, Interview, 1/10/19).
		Things are mandated, but let's not pretend that it's okay (9)	"You know, all these county mandates and things are great, but let's not sit around and pretend that they're okay. At the end of the day there might be some way to do what's best for your children" (Avery, Interview, 1/14/19).
		I speak up, but don't make waves (11)	"I'm not that teacher who pushes back against everything that someone says or suggests. I do sometimes, but it's just easier to go with the flow and not make waves" (Kayla, Interview, 2/19/19).
	Tempered Radicalism Responses	I lead by example (2)	"The most effective way to speak truth to power and change things is to lead by example. That's what I try to do from my classroom" (Dawn, Interview, 12/20/18).
		I speak up and push back (15)	"I'm the push back person. I'm more vocal. Not only do I want for my children, but I also want to push my colleagues to quit sitting at the table and not having the meaningful discussions" (Willa, Interview, 1/9/19).
		I'm a rebel or known for making "trouble" (7)	"I can see where some people think that most elementary school teachers are rule followers, but they haven't met me. I'm the rebellious one. I'm the rebel, the one who pushes the envelope. I'm the one who says 'no' if I don't believe it benefits my students" (Marlene, Interview, 1/2/19).
		I'm upfront and honest (19)	"If there is an opportunity, I'll speak up. I'll be upfront and honest and tell you exactly what I'm thinking" (Samara, Interview, 2/22/19).
		I don't ask for permission before acting (8)	"I'm kind of known as the ask for forgiveness kind of do my own thing kind of person. Ultimately my goal in teaching is to make a positive change in the lives of my students, and sometimes that's how you have to do it" (Zoie, Interview, 1/2/19).

Table 4.4

Cont.

Teachers' Perceptions of Speaking Truth to Power and Responses to Dilemmas	Tempered Radicalism Responses	I quietly do my own thing (9)	"In general, science won't happen in my classroom until I just close my door, quietly do my own thing, and implement it myself" (Elle, Interview, 12/5/18).
		I don't agree so I make it my own (14)	"I might not be doing it how some people think is the correct way, but I might not approach it that way. If something isn't a good fit or it's not working, I'm just going to do it my way and make it work" (Susan, Interview, 1/2/19).
		I question things and people (8)	"I've always made waves, but not intentionally, but I've always questioned everything. If I don't understand why something is going on, I'm going to create some pressure until we can get the purpose clarified" (Alina, Interview, 12/5/18).

Note. Numbers in parentheses are frequency counts of mentions.

Though teachers made statements that spanned all forms of responses, they tended to speak more about one type of response than others. Teachers' responses varied over time and context. Take, for example, Maggie, who made statements that only fell within *compliance* and *deferential resistance* responses, or Willa, who narrated her responses as both *deferential resistance* and *tempered radicalism*. Only five teachers described their responses to dilemmas and how they spoke truth to power in a singular way—Jayleen, Bridget, Sadie, and Teonna as responses of *deferential resistance* and Karleigh as *compliant* responses. The following sections and excerpts are representative of what it meant for teachers to respond to dilemmas with *compliance, deferential resistance,* or *tempered radicalism* responses.

When teachers experienced conflict between what they held as personal ideals and professional vision for science and engineering instruction and their institution's ideals and demands, they perceived these as dilemmas that were specific to their unique contexts. Teachers' responses to these dilemmas fell into three main forms, with teaching responding to dilemmas with inaction or *compliant* responses, by speaking up and sharing their ideas with *deferential resistance* responses, or by actively taking a stance and attempting to create change with *tempered radicalism* responses. In the following sections, I use these kinds of responses to frame the ways elementary teachers responded to dilemmas while working to integrate and enact science and engineering into their classrooms by first exploring how teachers' narratives of a dilemma and then illustrating how teachers responded.

Dilemma #1: Roles of a Teacher

> I feel that my role as a teacher is to educate, nurture, and help to mold children into responsible, productive citizens who think scientifically about the world.
>
> I think the state's educational system, beyond our school doors, believes that we just educate students, that we just fill them with facts and then move on, when, in reality, teaching is much more than that. We are teachers, mothers, fathers, nurses, counselors, and advocates for our students. I'm not sure people realize what we do because they aren't in our classrooms witnessing what all it takes to go through a school day. (Elliot, Interview, 2/23/20)

Teachers who were committed to enacting science and engineering instruction in their classrooms and with their students expressed ideal images of their position as teachers and their vision of their roles. There was a disconnect between teachers' perceptions of their roles and how they felt they were positioned by their schools, school districts, or state school system. This tension was perceived as a dilemma. Some teachers responded to this dilemma by attempting to work within and around institutional structures and ideas of what a teacher's role should be. "There's just this disconnect between who I know I am as a teacher and who they think I should be. I mean, what do I do about that?" (Laura, Interview, 12/21/18). Part of teachers' professional vision was a set of images revolving around their role as a teacher—in their classroom, in their school, and in education, in general. When teachers perceived a disconnect between the role for themselves that they envisioned and the role that education afforded them, teachers experienced this tension as a dilemma and responded to it accordingly. Teachers' visions of their roles included an ideal environment or context where they could rely on their own expertise and professional judgment rather than education taking control of instructional practices and choices.

Illustrating Dilemma #1. "I'm a professional, damn it. I just wish someone would trust me to teach like one" (Alice, Interview, 2/21/20). Alice saw herself as a professional with unique expertise. "I know my students best. I know the science content better than most. I know what I'm teaching and how to teach it. Why are they expecting me to read out of a manual and follow their plans?" (Alice, Interview, 3/16/19). Alice, like many other teachers, held a view of her role as a teacher as part of her professional vision. When schools, school districts, and the state educational system diminished teachers' professional judgment and expertise, they implied their vision of teachers' roles.

> But a lot of times I'm basically told to like sit down and shut up and do it. I mean, they don't say it that way. But the message is basically to forget what I know and do it their way, because they know best. (Alice, Interview, 3/16/19)

This was the foundation of the dilemma Alice experienced—the vision she held for herself as a teacher ran counter to how she felt her school and school district saw her.

> Even though I'm not a classroom teacher, I believe that my role is to ensure that all students have access to quality, equitable learning experiences by supporting their teachers. I feel that it's my place to help teachers meet the educational needs of all of their students, especially when it comes to science. However, this is difficult because there are many people at the school and at the district level who view my position as a paper pusher or someone that is a curriculum and testing compliance officer. (Kay, Interview, 2/24/20)

Kay was a curriculum facilitator at Haskell Elementary School. As a curriculum facilitator, Kay's role was to support teachers in their curriculum and instructional practices. Kay also associated that role with having an impact on students through the instructional choices of their teachers. However, Kay distinguished a definitive difference between how she imagined her role to be and how her school and school district envisioned that role. Instead of being considered a mentor, an expert, and someone whose professional judgment was valued, Kay felt that the school district viewed her role as a "curriculum and testing compliance officer" (Kay, Interview, 2/24/20).

Alina was quick to recognize and describe this dilemma. "I can tell you what I'm not. I'm not a leader. I'm not a professional. I'm not qualified to make decisions for my classroom. Or at least, that's how the school sees me" (Alina, Interview, 12/6/18). Alina was an experienced teacher of 27 years, always teaching in high-needs elementary schools. She considered herself an "outlier," an "out-of-the-box thinker," and a passionate advocate for the children in her classroom. Part of Alina's professional vision for science and engineering included seeing herself as a lifelong learner, an expert, and an innovator in the classroom. However, Alina acutely felt that this was not her school's vision of her or her role as a teacher. Alina's image of herself and her role as a teacher diverged from how she felt her school viewed her, causing Alina to experience this deep dilemma as she worked to integrate science and engineering into her classroom.

A component of teachers' professional visions for science and engineering instruction was an impression of their role as a teacher. Teachers experienced deep dilemmas when what they envisioned their role as a teacher to be conflicted with that of their school or school district as they sought to integrate and enact science and engineering in their elementary curricula.

Responding to Dilemma #1 with compliance, deferential resistance, and tempered radicalism.

> My vision of myself as a teacher is someone who nurtures a love for learning and imparts the skills necessary for my students to grow academically, socially, and in their perspective of life. I see myself in the role of someone who facilitates that when I give my students the wonders of science. But, I don't always feel like I can live into that vision, because I believe "the institution" understands a teacher's role to be teaching a predetermined program to a potentially misaligned curriculum so we can produce a "grade level student" as if we were uniform factory workers. (Zoie, Interview, 2/23/20)

Zoie was resolute in her professional vision for science and engineering. She easily stated that science was "what opens doors for students. It opens doors and opens their minds and is what every student deserves" (Zoie, Interview, 1/2/19). A component of Zoie's professional vision was a clearly defined definition of her role as a teacher. When this was counter to how Zoie perceived "the institution" to think of teachers, she confronted this deep dilemma.

All teachers experienced this dilemma—the tension between how they envisioned their role as a teacher and how others conceptualized that role within their workplace. Every teacher experienced threats to their professionalism when they felt pressured to conform to certain instructional practices or to teach using specific, standardized programs. Teachers did not respond to this dilemma in uniform ways. A few teachers, while still holding strong professional visions, responded with *compliance* to the roles and visions of their schools or school districts. Other teachers offered *deferential resistance* responses or *tempered radicalism* responses in light of this dilemma.

Reponses of compliance. Kate, a first-grade teacher, was "the kind of teacher who would go the extra mile for [her] students" (Kate, Interview, 1/23/19). "Going the extra mile" meant that Kate's role as a teacher was to seek out resources that could "bring the content to life and make it matter" (Kate, Interview, 1/23/19) for her students. Kate also talked about being a rule-follower, but spoke of it only in terms of what and how she taught. "Well, in my class, I make sure I cover what is required in my curriculum" (Kate, Interview, 1/23/19). Kate later went on to say, "I work on their [district] directives. I make sure I implement those in the classroom and I follow their rules and procedures. I also follow the administration here, be respectful, and do what they expect in the classroom also" (Kate, Interview, 1/29/19).

Kate wanted to implement more science and engineering that was personally relevant for her students in her classroom. That was a key part of her envisioned role as a teacher. But when the administrator and instructional coach reminded her of the expected district pacing guide and curriculum, she sensed their resistance and responded to this dilemma with *compliance*. I asked Kate why she *made sure* to implement curricula and follow the rules and procedures, and she indicated that this is how she considered schools to work. For Kate, even though she saw herself as a teacher who would "go the extra mile," she conformed to the school's and district's standardized view of teachers. She saw her place or job within this system as someone who respectfully carries out the directives given from those above her.

Sadie, a second-grade teacher at Pine View Elementary School, also responded to this dilemma with a *compliant* response.

> You know every time I suggest that we take some time out of the schedule for science, I'm always reminded that science is already in [Reading Program], so we don't need that extra time. I mean it's not really. I know what I'm talking about. Anyone can see that. There are entire modules that have no science integrated in at all, but what can I do? (Sadie, Interview, 12/17/18)

Though Sadie was still a beginning teacher, she felt that she had knowledge to leverage when it came to the implementation of the district-mandated reading program and the role of science in her classroom. However, instructional coaches and administrators at Pine View Elementary continued to remind Sadie that the district-mandated reading program imbedded science into the curriculum, so there was little need to make more room for science in the daily schedule. Sadie interpreted that message as a stripping away of her professional judgment and being compelled to conform to a standardized schedule and set of practices.

As Sadie confronted this dilemma, she responded with *compliance*. ". . . but what can I do?" she asked. When I pressed Sadie to tell me more about what she did, she stated that she simply "did nothing." "I didn't think there was anything I *could* do. That was the way that [Instructional Coach] wanted it and how she saw it happening. It was better to just do it than to keep pressing the issue" (Sadie, Interview, 12/17/18). Sadie's compliant response to this dilemma meant that she suspended her quest for additional time for science in her second-grade classroom.

Responses of deferential resistance. There were two kinds of ways in which teachers responded to this dilemma with *deferential resistance*: (a) by speaking up and resisting demands within a given structure, and (b) with deference to authority within the classroom and resistance outside of the classroom.

Keira cried as she described the impact her third-grade teacher, Mr. C, had on her life.

> I had a lot of really rough teachers in elementary school, they just didn't seem to care. They were there for a paycheck or they were just there to do what the school told them to do. But, Mr. C, he never gave up on me. He saw the potential in me and took a lot of special time to make sure that I had what I needed, that I was learning, and that I was okay. He inspires me to do the same for every kid in my classroom. He's the reason I became a teacher. That's who I want to be. That's my vision of me as a teacher. (Keira, Interview, 1/8/19)

Keira wanted to be the kind of teacher who could change the world. She saw herself just like Mr. C—caring, thoughtful, compassionate, knowledgeable, responsive, going above and beyond for each of her students. However, Keira felt as if this was not how her school district saw her role as a teacher. "There's just no time for all of those other things" (Keira, Interview, 1/8/19). "Those other things" that Keira referred to were things like teaching in ways that might meet students' individual learning styles and interests or extending science lessons to capitalize on student engagement and interest. The school district's view of Keira's job held her back from emulating Mr. C.

"I'm just driven to stay on pace and to be on their schedule. It's like they just see me as a scheduling task master. That's my job" (Keira, Interview, 1/8/19). I pressed Keira to tell me more about what she did in the face of this dilemma. Keira envisioned herself to be a teacher like Mr. C, but she felt the district considered her to be a "task master" and a teacher who stays on pace and covers the curriculum.

> I'll stick to what I'm supposed to do legally as a teacher, like contract binding stuff. I'm not going to make waves by just flat out refusing to follow the pacing guide or teach the curriculum they give me. But, ultimately, I'm going to continue to advocate for my students. Sometimes that means reminding people what's in their best interest. And sometimes it means that I need to adjust little things here and there so that I can keep in my direction and vision while still keeping things, you know, within the fidelity that people expect of me. (Keira, Interview, 1/8/19)

Keira responded to this dilemma with *deferential resistance*. "Sticking to what she's supposed to do" and "not making waves," Keira was complacent, to an extent. She continued to resist the district's expectations of her role as a teacher by continuing to advocate for her students in small ways—being vocal with her opinions and finding ways to emulate Mr. C in small ways.

Still other teachers responded to this dilemma with *deferential resistance,* but the resistance took place outside of their classroom. These teachers felt as if there were too many barriers keeping them from pushing back against the institutional conceptualization of what and who they should be as teachers. Those tensions and barriers kept teachers from enacting *deferential resistance* responses in their classrooms, so some teachers sought to affect change outside their classroom context. "You know that's why I go to all these textbook adoption things over the summer, right?" (Alina, Interview, 12/5/18). School and district mandates (both curricular and scheduling) had stripped away Alina's time for science in her second-grade classroom. "There's no time for good science anymore, and what they tell me to teach definitely doesn't align with the standards.

What’s the point if they’re just going to tell me what to teach?” (Alina, Interview, 12/5/18). Alina felt that as the district continued to demand prescribed curricula that they no longer valued her professionally.

> I know it seems ridiculous to go to all these meetings. But I keep hoping that my voice will be heard and that maybe I affect *some* change. I mean, if I can’t do it here [her classroom], then maybe I can change things before they get here. It’s like if I do this the right way and keep with the process, maybe someone will listen and some things can change. (Alina, Interview, 12/5/18)

Alina felt beholden to the curriculum and expectations of her school and school district and responded to this dilemma by yielding to demands with her instructional practices in her classroom. Outside of her classroom, however, she responded with *deferential resistance* as she tried to “keep with the process” but seek opportunities to affect change and disrupt the system before curricula and mandates made their way to her classroom.

Marlene, a fifth-grade teacher, wanted more from the curricula, resources, and expectations of her forwarded by her school district and leading curricular experts at her magnet school. “We have this philosophy at our school, that we nurture every child’s natural desire for knowledge. But some of the ways that they want us to teach the students just don’t align with that philosophy” (Marlene, Interview, 1/2/19). The science lessons provided by the district often began with a review of vocabulary and often lacked any student-led exploration of the topic. This did not align with Marlene’s vision of science instruction for her students.

"I don't feel like I can just say to [principal], I'm not going to teach this or teach this way" (Marlene, Interview, 1/2/19), Marlene considered herself powerless to change much regarding the science instruction in her classroom.

> I think everything falls in place when what we do in the classroom is fitting, it's like a puzzle. And when all the puzzle pieces fit, everything else will fit. Sometimes, I feel like they [administrators] don't have all the puzzle pieces, or they don't even know that there are more puzzle pieces out there. (Marlene, Interview, 1/2/19)

Marlene's response in her classroom was *compliance*, but outside of the classroom, her *resistant* response was two-fold. After seeking out ways to learn about new, different, and more rigorous pedagogical practices for science and engineering, Marlene took her knowledge and expertise to school and district level curriculum meetings.

> You all [STEM Program] really helped me get smart about how science should look. I think I always knew it, but now I had the information to back it up. So when I walked into those county meetings with [Superintendent] or our lead team meetings here at [School], I was able to say with confidence how our instruction could improve, how to make those puzzle pieces fit together best. (Marlene, Interview, 1/2/19)

The thought-provoking part of Marlene's statement was not the support she received from STEM Program and the perceived value of that support; it was, instead, the fact that here, again, was another teacher who was unable to respond to this dilemma with change in the classroom, but sought to advocate for change outside of her classroom.

Responses of tempered radicalism. Still other teachers responded to this dilemma by recognizing the power dynamics and how roles were conceptualized differently within their schools, and not allowing it to define their role or who they were within their workplace; they spoke up, spoke back, and took action with *tempered radicalism* responses. For Alice, a first-grade teacher at a traditional elementary school, this dilemma was a daily tension. As she attempted to ensure that her students consistently received reform-based, standards-based science and engineering instruction, Alice found her district-mandated, scripted reading program to be at odds with the science instruction she wanted to implement.

> They like to say that there's science integrated into [Reading Program], but it isn't enough and it doesn't align with our standards. So, I feel like I found myself speaking up a lot. Like, I would talk to my curriculum facilitator and in team meetings and to the [Reading Program] coach and to the principal about how I didn't feel that the curriculum was what's best for the kids, that I felt that the content wasn't aligned to our science and social studies standards. But, I didn't seem to get me anywhere. I was like a thorn in their side, but it didn't make a difference with people at that level. (Alice, Interview, 3/6/19)

Alice expressed her concerns about the disconnect between the reading program, state science standards, and her science and engineering instruction, but felt as if voicing her concerns and opinions did not penetrate the views of coaches and administrators who seemed to hold authority over her instructional practices and content.

With her *tempered radicalism response*, Alice did not allow that to affect her practices. "It can't stop there, no good teacher should just give in like that" (Alice, Interview, 3/6/19). Alice believed that it was her responsibility to speak up and push back in service of something she believes was in the best interest of her students. When pushed to talk about what not giving up looked like for her, Alice responded to this dilemma by attempting to work with those who may have held sway over her content and instruction and then working around the tension. "I just kind of have to shut my door and try to get away with as much as I can because I know what's best for my kids. I keep being a rebel too. That's just it. Sometimes you just have to do something" (Alice, Interview, 3/6/19).

Alice responded to the tension and then creatively worked around it to implement the instruction she felt was appropriate and needed. Alice acknowledged and accepted the differing ideals and demands of those above her, comprised of colleagues such as instructional coaches, administrators, and the school district, and then followed with action. Alice, without clear deference to the authority around her, chose to close her door and do what she considered best for her students. She was a change agent for the needs of the learners in her classroom.

Alanza talked about responding to this dilemma similarly. "I'm known as the pushback person because I'm more vocal. But, I don't only pushback for my children" (Alanza, Interview, 12/20/18). Alanza had no issues with speaking up, pushing back, and creating change when it came to advocating for her students. "I'm not afraid of the negative consequences. I'm not worried about what all those people think of me. If it's what's best for my kids, I'm doing it" (Alanza, Interview 12/20/18).

Alanza also felt the need to push her more reticent colleagues to speak up and create change, much like herself.

> I also want to push my other colleagues to quit sitting at the table and not having the real conversations. They are afraid of the negative consequences. I think they think they don't have the power to say what they want to say. A lot of times they want me to be the collective voice for the group, which is okay most of the time, but I want them to be able to stand up for their own ideas. (Alanza, Interview, 12/20/18)

Alanza would have liked her colleagues to respond with more *tempered radicalism* like herself, and I asked Alanza how she encouraged that and created that change. “You do what you can, right? I mean, I can’t just start a rebellion! But, I can lead by example, encourage my team to speak up and do things for themselves. You just got to show them what’s possible” (Alanza, Interview, 12/20/18).

Dilemma #2: Curriculum and Pedagogy

Part of teachers’ professional vision for science and engineering instruction in their elementary classrooms included ideal images of curriculum and pedagogy, or how and what they envisioned teaching their students. For some teachers, this vision diverged from institutional ideals and demands, resulting in tensions as they attempted to balance seemingly incommensurate content expectations and instructional practices.

> My vision for science in my classroom? I want to teach in a way that they [students] make connections between them and the world, I want to teach about how things work and what they see in their world.
>
> I think that they [district] want me to teach their concepts, do an experiment, and then just move on. Where’s the connection in that? (Jemma, Interview, 2/19/19)

Jemma and other teachers experienced this dilemma, pulling them in contradictory directions between their professional vision for the content and instructional practices for the instruction they hoped to enact in their classroom and those of their school or school district.

Illustrating Dilemma #2. Some teachers enjoyed complete freedom and autonomy within their classrooms and schools, not experiencing this dilemma at all. “We have complete freedom here. I can teach what I want, how I want. No questions asked”

(Bridget, Interview, 12/21/18). A first-grade teacher in a magnet school with a history of university involvement and support, Bridget had complete autonomy over instructional practices and content. Teachers' professional visions and those of the school or district were not at odds, and there was no dilemma with which to wrestle. Teachers with similar perceptions of autonomy and freedom reported having the *trust* of administrators, the *freedom* to make decisions in their classrooms, and that they, meaning teachers and administrators, *saw instruction the same way*. Their professional vision aligned with their school's vision for how and what they taught.

> I feel like we're all on the same page. I'm able to teach the way that I want to and that it's okay. I don't feel like I need to justify why I'm doing things that way. Other teachers might have the, you know, higher-ups who may not see things like that, but I have the freedom to teach the things kids are interested in and how I know they'll learn. (Teonna, Interview, 1/11/19)

However, Bridget and Teonna were exceptions in the data. The vast majority of teachers perceived a tension between their ideals of instructional practices and content and what their school was expecting or asking of them.

> It's like, you know, we're hearing from the county what they want. They want certain assessments. They want us to do these curriculums, and there's a lot of what they want. I feel like a lot of times I'm kind of in this limbo of like trying to balance what I want for the students, providing choice, teaching in a certain way, connecting things for them, but then also trying to be what the county wants as well. It's hard. It just doesn't balance out most of the time. (Kendall, Interview, 1/2/19)

Kendall, a third-grade teacher, wrestled with this curriculum and pedagogy dilemma. She found it difficult, at times impossible, to balance the science and engineering instruction that she envisioned for her students with the expectations of the school district. Kendall's professional vision for science and engineering instruction was a classroom where "students don't just see themselves as students, but where they think 'I could be a leader' or 'I could be an advocate in my community' and even 'I am a problem solver'" (Kendall, Interview, 1/2/19). Kendall desired to teach in a way where students "understand that about themselves and see those possibilities" (Kendall, Interview, 1/2/19). Even with this vivid image of science and engineering practices and content in her classroom, Kendall struggled with the tension between her vision and the expectations of the school district—curricula, assessments, and expected instructional practices.

"There are just so many things keeping me from making changes in my classroom. We're focused on testing, I'm supposed to only teach like the manual tells me to, and there are always people checking to make sure that I'm only doing that" (Tana, Interview, 1/16/19). Following the STEM Program Summer Institute, Tana "just saw this new way to do engineering and science" (Tana, Interview, 1/16/19) with her students. She envisioned herself facilitating learning experiences where students would be engaged with hands-on science, but Tana struggled with the difference between her new vision and how her instructional coach was expecting her to teach. "It just seems so different from what they want to see. I don't know that I can do it" (Tana, Interview, 1/16/19). When Tana referred to "it," she meant teaching in line with her new vision. Tana, like many other teachers, experienced competing visions for how and what to teach when it came to the science and engineering instruction in her elementary classroom.

Responding to Dilemma #2 with compliance, deferential resistance, and tempered radicalism.

> I came back to my classroom with all of these plans for science and engineering, but then I realized how much buy-in it was going to take from so many people. So many people want things one way, and now I want to teach in a different way. My biggest worry was convincing everyone else that I should do it my way instead of their way. (Janice, Interview, 1/7/19)

Janice wanted to implement inquiry-based science and engineering instruction in her third-grade classroom, and but had pushback from colleagues and administrators. Many teachers faced this same dilemma revolving around how they wanted to teach science (or, sometimes, just the fact that they wanted to teach science at all) and being greeted with resistance from administrators, colleagues, and coaches due to an already present and historically entrenched institutional vision.

In the face of this dilemma, most teachers did not give up on their professional vision for the content and methods of their ideal science and engineering instruction. A few teachers responded to this dilemma with *compliance*. The majority of teachers countered this dilemma and threat to their autonomy with responses of *deferential resistance* and *tempered radicalism*.

Responses of compliance. When I asked Karleigh, a first-grade teacher at Haskell Elementary School, why she taught science, she responded, “Because I’m told to” (Karleigh, Interview, 1/7/19). Karleigh felt that the administration and curricular lead team had absolute say over how and what she taught. Karleigh previously indicated that she was excited and motivated to implement engineering in her first-grade classroom, even knowing that engineering was not part of the school- and district-mandated science curriculum. I asked Karleigh how or if she planned to integrate engineering into her instruction.

> It's something I'm working on now. Usually I just stay to myself and just do what they tell me to do, so I don't know if I'll get to do it. I've learned that I do need to stick up for myself and my students, but they have so much more experience than me and know what is best to do. I just don't feel like I can ask to do this in my classroom. (Karleigh, Interview, 1/7/19)

The "they" Karleigh referred to was her principal, curriculum facilitator, and instructional coach—all members of the Instructional Support Team and the school's administration. Karleigh said that members of the administration curriculum lead team had "much more experience" and knew "what [was] best to do." This Instructional Support Team had a vision of instruction at Haskell Elementary School, which dictated the demands put on Karleigh's science and engineering instruction. Being in a position of less knowledge and authority and thinking of herself as a rule-follower meant that Karleigh responded to this dilemma by doing nothing. Though she held a different vision for engineering instruction, Karleigh accepted this dilemma and functioned within it with a *compliant* response.

"I do science for everybody. I teach science and engineering because it provides students with that engagement and success that not every student gets to experience every day in other places" (Adeena, Interview, 1/9/19). Adeena's vision for her science and engineering instruction was clear, well-defined, and deeply rooted in her personal biography. Adeena was inspired to cultivate her interest in science when her first-grade teacher “showed me that science was for everybody, even African American girls. That’s why I say that I do science for *everybody* [her emphasis]” (Adeena, Interview, 1/9/19).

“I want my science instruction to be relevant and connected to the students’ lives, hands-on, and engaging. So, I plan lessons that reflect that” (Adeena, Interview, 1/9/19). Adeena drew on her professional vision—complex science experiences and instruction for all students—to define the way would like to teach in the classroom. This past year, Adeena found herself unable to turn her professional vision into practice. “It’s like the school doesn’t have the same vision that I have for teaching the students,” Adeena said (Interview, 1/9/19). She continued to explain how this was affecting the implementation of her professional vision:

> Well, in years past, we’ve as a team of teachers, and even as individual teachers, we’ve been given a lot more flexibility as to how we teach. Because we all know the standards are what the kids have to be able to do and what they need to know, but they don’t tell you how to teach it. So we used to be able to get much more creative with how we could reach and teach the kids. But now it’s more—it’s very prescriptive. They’re telling us what and how to teach, and that doesn’t leave a lot of room for how I know we should be teaching science. (Adeena, Interview, 1/9/19)

Adeena’s school expected her to implement semi-scripted curricula, leaving little to no room for her professional judgment. Adeena felt as if the school was prioritizing and emphasizing “prescriptive” curricula over allowing teachers to use their professional vision and creativity to craft lessons based on standards and the needs of their learners. “What do I do? I end up just going with the program, even though I don’t think it’s right” (Adeena, Interview, 1/9/19). Adeena responded to this dilemma with *compliance*; it had become what Hammerness (2004) would call a roadblock. The dilemma evoked a compliant response from Adeena, even though she aspired to teach against the grain and enact her ideal images of content and pedagogical practices.

Responses of deferential resistance. Teachers who held strong, vivid professional visions for their science and engineering content and instructional practices and found these in conflict with their school's content and pedagogical demands responded to this dilemma with *deferential resistance*. These teachers were not compliant; they did not yield to institutional demands and conform their vision. When confronted with this dilemma of practice, teachers resisted institutional demands and ideals by speaking up and contributing to the professional conversation, while giving regard to all stakeholders' viewpoints.

Kayla responded to this dilemma—competing images of how and what to teach—by making accommodations and amending her professional vision. A teacher in a multi-age classroom of second and third-graders, Kayla finished the STEM Program Summer Institute focused on integrating engineering into her elementary curriculum. When I asked her about the Summer Institute, Kayla immediately responded, "It was the best PD I've ever been to. I just knew it would change everything!" (Kayla, Interview, 2/19/19).

The Summer Institute reshaped parts of Kayla's vision for science and engineering. Before attending the Summer Institute, Kayla had never considered integrating engineering into her second- and third-grade curriculum or its possibilities in conjunction with the science curriculum. I asked Kayla about how her experience changed her vision for instruction and her instructional practices.

Alison: So, let me ask you about the changes that you saw in yourself and your vision and your teaching in those first few weeks following the STEM Program Summer Institute.

Kayla: I immediately knew that I needed to get more STEM into our day. What I learned that week made me see my teaching different. I think I saw a more hands-off approach where I stood back a lot more as a facilitator instead of telling them what to do and how to do it. For the second little STEM project we did, oh, it was horrible. It was just, it wasn't working out, but we did like tower building challenge with pumpkins. I was so focused on those pumpkins breaking. I had to stop myself, and I was like, Kayla, no. I was like, just let them break and let's see. You know the kids, they molded them back together. I was so happy that I and I stepped back, took a moment, and saw it. Before, like before the summer institute, I would've just thrown it all in the trash and been done with it and given the kids more pumpkins. But those kids were like, no, we have to use *these* pumpkins, *this* amount, and *that* kind of stuff [her emphasis]. And I feel like that took control off my plate. But because I made that change, I got to see children blossom within that. So I really feel like the problem solving has gotten a lot better because I've changed how I teach. (Kayla, Interview, 2/19/19)

Kayla's vision now included more student-centered, engaging, and consistent instruction, which would help her students to grow socially and emotionally. Kayla felt passionate about teaching STEM in a way that "fosters that ability to go into a science or engineering field" (Kayla, Interview, 2/19/19).

"But it's hard," Kayla explained. "I want to show the kids what scientists do and that they are capable of doing that. And I have what I need to do that, I have the resources, and I know what that looks like" (Kayla, Interview, 2/19/19). I pushed Kayla to tell me more about why she considered this hard or difficult. For Kayla, her vision of science and engineering instruction—teaching in a relevant and engaging way which shows students that they *are* and *can be* scientists or engineers—was not very similar to the school and district vision, and therefore the policies they forwarded.

> It’s hard because we don’t have a lot of the resources. Luckily, you all [STEM Program] have been able to help us out with some of that, but going back to that pacing guide, I feel like I have to work within the units that [District] says. I would like to spend a little more time on STEM things, but [District] says that they want us to teach X, Y, and Z, so [School] says that we have to teach X, Y, and Z. It’s just not the same as what I think we need to teach. It doesn’t go far enough. (Kayla, Interview, 2/19/19)

There was tension between Kayla’s vision and the vision of the district (and therefore, her school) when it came to how and what to teach. “We have science on our schedule most weeks, but it’s not always the science I think we should be teaching” (Kayla, Interview, 2/19/19). Kayla’s vision included a well-defined set of instructional and pedagogical practices and reasons why she felt passionately about them, but she also did not agree with the content that the school district, and therefore her school, prioritized in the unit plans and pacing guides. Kayla deemed the curriculum and pacing guides to be insufficient and thought that they should cover more topics of relevance to students more deeply.

> Alison: So now we’re halfway through the school year. How are those changes going?
>
> Kayla: You know I think I came back from the summer thinking that this could completely change how I teach science, and then I was back to where I was and just struggling to get it in. Well, I’d still like to do more. And, I guess, I really do do more. I sat down and made my own pacing guide. I figured out what would be meaningful to the kids and what I can do and when I can do it, but I still do what the [District] pacing guide says. (Interview, 2/19/19)

Kayla, who found herself with little time and flexibility to teach science and engineering as her ideal instruction fell outside of the school district’s units and pacing guide, resisted the district's vision and mandates by working within the given parameters. Concerning the school and district guidelines and curriculum, Kayla integrated her vision of science and engineering whenever and wherever she could, even writing her own parallel pacing guide to see the possibilities of integration and implementation. Kayla responded to this dilemma with *deferential resistance*—regarding and accommodating school and district policies, while incorporating her own vision of ideal classroom content and instructional practices.

Responses of tempered radicalism.

> You know I feel like I'm in the middle of a teetertotter. On one side, I have all these things I've learned about great science and the things my team and I want to try. And then on the other side, I've got [District] saying that I have to teach this way or that I can't teach that. We see it two different ways, and it's like this weird balancing act to make everyone (including myself) happy. (Amelia, Interview, 1/10/19)

Amelia summarized the dilemma perfectly with the phrase, "We see it two different ways . . ." (Amelia, Interview, 1/10/19). Amelia maintained a vision for science and engineering instruction, which was in opposition to her school district's. Allowing her professional vision for science and engineering content and methods to propel her forward past deferential resistance and into action, Amelia responded with *tempered radicalism*. "I know what they want. I know what they say to do. But it's not right for my students. So, I'll just put my own spin on it and do it my way" (Amelia, Interview, 1/10/19). Here, when Amelia says "they," she means her school, more specifically the curricular leaders and administrators with whom she works. A fifth-grade teacher, Amelia taught science and engineering because:

> I just want to reach as many students as I can in some way, shape, or positive form. I don't just teach science because it's fun. I mean, I do. That's part of it. But in science they can learn to fail and be problem solvers and be resilient. It's just so much more than just teaching about life cycles or weather. (Amelia, Interview, 1/10/19)

Amelia knew what was best for her students, even though others at her school asked something else of her instruction. She responded to this dilemma by doing it "her own way." When I asked Amelia what "putting her own spin" on her instruction and "doing it her own way" looked like, she told me that she liked to use standards, baseline expectations, and school requirements as a "jumping-off point." "I'm not going to let them limit my teaching" (Interview, 1/10/19). Amelia drew on her teacher vision, her hopes and dreams for her students *and* her instruction, allowing that vision to play a significant role in shaping the how, what, and why of her science and engineering instruction.

Similarly, Susan's vision for science and engineering instruction in her classroom included images of content and methods that were student-driven. Susan wanted her students to drive their own science learning—pursuing high-challenge topics and questions that were personally relevant. Susan felt that her instructional practices were facilitated and supported by two different sources—her administrator and a university professor—but that scripted curricula constrained her instruction, "standards that don't make sense or align with anything" (Susan, Interview, 1/2/19), and a school-wide focus on high-stakes assessments. "What they want me to teach and how they want me to teach, you know because of [State Test]'s isn't what my kiddos need or want" (Susan, Interview, 1/2/19). Susan disagreed with the school district's vision and expectations, especially parts of the curricula and instructional practices she was expected to carry out with her fourth-grade students.

Susan responded to this dilemma, with resistance, action, and quiet push back—a response of *tempered radicalism*.

> I would definitely say, that especially this year, I think I've realized, well kind of we've realized, that we need to take the approach of doing what's best for our children. Some teachers who do this hide that approach when the [district coaches] are here. But, I don't do that. Like this one time when [district coach] came in, he said, 'Well, that's not what you're supposed to be doing.' and I just told him that my children learned differently, so I was going to do it this way instead. (Susan, Interview, 1/2/19)

Susan changed the content and how she delivered that content to meet the needs of her students, rather than the expectations of people outside her classroom. She pushed back both verbally and with her actions. I asked Susan how she did this, how she pushed back against curricula and practices that she disagreed with so verbally and actionably. Susan felt that expectations for how and what to teach were not appropriate for or connecting with her students. Instead, Susan used less and less of the expected curricula, squeezing it into fewer and fewer days, and replaced it with a more student-centered and student-driven approach.

> I just remember saying to Dr. M that teaching these disconnected standards wasn't engaging or appealing to the kids. He and I started reflecting every day and looking back over what the kids said and did to figure out what we should investigate. That's when he started his tooth experiment. We had read about teeth and noticed that they had all these questions about teeth. So we decided that we would just teach everything through that. You know, I looked at the standards and I looked at the other stuff and we just started designing learning around what the kids wanted to figure out. (Susan, Interview, 1/2/19)

Dr. M was a local university professor who volunteered in Susan's classroom a few days a week. With the support of Dr. M, Susan redesigned the curriculum, parts of the content, and her instructional practices to address student interest and engagement better and push back against the ideals and demands that were no aligning with her professional vision.

"If you're going to cut my science time and tell me to teach a scripted reading program, I'm going to make it my own" (Zoie, Interview, 1/2/19). Zoie, a first-grade teacher at Weaver Elementary School, believed that science and engineering should hold a significant place in her students' lives and was worried and upset when an instructional coach said she would need to cut her science block in half, bringing it down to 15 minutes; this would allot time for the district-mandated, scripted reading program. Zoie understood and acknowledged that this was not her instructional coach's unilateral decision, but instead the school's interpretation of a district mandate. That, however, did not mean that Zoie appreciated the curricular directives.

> This is my first year teaching first-grade, and I immediately noticed that there was so much sitting and listening. I was supposed to have them sit and listen in reading and then again in math. So, I immediately took the curriculum and started looking at all the ways I could change the programs and integrate STEM. U. I wanted to figure out ways that I could get the raw materials in their hands and give them a way to explore it, still grasp the concepts, and still follow the reading program and math program as best I could. (Zoie, Interview, 1/2/19)

Growing frustrated, Zoie reappropriated the district-mandated model, seeking out ways to use her reading curriculum for a dual purpose—the integration of science content and literacy instruction.

> So I had to be little bit more inventive and think quick on my feet. Sometimes I'd just be in the middle of teaching and had all of a sudden had this idea and be like, wait, we're going pause right now and do some science. This one time I was reading out of the manual about the human body. We're reading about the digestive system and they weren't really getting that you have stomach acid and that it breaks up stuff. The kids were like, what are you talking about? Through all of this listening and learning, they still weren't getting it. I went and grabbed a whole bunch of baggies and I gave them all baggies. You know I'm a Diet Coke fanatic so I always have Diet Coke. I grabbed like two or three cans and gave each of them a baggie and some Smarties. I said I want you to use the Diet Coke and the Smarties, and I want you to figure out how is this like your stomach acid. And they took the bags, and they started pouring lots of Diet Coke in there and they put the Smarties in, too. When the Smarties started to dissolve, they got really excited. They're like, oh our stomachs do that? That's so cool. I've learned that all this is possible, but it's taught me to be creative and think on my feet if I'm going to somehow put these together. (Zoie, Interview, 1/2/19)

Time and time again, Zoie deviated slightly from the reading program's script to make science connections or include a hands-on learning activity that reinforced or extended her students' learning to make up for the reduced science time in her schedule. I asked Zoie about why she felt able to reappropriate and amend the mandated curriculum in the way she did.

> I feel like I can do this because of two things—The Weaver Way and [Principal]. Our school has a saying that we need to give every student a chance to learn every day. If that means that I need to do things different from the way that the district is telling me to, then I will. But, then there's the fact that [Principal] trusts her teachers. I can do this knowing that if [Principal] walks into my classroom, she's not going to write me up, she's going to ask why I'm building bridges in the middle of reading. (Zoie, Interview, 1/2/19)

Zoie's *tempered radicalism* response did not completely resist the programs and mandates threatening her science and engineering instruction, but instead worked within norms and expectations to find ways for her reading instruction to serve a dual purpose—advancing literacy knowledge and science content—at the same time.

Dawn's *tempered radicalism* response to this dilemma was similar to Susan's. Dawn was a fifth-grade teacher at a Title I, low-socioeconomic, highly minoritized magnet school. As a fifth-grade teacher, Dawn was expected to prepare her students to take an end-of-year standardized test to assess their grasp of science content. "It's hard," Dawn said, of teaching the fifth-grade science content. "I've done this a while. There are standards and things the county wants you to use, the pacing guide. There's the quizzes and questions and vocab they want you to do. There's so much that's better than this" (Dawn, Interview, 12/20/18).

Dawn felt the curriculum and resources that the school district expected her to use to "cover the content for the [State Test]'s" (Dawn, Interview, 12/20/18) and the pacing guide, which dictated the content she would teach each day, constrained her instruction and affected her students' depth of learning. This constraining vision did not align with Dawn's vision for science and engineering instruction. In response to this dilemma, Dawn took matters into her own hands.

> Dawn: Yeah, so there are lots of things that influence the way I teach. You know, you get all gung ho and excited about teaching your students, and then, well, things happen. There are all these things that they want you to do. Sometimes I feel like I don't have control over my own classroom.
>
> Alison: What do you do about that?
>
> Dawn: I have to strike a balance. Actually, it's more than that. It's not a balance at all. I take what they give me and what they want and use and I start from there. From there, I make sure that my students have the science

> experiences and the engineering experiences that they need to make those connections. Without all that, we're just speaking the language and going through the process mentally and that's not enough. They [district coaches] want to see that they're [students] answering questions. And they are. But at the end of the day, I can't leave it there with my students. They need and deserve more. I'm not going to let the county pacing guide and resources limit their learning. (Dawn, Interview, 12/20/18)

Dawn's vision for her science and engineering classroom included:

> An engaging classroom, where the productivity and how the students achieved isn't just based on how they perform, but on how they're thinking. Children have bright ideas and my classroom should be a place to nurture those burning ideas. (Dawn, Interview, 12/20/18)

But the school district's resources, pacing guide, and curricula for fifth-grade science instruction left Dawn experiencing a dilemma. Feeling that these instructional expectations did not meet her students' needs or align with her vision of rigorous, reform-based science and engineering instruction, Dawn responded to this dilemma with *tempered radicalism.*

Dawn responded by actively pushing back, designing and implementing hands-on science and engineering experiences and what she considered more rigorous ways to teach the expected standards and content. Undaunted, she did not accept the school district's vision or mandates as limitations but instead responded with action, resistance, and change.

CHAPTER V

FINDINGS PHASE II

In this chapter, I explore the nature of teachers' STEM-linked professional agency. The research question that informed this phase of the study was:

- How do teachers who work in high surveillance cultures and have strong commitments to their professional vision for science and engineering narrate the nature of their STEM-linked professional agency over a school year?

As outlined in Chapter III, the participants of Phase II of this study included 18 elementary teachers (see Table 3.3 in Chapter III for teacher demographics), selected through purposeful criterion case sampling (Patton, 2002). These cases were worthy of further, in-depth study because they provided detailed insight into teachers' lived experiences and STEM-linked professional agency. While they were ultimately a representative sample of the demographics, I selected these teachers because they met the following selection criteria:

- teachers described working in schools with what they perceived as high surveillance cultures, with high surveillance cultures defined as a culture of unrelenting scrutiny of teachers' decisions and practice.
- teachers indicated that they made multiple changes to their instructional and pedagogical practices involving science and engineering;

- teachers held strong commitments to robust professional visions for science and engineering instruction; and
- teachers who responded to dilemmas with responses of deferential resistance or tempered radicalism (defined in Chapter IV).

The Nature of Teachers' STEM-Linked Professional Agency

Teachers' narratives and descriptions of their professional agency focused on their enactment of science and engineering instruction; therefore, I consider this content-specific form of professional agency as STEM-linked professional agency. While many forms of professional identity have been centered on teaching as a whole and a teachers' ability to affect change within multiple parts of their classroom or their school (Hökkä et al., 2017; Toom et al., 2015), STEM-linked professional agency focuses on teachers' active efforts to make choices and take intentional action in a way that makes a significant difference concerning their science and engineering practices and teachers' abilities to act in new and creative ways when integrating science and engineering into their curricula.

In this section, I present a refined framework for STEM-linked professional agency, one which, while still informed by the literature, is enhanced with study-specific details from data analysis. The process of deductive and inductive reasoning during data analysis left me with a framework that is consistent with the literature and simultaneously grounded in this study's data. I conceptualized STEM-linked professional agency as "the dynamic phenomenon of working creatively within the contexts of high-needs schooling to create change and align practice with professional vision for science and engineering in innovative and responsive ways" (see Figure 5.1).

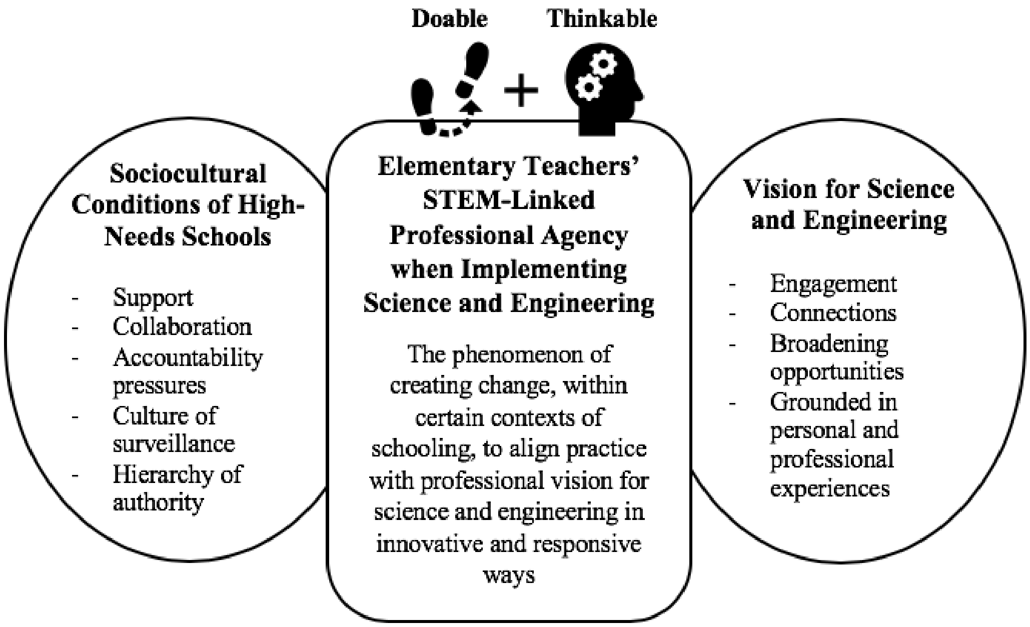
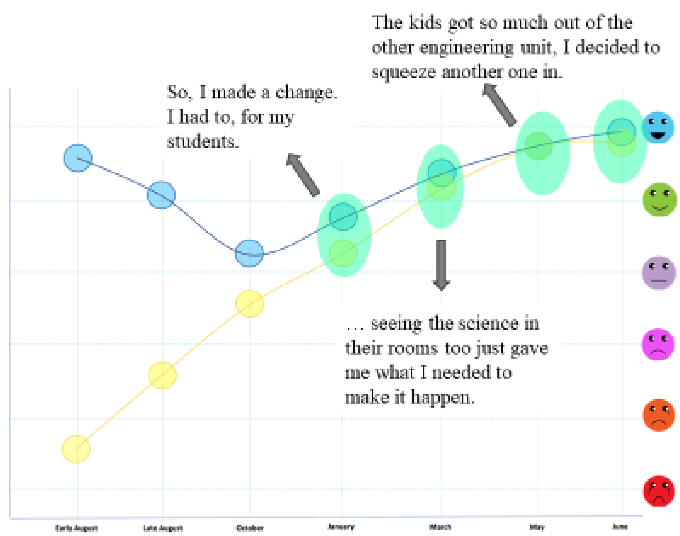
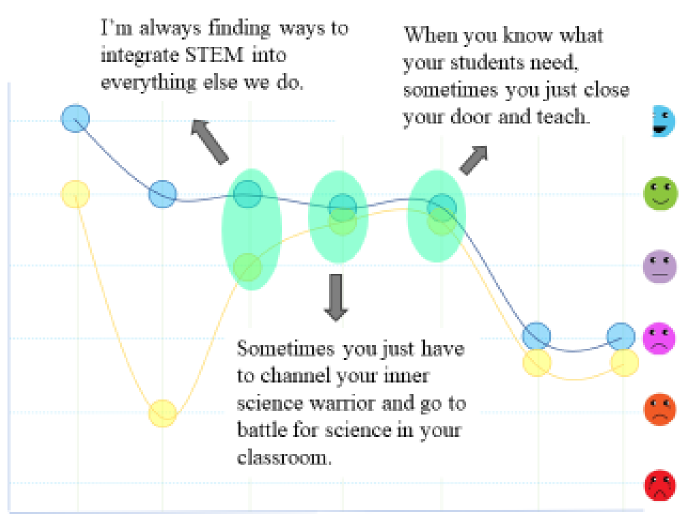


Figure 5.1. Framework for the Nature of Teachers' STEM-Linked Professional Agency. Explanations and Definitions in This Framework are From the Literature and Grounded in This Study's Data.

The primary source of data was narrative interviews that used an elicitation device called STEM journey maps (see Chapter III). Throughout this study, I lovingly referred to teachers' STEM journey maps and their associated narratives as "roller coasters of STEM" since the peaks and valleys of their visuals journey maps were striking. As indicated by Figure 5.2, moments of STEM-linked professional agency are visible in the STEM journey map interviews during moments when science and engineering are highly thinkable (aspirations and vision for science and engineering instruction) and doable (instruction they were able to enact). In Figure 5.2, I demonstrate that, in moments where thinkability and doability for science and engineering integration were high, teachers discussed action-oriented changes in their instruction or commitments to aligning their vision with their practice (see quotes in Figure 5.2).



(Marlene, Interview, 6/12/19)



(Alice, Interview, 6/10/19)

Figure 5.2. Visualizing STEM-Linked Professional Agency. Arrows Represent Moments of STEM-Linked Professional Agency, as Conceptualized in This Study, Where Thinkability (Blue Dots) and Doability (Yellow Dots) are High, and Where Teachers Narrated a Change to Their Practice or an Effort to Align Vision with Practice.

STEM-linked professional agency ebbed and flowed throughout the school year; it did not take on a static or fixed trajectory. Thus, I assume that STEM-linked professional agency is never a final-form accomplishment, even for the most experienced, visionary, knowledgeable, and skilled teachers. This is understandable, given the multifaceted pressures teachers in high-needs school face—e.g., incredible pressures to raise test scores, cover mandated and scripted curricular content, conform to prescribed practices, and be on the same page as the teacher across the hall. Furthermore, the more frequent the surveillance by school-level and district-level administrators, the greater the threats to teachers' professionalism and their STEM-linked professional agency. Pressures to implement a narrowed curriculum leave little room for and demand a greater amount of audacity, creativity, and commitment to one's own vision to overcome. This chapter tells the story of teachers who fought, sometimes with moments of victory and other times with moments of despair, to work in science and engineering creatively.

Narratives of STEM-Linked Professional Agency

In the remainder of this chapter, I present the narratives of six teachers' STEM-linked professional agency over the 2018-2019 school year. Using the STEM journey map, each teacher described ups and downs unique to their own lived experiences of trying to enact science and engineering in their elementary classrooms. I selected Elliot, Alina, Holly, Marlene, Willa, and Elle because of their narratives' distinctive qualities. While all begin optimistically, their narratives each took very different paths throughout a school year. These teachers also represented a spectrum of experience. Elliot and Holly were beginning teachers (3 years of experience and a first-year teacher, respectively), while Alina and Marlene were veteran teachers (with 27 and 22 years of experience, respectively), with Elle and Willa falling somewhere in between (with 8 and 14 years of experience, respectively). These six teachers illustrated the diversity of the sample of 18 teachers—representing all grade levels (first through fifth), including the one male of the sample, three African American teachers, and three White teachers.

Weaver Elementary School: Elliot and Holly. Elliot and Holly both taught at Weaver Elementary School, a traditional public school situated in a moderately urban center of a small mid-Atlantic city. Weaver Elementary School had a student population of 511 students, 99% of whom qualified for free or reduced lunch, 92% of whom were minoritized students, and 38% of whom were English language learners, with most speaking Spanish as their first language. Elliot enjoyed and appreciated his workplace. “I count myself blessed every day that [Principal] saw something in me and asked me to move into a classroom here. I couldn’t imagine working anywhere else” (Elliot, Interview, 2/11/19). An African American, male, fifth-grade teacher, Elliot had been a classroom teacher for 3 years, though it was his 10th year in the field of education, having previously been a classroom assistant. Loyalty to Weaver Elementary School was common among teachers, both veteran teachers and newcomers alike. Holly, a White female, was the youngest teacher in the study and, as a first-year teacher, had been teaching fourth grade for 9 months at the time of our first interview. “I’m happy that this is where I ended up. It’s been a good place to work so far. Everyone just talks about Weaver this and Weaver that” (Holly, Interview, 5/20/19).

The "Weaver Way," or the school ethos and philosophy, permeated life at Weaver Elementary School. Instituted almost 20 years prior, the Weaver Way shaped teachers' approach to teaching, learning, and working at Weaver Elementary with the idea that everything faculty did was for "every student, every day." "From what I understand, it's just the way things have always been done. You know you just hear, well we do it like this, it's the Weaver way" (Holly, Interview, 3/11/20). For some teachers at Weaver Elementary School, this mindset was a focus on adherence to methods and instructional practices. In fact, Elliot spoke of new faculty at Weaver Elementary School as being "Weaver-ized."

> I hate the phrase, but lots of people love it—Weaver-ize. That's what we do here, we Weaver-ize people. It's a mindset. It's a concept that they [administration] want. We're all supposedly Weaver-ized in the same way, but some of us see it differently. As a teacher, you have to understand that there's a mindset that you're supposed to have here at Weaver about learning. There's a mindset that we have about how we are going to teach our kids, how are we going to treat discipline and how are we going to promote learning. And when we Weaver-ize someone, it's really supposed to be like supporting our new teachers. It's truly someone's process for making sure that we share the same vision for our teaching and learning.

Elliot "hated" the idea of being Weaver-ized because it implied that everyone at Weaver Elementary School should think and teach similarly—e.g., use carbon-copy approaches for teaching literacy, exercise standardized behavior management systems, and maintain traditional systems for teaching, learning, and assessment. However, Elliot and Holly, both beginning teachers (having 3 or fewer years of experience), described leveraging this "common vision" to support their classroom practices. For as long as anyone could remember, Weaver Elementary School fluctuated between being a "C" and

“D” school, according to the state’s school report cards and achievement data. Each year that Weaver Elementary did not show proficiency and growth with its student achievement data, as measured by state-mandated end-of-year assessments, administrators increased strict adherence to data-driven instruction, with standardized instructional practices and strategies. In response, Elliot and Holly capitalized on the language of the Weaver Way to support their own interpretation and advocate for changes in classroom practices.

“If you’re going to say ‘every student, every day,’ I’m going to interpret that as ‘do what you need to do to reach every student, every day’” (Elliot, Interview, 2/11/19). Elliot, Holly, and the six additional teachers in this study from Weaver Elementary (all of whom have taught for 7 years or less) leveraged the Weaver Way to support their visions of science and engineering instruction. Instead of falling in lockstep with the “traditional” way of doing things, they re-interpreted the Weaver Way to support their integration of science and engineering into literacy and mathematics instruction, to justify changes to their schedules and curricula, and to aid in pushing back against a vision of teaching and learning with which they did not always agree.

The reinterpretation and leveraging of the Weaver Way created a source of tension between teachers at Weaver Elementary School and the administration. Compounding this tension was the fact that teaching at Weaver Elementary was competitive and an individual endeavor. Driven by accountability and achievement pressures, teachers guarded their success, creating an impression of noncooperation and disunion. A divide between teachers and grade levels widened, driven by state bonuses for testing achievement by individual teachers and advanced by members of the administration who held individual conferences focused on how to raise *their students'* test scores. While the Weaver Way may have influenced how teachers taught *their students* in *their classrooms*, there was little sense of collaboration, sharing, or trust among many teammates. These tensions affected the teachers at Weaver Elementary School, coloring how they felt able to enact science and engineering.

Narrative #1: Elliot. "I'm a quiet agitator. That's not right. How do ya'll put it? Either way, I know what needs to be done for my students. You know, sometimes you've just got to do it" (Elliot, Interview, 6/12/19). When I told Elliot that I wanted to talk about the science and engineering instruction in his class over the past year, he bubbled with excitement, barely able to contain his pride in declaring himself a "quiet agitator" (he was searching for the phrase "tempered radical"). Like almost all teachers in this study, Elliot attended the STEM Program Summer Institute, a three-day professional learning opportunity focused on engineering practices for elementary classrooms. In June, 10 months later, Elliot was eager to share how that had shaped the science and engineering instruction in his classroom this past school year. "I can't wait to tell you about our year," Elliot declared in his email confirming his interview time (Elliot, Personal Correspondence, 5/24/19). Figure 5.3 shows Elliot's STEM journey map or how he narrated the science and engineering in his classroom for that year.

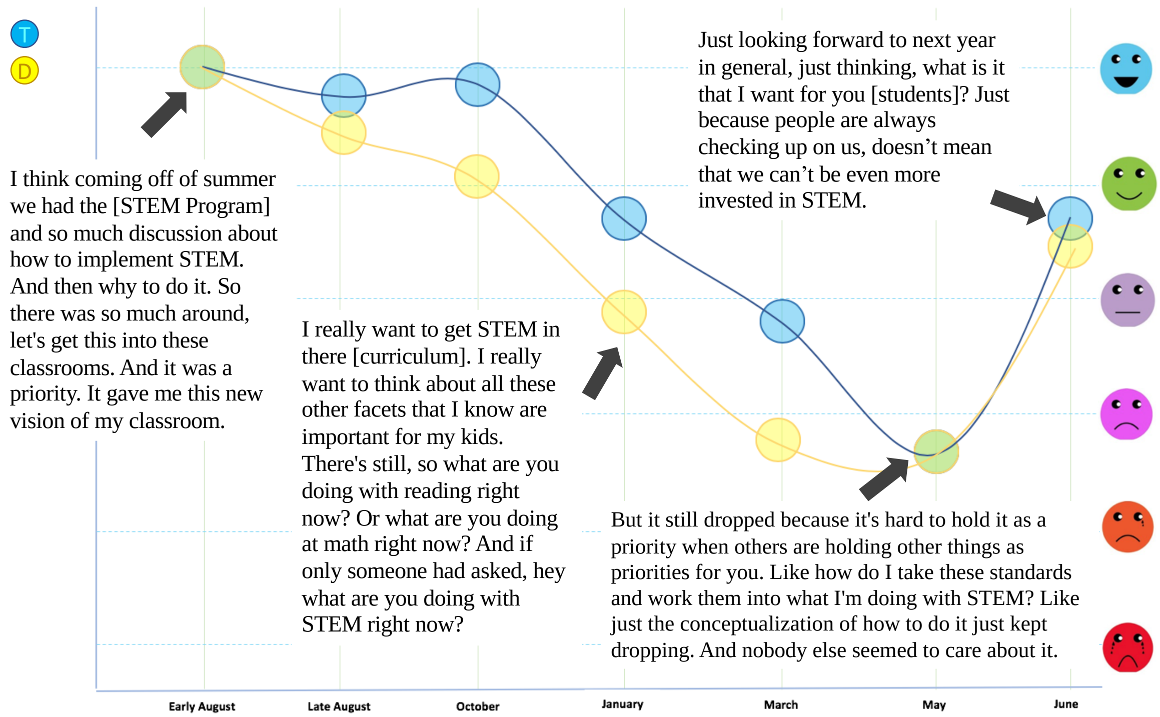


Figure 5.3. Elliot's STEM Journey Map. Select Quotes Demonstrate Moments of High and Low STEM-Linked Professional Agency.

In early August, Elliot began his school year at the STEM Program Summer Institute. He was excited to be involved with the STEM Program, registering for the Summer Institute based on a colleague's recommendation. "You know, I wouldn't have come if it hadn't been for [Susan]. It's like she knew how important this would be for me. She told me I had to come!" (Elliot, Interview, 6/12/19). When reflecting on those moments in early August, Elliot indicated that science and engineering were both highly thinkable and doable for him.

> I think coming off of summer we had the [STEM Program] and so much discussion about how to implement STEM. There was this huge excitement for one doing it. Then two, how to do it. And three why to do it. So there was so much around, let's get this into these classrooms. And it was a priority. It gave me this new vision of my classroom (Elliot, Interview, 6/12/19).

At this point, before he even had students in his classroom, Elliot was feeling optimistic about his science and engineering instruction. That professional learning opportunity had given Elliot a “new vision of [his] classroom,” one of the reasons that Elliot had appraised the thinkability of science and engineering as high. The engagement, excitement, and meaningfulness of the STEM Program Summer Institute had not only given Elliot a new vision of the science and engineering that is possible in his classroom, but also ideas for “how to do it.” “I came back knowing that I wanted to make time for science and getting the kids to understand the nuts and bolts of it. I wanted science everywhere and I saw how to do it” (Elliot, Interview, 6/12/19). Elliot returned to the new school year planning to make science an intentional part of his instruction, looking for ways to integrate science and engineering into his schedule, and making this kind of instruction highly doable at the beginning of the school year.

Elliot indicated that by October his STEM-linked professional agency had dipped slightly. He described how he began to feel a disconnect between colleagues’ value of science versus their priorities for other content areas such as reading and mathematics.

> And even though that energy is still high from saying, I really want to get STEM in there [the curriculum]. I really want to think about all these other facets that I know are important for my kids. There’s still, so what are you doing with reading right now? Or what are you doing in math right now? And if only someone had asked, hey what are you doing with STEM right now? (Elliot, Interview, 6/12/19)

Elliot expressed that his “energy [was] still high” and that he “really want[ed] to get STEM in there” (Elliot, Interview, 6/12/19). Science and engineering’s thinkability remained high because Elliot remained motivated to integrate science and engineering into his pedagogical practices. Elliot observed that someone was always surveilling tested subject areas, but the same oversight never occurred with his science instruction, leaving him with the impression that science did not hold equal importance as other content areas, leading to the perception that teaching classroom science was now more difficult.

When I asked Elliot what made science and engineering thinkable in his classroom, he replied with an explanation that was linked to his professional vision.

> Knowing how it bridges between more than just science. I mean knowing that STEM goes so far beyond a science standard. It goes into how do kids succeed in reading? How do they use math to be successful? How do they think beyond what is success? Just the way it challenges and changes their brains is what gets me excited for them personally. It's why I teach science and why I push to get it in there. (Elliot, Interview, 6/12/19)

Elliot's professional vision for science and engineering instruction drove and influenced how and what he taught and to what degree he would push back against leadership and school norms to execute and achieve his vision.

> So I mean I tried, I did. I had done so much up until now [May]. We had done science during recess, I had told [Administrator] that I really just couldn't do test prep every day all day and that I was going to do my thing. It's just part of what I see for these kids. (Elliot, Interview, 6/12/19)

As Elliot reflected on his instruction going into May and looked at his placement of dots on the STEM journey map, he drew a huge breath and said, "Wow. I'm actually really ashamed of what this says about me as a teacher right here" (Elliot, Interview, 6/12/19). I assured Elliot that this was not an uncommon trajectory and that many teachers struggled to maintain science and engineering in their classrooms. He described his STEM-linked professional agency for science and engineering instruction to be at its lowest in May.

> But then, it's just . . . there's a name for it, I can't think of what it is, but the long haul to testing. And once you even get in the mindset of testing, and it's ridiculous because right here [March], right before testing, right before spring break, the kids still had a fervent passion for science. And like, oh, when are we going to look back at this? When are we going to do some more with this? And they still have that passion. But even they click, once we get in testing mode.
>
> But it still dropped because it's hard to hold it as a priority when others are holding other things as priorities for you. Like how do I take these standards and work them into what I'm doing with STEM? Like just the conceptualization of how to do it just kept dropping. And nobody else seemed to care about it, so it was just so hard to keep pushing when there's this climate of other priorities. (Elliot, Interview, 6/12/19)

Elliot felt as if he were fighting a losing battle. Constant accountability pressures, a narrowed curriculum, and pressure to ascribe to certain pedagogical practices (e.g., a gradual release model, data-driven interventions as forms of instruction), combined with the impression that he held priorities that his colleagues did not share, led Elliot to feel as if the path forward with science and engineering was difficult and muddled. Elliot narrated that at this point [May], the instruction that he had envisioned since STEM Program Summer Institute as a key part of his classroom culture and pedagogy seemed far from thinkable or doable.

> It's an entire culture and it's kind of sad that everybody shifts to those priorities. And not even a way that's almost an academic love for it. It's what do I need to pass? It's what do I need for the test? I wish this almost could have been opposite right here [May]. It was weird how they kind of closed together because this was settling for it rather than working for it.

Elliot continued to narrate how colleagues' priorities shifted to a focus on high-stakes testing and tested academic subjects. He was disappointed in himself at this point [May] in the reflection because he realized that he succumbed to accountability pressures and "settl[ed] for it rather than working for it," implying that he continued to hold a vision of what could be, but concluded that the constraints on his ideal instructional and pedagogical practices were too great.

Everything was not all doom and gloom for Elliot. Elliot indicated [in June] that he, again, considered himself to have a stronger sense of STEM-linked professional agency. Projecting forward through to the summer and into the next year, Elliot used his strong professional vision to determine actionable steps to make STEM doable in his classroom at the beginning of the upcoming school year.

> Just looking forward to next year in general, just thinking, what is it that I want for you? What do you want for yourselves? How are you going to grow as future citizens? And understanding that it's still high priority for them [students]. Knowing that it's honestly a high priority for me. I really want them to be invested in science, technology, engineering, math. I want them to have the same passion for it that other people have for their test scores. I don't want us to be brought down by other people's demands and priorities. Just because people are always checking up on us, doesn't mean that we can't be even more invested in STEM. (Elliot, Interview, 6/12/19)

Elliot wielded his professional vision, his prioritization, and investment in science and engineering to think through how he might enact his vision of instruction. "You know, if I could, I would do it differently. Next year I'm starting with the integration. I want science to be central to their learning and just an indisputable part of my teaching" (Elliot, Interview, 6/12/19). Despite the disconnect in prioritization and constant surveillance that came with teaching in a "tested grade," Elliot felt as if he could make science and engineering not only thinkable, but doable in his classroom.

Narrative #2: Holly. Holly was the youngest teacher in the study and, as a first-year teacher, had been teaching for 9 months at the time of our first interview. "It's everything I could do to feel like I was making a difference this year. I'm not sure that I was really prepared for the reality of teaching in my own classroom" (Holly, Interview, 6/12/19). Holly described having a year of ups and downs—not just regarding her science instruction. As a beginning teacher, Holly found herself grappling with establishing her ideal classroom culture, understanding the norms of high-stakes testing and what these accountability pressures meant for her classroom practices, and figuring out how to advocate for herself and find support outside of her third-grade team. Unsurprisingly, Holly's STEM journey map oscillated between the highs and lows of thinkability and doability (see Figure 5.4).

Unlike Elliot, Holly had not spent part of her summer at the STEM Program Summer Institute. Instead, Holly devoted the early weeks of August to scavenging the city in search of resources for her new classroom. "I felt like a hoarder," Holly recalled with a chuckle. "If it was free and I thought I could use it in my classroom, I just grabbed it and saved it" (Holly, Interview, 6/12/19). However, it was this excitement and optimism that allowed Holly to hold science as highly thinkable in her classroom, even before her students stepped through the door.

> I feel like also in early August I was just coming from a cohort of people who were all so equally passionate. It was like, well at [University] if you want to do science then let's go to the makerspace and think about this, let's go to the

> [School of Education Resource Center] and put this and that together. We could just do all kinds of stuff. Even before knowing what my students would be like, I could already picture the science that we could do in our class. (Holly, Interview, 6/12/19)

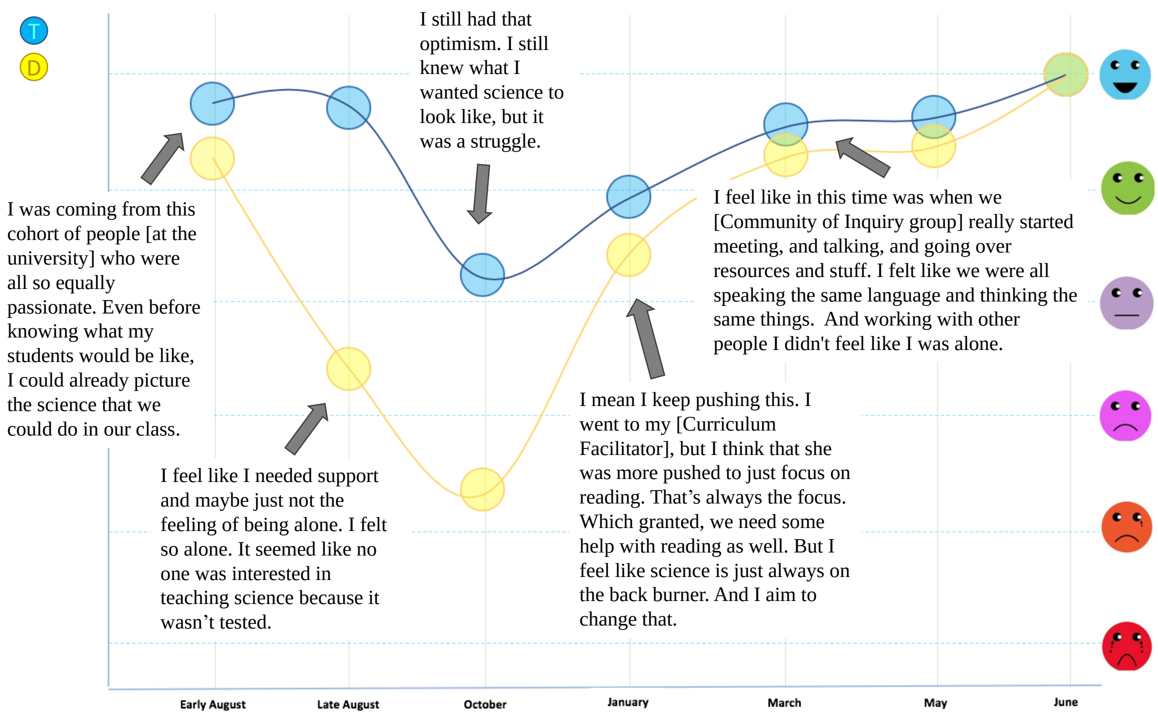


Figure 5.4. Holly's STEM Journey Map. Select Quotes Demonstrate Moments of High and Low STEM-Linked Professional Agency.

Holly had a vivid vision for science in her new classroom, supported by her university experiences as a pre-service teacher. This vision, combined with the support she garnered from fellow beginning teachers and the resources that she collected over the summer, also gave Holly the impression that science would be thinkable and doable with her students.

However, as the school year progressed into late August, Holly found herself struggling to feel like science was doable in her classroom. "I still had that optimism. I still knew what I wanted science to look like, but it was a struggle" (Holly, Interview, 6/12/19). While Holly continued to hold on to her vision of science in her classroom, her perceptions of science's doability dropped significantly in October.

> I just didn't know which way was up. I don't know, I didn't feel like I had a whole lot of experience with it [teaching science] either. So the lack of experience along with others who were like, "Ah. It's not tested in third grade, you're fine." I'm like, "Please . . . There's got to be something better." (Holly, Interview, 6/12/19)

Holly explained that her lack of experience teaching third-grade science, coupled with the lack of support she received from teammates, contributed to her perceptions of science as less than doable. I asked Holly what would have made a difference at that point in the school year. "I feel like support and maybe just not the feeling of being alone. I felt so alone. It seemed like no one was interested in teaching science because it wasn't tested" (Holly, Interview, 6/12/19).

Indicating a time between October and January, and later acknowledging that this was just before Thanksgiving, Holly again brought up the notion of "being alone" and lacking experience,

> I feel like pretty much always my thinkability for science has always been sort of high. It kind of got lower down there between the October and January area just because I was like, nobody else is doing this. You know what I'm saying? It's just so hard to keep trying to do something that you know is right when you're alone in that struggle. I was beginning to second guess myself, and I definitely didn't feel like I had any support to make it happen.
>
> And at this point most of my team was like, "Okay. Let's start that Red Book." And I'm like, "But we still have so many science standards left." And their response was, like, it didn't matter. I get that they have the experience with teaching third grade and they thought they knew how to get the results that people are looking for, but how can you do that to kids? How can you just decide for kids

> that a review book is better for them than actual learning? (Holly, Interview, 6/12/19)

The "Red Book" to which Holly referred was a booklet of reading passages and multiple-choice questions meant as a supplemental review for end-of-grade standardized tests. Already in the second quarter of third-grade, Holly's teammates suggested beginning preparations for high-stakes testing. Holly felt alone in her mission to teach science and address the state science standards with her third-graders. She also second-guessed her vision and motivation for science instruction altogether. Holly noted that her teammates, all with vastly more experience than she, "knew how to get the results that people [were] looking for." Holly felt unable to enact the science she envisioned for her classroom due in part to professional loneliness and lack of support. Holly also believed that her teammates' experience equated to enhanced professional judgment and sometimes second-guessed her professional vision for science in her classroom.

> I think sometimes you just kind of second-guess yourself. But you have to remind yourself that you're doing this not just for you but for all your students. There's a future scientist out there that doesn't even know they love science yet because they're never done it. I need to make sure they get that chance. (Holly, Interview, 6/12/19)

Holly was resilient and sought support and remedies to professional loneliness outside of her grade level team. Her deep-seated belief in her students and their need for science in their personal and educational lives continued to drive her professional vision and bolster the thinkability of science in her classroom.

> But I feel like it's [teaching science] really necessary because you also have to think that in this group of kids, there's some kids in here who are going to be scientists. My parents used to say, "Well, I didn't need algebra because I worked in construction, so I really needed geometry. So that's what I focused on, that's what I was great at." And I'm like, "Oh. Okay." But also you can't say, "Well we're focusing on reading because we want readers." And yes, we want readers, but also there's those kids who are going to figure out what they love based on what they do in the classroom. And if it's not there, if the science's not there, then how will they know if that's what they need? If that's their element, if science and STEM is their element, then how else are they going to enjoy school if they're not even exposed to it? (Holly, Interview, 6/12/19)

> But it's sad, I think. I mean I keep pushing this. I went to my CF [Curriculum Facilitator], but I think that she [CF] was more pushed to just focus on reading. That's always the focus. Which granted, we need some help with reading as well. But I feel like science is just always was on the back burner. And I aim to change that. (Holly, Interview, 6/12/19)

Holly talked about how she tried to garner the support of her third-grade teammates. She went to the curricular leadership and administration for support in navigating the tensions between her envisioned science instruction and the demands she felt were imposed on her by the testing culture of her school. In March, Holly noted that while she felt that her thinkability had risen, the doability of science had also dramatically increased—levels that she would continue to narrate through the end of the school year.

In March, Susan, a fourth-grade teacher and a Teacher Leader through the STEM Program, noticed Holly's struggles and suggested that Holly connect with the STEM Program. Holly, who had never been affiliated with the STEM Program until this point in time, joined an ongoing professional learning community called Communities of Inquiry (COI) (explained in Chapter III). I was the organizer and facilitator of this professional learning community of four, third-grade teachers from multiple schools across the school district focused on collaboratively planning science experiences and participating in reflective inquiry into teachers' practice. This is how Holly and I first met. She joined the third-grade COI group reserved and with the impression that she "would be like the broken leg of the group" (Holly, Interview, 6/12/19). Holly went on to explain that she was still sure that as a beginning teacher, she would have less expertise to offer and might hold the group back. In fact, the opposite was true, and over a short amount of time, Holly's participation in the third-grade COI made a lasting impact on how thinkable and doable science was in her classroom.

> I feel like in this time was when we really started meeting, and talking, and going over resources and stuff. Talking about how we're going to go to marine life in reading and how can we support that with science, like how can we do that? I felt like we were all speaking the same language and thinking the same things. And working with other people I didn't feel like I was alone.
>
> But I feel like with our thing [COI], I came back to my classroom and I really thought I could do more. And then my doability went up a little bit higher, probably to still like here, because I believed it and felt like I finally had the support to make it happen. And then [March], it just stayed there. I mean, I don't think I really understood how my school and testing and the curriculum and my team weighed me down. And then here [May] it didn't matter that I was just starting as a teacher, I found my people and I found that thing that reminded me that I could do it. (Holly, Interview, 6/12/19)

Pine View Elementary School: Alina and Elle. Alina and Elle were both teachers at Pine View Elementary school, teaching second and fourth grade, respectively. Pine View Elementary School was a traditional public school in a small, manufacturing town on the outskirts of the county and school district lines. Pine View Elementary School had 484 students; there were 22 students in Alina's second-grade class and 32 students in Elle's fourth-grade classroom. A high-needs school with a diverse student body, 99% of Pine View's students qualified for free and reduced lunch, 92% of the students were students of color, and 51% of the students were English language learners. In fact, it was not unusual for 12+ languages and dialects to be spoken in Elle and Alina's classrooms.

At one time, Pine View Elementary School was one of the lowest-performing schools in the state, leading to its distinction as a "turnaround school." As a turnaround school, Pine View hired entirely new staff and began the implementation of new curricula and instructional practices. This was when Alina joined the staff at Pine View Elementary School 10 years ago; she was chosen specifically through an intensive interview process to help turn the school around. "Since that day, it's been like a parade of different things to try in the classroom. Each year we're given a different way to teach, and then it's data, data, data" (Alina, Interview, 12/5/18). It was not uncommon for teachers at Pine View Elementary School to describe a constant barrage of new programs and curricula, initiated and mandated by both the school and the district. Plus, Pine View prided itself on being "data-driven" to the extent that a sign hung in the administrative offices, declaring, "In God we trust, everyone else bring data!" Assessment data, both formative and summative, was often the focus of staff meetings, grade-level meetings, PLCs, and teacher-administrator conferences.

> It's constant. It's like we only consider students to be numbers and data points instead of actual children. And it's constant. It's always, what are you doing? You're not moving them fast enough. I feel like we're only supposed to care about their data because that's what the people who are always checking are looking for. They're making sure that you are moving kids quickly. There's a big sense of urgency, like move the kids faster, faster, faster, but there's so much more to teaching children than that. (Elle, Interview, 12/5/18)

Since becoming a turnaround school, Pine View Elementary School's achievement on state-mandated, end-of-year tests in third- through fifth-grade had risen steadily. Pine View met expected growth most years but had never risen above 35% proficiency in English language arts and 44% in mathematics—well below state-wide proficiency averages.

All schools are socially dynamic, usually with inner and outer circles of influence and privilege. Concentrations of power reside among certain groups of teachers and not others—e.g., leadership opportunities, recognition of expertise, and allocation of material and cultural resources. Pine View Elementary School was no different. These social dynamics and power discourses colored both Elle's and Alina's narratives, but Alina's to a greater extent. At Pine View Elementary School, teachers who were outside of the "inner circle" spoke to me about feeling marginalized. Neither Alina nor Elle considered themselves to be part of the "inner circle" at Pine View Elementary School, but this marginalization weighed heavier on Alina than Elle, as Alina had experienced it for the entirety of her 10 years at Pine View, whereas it was only Elle's second year. These dynamics, mixed with the data-driven accountability pressures at Pine View Elementary School, factored into the tensions and dilemmas Alina and Elle experienced as they worked to teach science and engineering.

Narrative #3: Alina. Even as an experienced teacher with a tenure of more than 20 years, Alina narrated a rise and fall of her STEM-linked professional agency. Alina's STEM journey map and narrative stood out because she held fast to how she authored herself as a continual learner with a mostly positive mindset and professional vision for science education in her classroom. She did not tell her narrative chronologically; instead, she chose to explain how a strong professional vision, high thinkability, and a positive, open mindset were facets of who she was that never really changed, leading Alina to focus on her position within her professional and educational community and its relation to her STEM-linked professional agency.

As I turned to enter Alina's classroom, Sadie, her teammate across the hallway, stopped me and said, "Oh my God, Alison, good luck getting in there, it looks like a demolition zone!" (Field Notes, 8/23/19). In fact, "demolition zone" was the perfect way to describe the state of Alina's second-grade classroom. That's because Alina and her students were completing an engineering unit focused on materials engineering, which culminated in the demolition of student-constructed walls, with rocks and flakes of mortar strewn across the floors.

As we sat down to begin our interview, Alina said, "I just don't know how good I'll be at the interview. I don't really do anything like I'm supposed to" (Alina, Interview, 8/23/19). The idea that she was always going against the grain and not doing "anything like [she's] supposed to" colored and affected Alina's instruction in the classroom and played into the fluctuation of Alina's STEM-linked professional agency (see Figure 5.5).

Like Elliot, Alina began the year at the STEM Program Summer Institute. That professional learning opportunity helped shape the thinkability of—or realistic aspirations for—science and engineering instruction in her second-grade classroom. Alina explained, "Now I have all these dreams and visions and possibilities that I want to do and I read about. You have possibility because you have that dream" (Alina, Interview, 8/23/19). At the beginning of the school year, Alina described science and engineering as being highly thinkable and doable. In fact, Alina represented science and engineering's thinkability and her vision as being high throughout the school year.

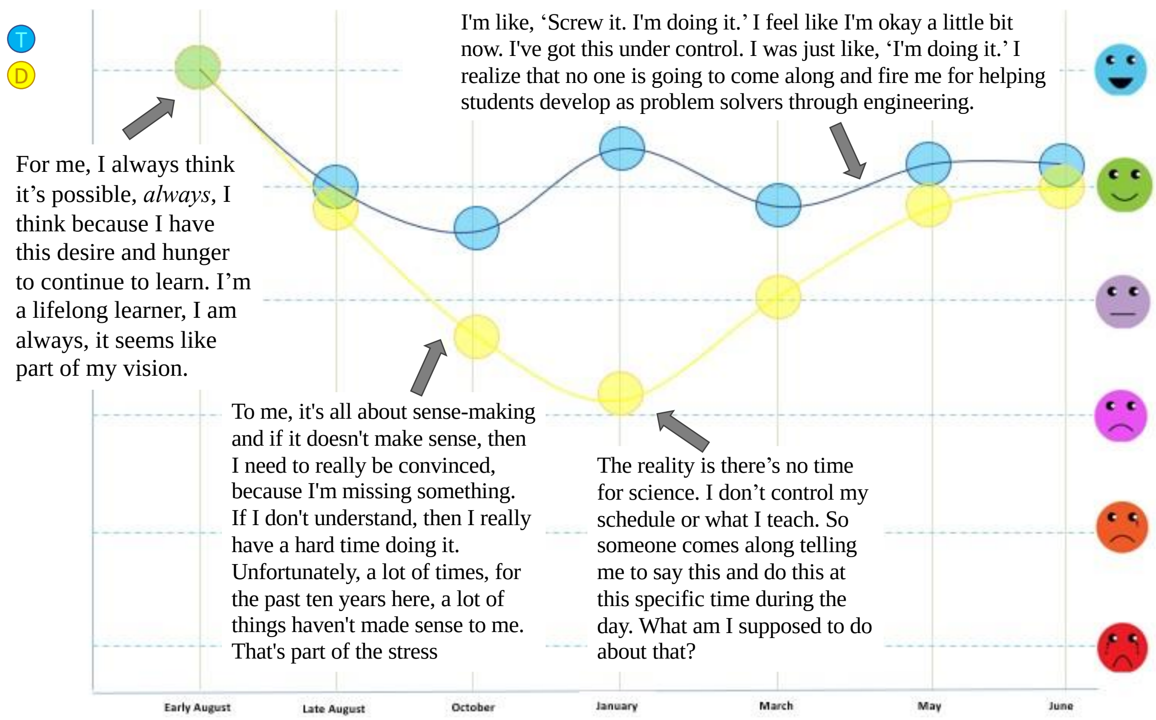


Figure 5.5. Alina's STEM Journey Map. Select Quotes Demonstrate Moments of High and Low STEM-Linked Professional Agency.

Though her STEM-linked professional agency fluctuated throughout the school year, Alina explained that she always held science and engineering as highly thinkable.

> My big picture is no matter what, I still have the high thinkability. I still think my positive thoughts about this. It's a mindset that I hold for myself. If I went back, I might even make this a little bit higher. I just think that is the overlying or overarching thing that really doesn't fluctuate that much.
>
> It's my mentality about the whole idea of science, technology, engineering, and math. I do think it's possible. I feel like it should be possible. I do feel like I can remain excited and enthusiastic and I'm still eager and hungry to learn even more

> ways to teach smarter and get more results with today's kids. That part is really pretty consistent. (Alina, Interview, 8/23/19)

There were times when Alina indicated that her thinkability fluctuated slightly, but she held it in high regard, describing it as her "mentality" and "mindset." Alina went on to explain that this was tied to her professional vision. "I have this dream of a classroom where everyone is learning, and everyone is doing their own thing and everyone is engaged. That's how we reach today's kids. We can do that with STEM" (Alina, Interview, 8/23/19). Alina's vision of what could be possible in her classroom drove her to envision science and engineering to be thinkable, maintain that throughout the year, and support her STEM-linked professional agency.

In contrast to thinkability, the doability of science and engineering fluctuated greatly throughout the year. Alina taught second-grade, a grade level that, while not expected to complete end-of-year standardized tests, was still directly impacted by accountability pressures. "You know we have two, new scripted curriculums this year, right?" Alina interjected while narrating her previous school year. "I mean, we don't even take those tests and they're telling us how to teach to get kids ready for next year" (Alina, Interview, 8/23/19). Alina indicated that a few months into the school year her STEM-linked professional agency declined.

> To me, it's all about sense-making and if it doesn't make sense, then I need to really be convinced, because I'm missing something. If I don't understand, then I really have a hard time doing it. Unfortunately, a lot of times, here [pointing at the PSSR], a lot of things haven't made sense to me. That's part of the stress. I'm being told what to do and I don't understand why we're doing it. (Alina, Interview, 8/23/19)

Alina valued understanding and connection; it was important for Alina to understand how parts of the curriculum fit together and its intended purpose, in part, so that she would be able to integrate science into other parts of her instructional day. However, at this point in the school year [October], Alina remembered feeling stressed. She did not have a clear understanding of these scripted curricula's purpose or science and engineering's place within them. Alina had lost autonomy in her classroom, which frustrated her and caused her to feel that science and engineering were less doable.

The yellow doability dots on Alina's STEM journey map continued a downward arc as the next few months progressed. Alina held on to her professional vision and "enthusiastic mindset" for her aspirations for science and engineering, but recognized it as less doable.

> . . . that's whenever the reality hits you in your face with the constraints of your curriculum, your schedule, your time, your students, whatever it is, testing. It's all these things that you feel like are already set in place that limit and prohibit you from having flexibility to do things that you would want to do, those instructional decisions. And I feel like I have less say or control over those instructional choices, that's why called them decisions rather than suggestions or expectations. (Alina, Interview, 8/23/19)

Alina alluded to the ways constraints placed upon her limited her professional judgment, decision-making power, and autonomy. This, in turn, kept Alina from feeling able to integrate science or engineering into her curriculum.

> The reality is there's no time for science. I don't control my schedule or what I teach. So someone comes along telling me to say this and do this at this specific time during the day. What am I supposed to do about that? I want my students to have a creative outlet, I want them to be immersed in problem-solving. But it

> doesn't seem to matter what I want, because in reality it's what the people randomly walking through my room expect to see (Alina, Interview, 8/23/19).

At this point during the school year [January], Alina's perceptions of the doability of science and engineering in her second-grade classroom had reached its lowest point. Alina felt like the constraints of curriculum, time, accountability, and surveillance prevented her from enacting the instructional practices and science content that she envisioned. The scripted mathematics and reading programs mandated by the school district left no "official" time for science in Alina's schedule.

Alina chronicled constant "walk-throughs" by administrators, leadership, outside instructional coaches, and district supervisors. "There's always someone coming in to observe, to watch me teach. Actually, it would be different if they were here to watch me teach. They're just interested in whether or not I'm following the program" (Alina, Interview, 8/23/19).

Toward the end of the school year, Alina perceived science *and* engineering to be more doable in her classroom; she narrated her STEM-linked professional agency to be stronger. She was able to make changes to the instructional life of her classroom and integrate an engineering unit (the same unit that turned her classroom into a "demolition zone") into the district-wide reading program.

> Then I got to this point in the year [April]. I'm like, "Screw it. I'm doing it." I feel like I'm okay a little bit now. I've got this under control. The coaches and everybody are not breathing down our neck. I've got this wonderful resource here, the Great Wall thing or yeah, Building Walls, which I was able to integrate with one of our units. I did want to align it and it was all happening at the same time. We were still able to make those connections. I was just like, "I'm doing it." I realize that no one's going to come along and fire me for helping students to

> develop as problem solvers through engineering. When you let that go, you feel like you do have more freedom and more flexibility to do things. (Alina, Interview, 8/23/19)

Alina's changing perceptions of her "coaches and everybody," the reduced oversight and surveillance, and her own sheer strong will and determination played into the integration of an engineering unit into the scripted reading program and the increase in STEM-linked professional agency.

The thinkability of science and engineering instruction in Alina's class varied less than her perceptions of how doable that instruction was in her classroom. Alina believed that her thinkability remained high throughout the year because she had a strong professional vision and felt it was part of who she was as a teacher.

> For me, I always think it's possible, *always*, I think because I have this desire and hunger to continue to learn. I'm a lifelong learner, I am always, it seems like part of my vision. I guess maybe this goes along with what you say about people who push back. I'm not going to. I'm not a lamb, though. I'm not a sheep. As [University Faculty] would say, I'm a tempered radical. (Alina, Interview, 8/23/19)

Unassociated with any period during her previous school year, Alina also spoke in more general terms about the possible effects on the doability of science and engineering in her classroom.

> I think this doability is also affected by someone else's perception or vision for you as an individual. I don't, for some reason, feel like I've ever been viewed as a teacher leader [at this school]. Therefore, the opportunities have not been afforded to me, unless I have gone to seek them out, which goes with my high levels of thinkability. If I want it, I've got to go after it and I've got to make it happen, because I don't see someone else pouring into me and investing in me. (Alina, Interview, 8/23/19)

Alina spoke to me about feeling marginalized and not part of the “inner circle” at Pine View Elementary School. This was a constant tension for Alina and factor influencing the doability of science and engineering in her classroom. Alina explained that since she rarely felt recognized for the work she did in her classroom and in service of her students, it impacted whether or not she felt confident in taking actionable steps to move her instruction towards her professional vision.

> I have all these dreams and visions and possibilities that I want to do, that I read about, but I’m like, “How do I make this happen?” You have possibility because you have that dream, but then it would be more doable if I knew that others expected that of me and supported me in that dream. (Alina, Interview, 8/23/19)

Narrative #4: Elle. Elle always worked to meet the needs of all of her students at Pine View Elementary School. Elle was an African American female with 8 years of teaching experience in third-grade, fourth-grade, and Exceptional Children classrooms (Special Education). Elle spoke about why she taught science and engineering to her fourth-grade students. “For some of these kids, it’s the only feeling of success they have all day. There are kids who struggle everywhere else, and for them, science is the one place they can shine” (Elle, Interview, 6/27/19). Elle’s students were part of her professional vision for science and engineering instruction and served as a catalyst and motivation when she exercised her STEM-linked professional agency, despite numerous constraints and roadblocks. Figure 5.6 shows Elle’s STEM journey map and the statements she made as she enacted her science-linked professional agency.

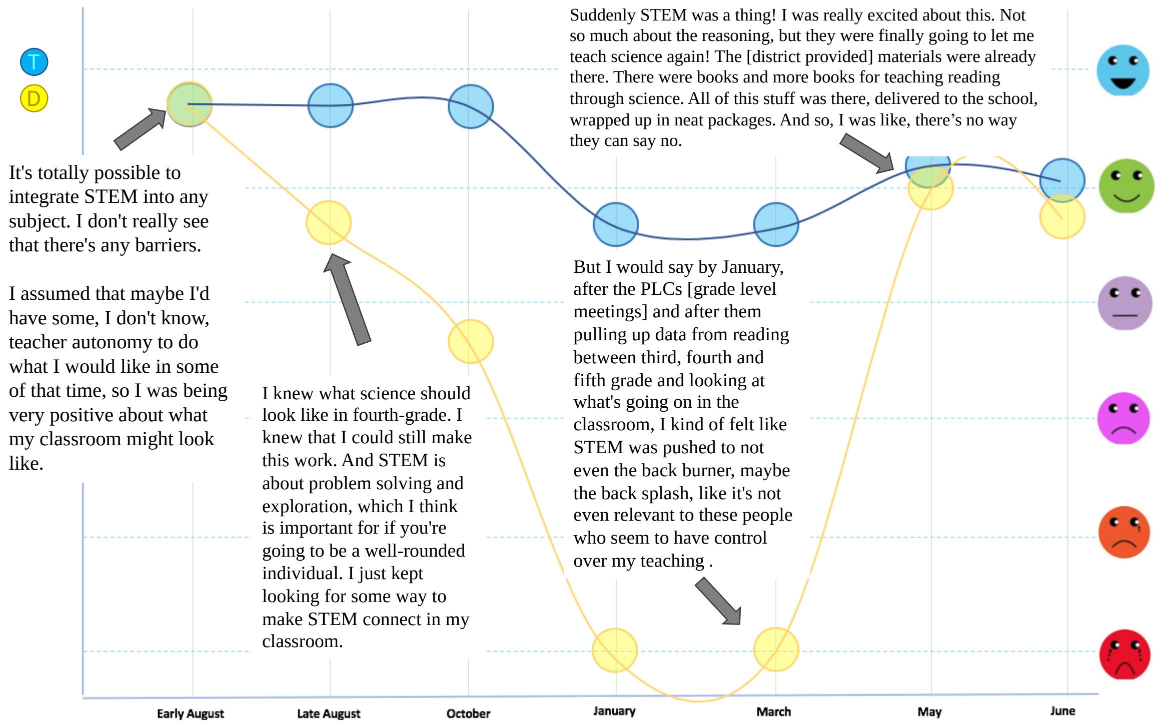


Figure 5.6. Elle's STEM Journey Map. Select Quotes Demonstrate Moments of High and Low STEM-Linked Professional Agency.

When I sat down to interview Elle there was a bird in her room. "What is that noise?" I asked.

> You know, at first I thought one of the kids set an alarm on an iPad. But that's not it. I'm pretty sure it's a bird. It's behind that shelf. So like, we'll be in the middle of small groups or something and it just starts chirping. Leo [fourth-grade student] likes to say that he's learned a lot by now, just hanging around our classroom. Leo says that he's probably learned muy bueno reading, you know Leo. I mean, hopefully he's learned a little science too. Anyway, he just keeps chirping away. (Elle, Interview, 4/27/19)

Although it seemed highly unlikely that a bird had lived behind her bookshelf for the last 3 weeks or so, I chuckled and continued with our interview. But, as Elle and I continued our conversation, something she said kept repeating in my head. "I mean, hopefully [the bird's] learned a little science too" (Elle, Interview, 4/27/19). The first year Elle taught at Pine View Elementary School, she was considered the "fourth-grade science teacher," teaching primarily science, while integrating *some* fourth-grade social studies content into her instruction. This year, however, Elle was told that she would not "be allowed" to teach science as she had done in the past. Instead, she was expected to teach three classes of small group reading interventions for the district's mandated literacy program. The administration felt that struggling students needed extra support in English language arts (ELA).

Despite that, Elle began the year optimistic about her instruction, even though she would not "be allowed" to teach science and engineering. Elle's STEM-linked professional agency was high in August.

> I think it's totally possible to integrate STEM into any subject. That's what makes it doable. I don't really see that there's any barriers. And so I assumed that since they [administration] had kind of created a role of just teaching small group reading, that maybe I'd have some teacher autonomy to do what I would like in some of that time. So I was being very positive about what my classroom might look like as far as still integrating some science, especially since I taught the science the year before. (Elle, Interview, 4/27/19)

The STEM Program Summer Institute also contributed to Elle's high STEM-linked professional agency at the beginning of the year before her students returned to school.

> It [Summer Institute] helped me see that STEM has a lot of critical thinking skills, which I think is important for if you're going to be a well-rounded individual. I know my job is to teach reading this year, but that also involves some critical thinking, and the engineering kits that we learned about and used also involved some reading, so in my mind, this was still totally doable. I can do this.

> And I feel like it [science instruction] worked well the year before. And then add to it this summer with STEM, so I just assumed that now that I have all these great toolkits and this great vision that also incorporates literacy, and well, here's an avenue for me to get STEM back into my classroom even though I'm not a science teacher anymore. (Elle, Interview, 4/27/19)

Knowing about Elle's sudden transition in the structure of her instruction was one of the reasons why her comment about the bird learning science stuck in my mind. This year, the integration and enactment of science and engineering in her fourth-grade classes had been next to impossible.

> I just assumed that I'd be able to teach reading through science. But with this reading program and all the coaches constantly coming in to check and see what the kids are doing, it's like impossible to do. It's really been an uphill battle, almost an impossible one this year. (Elle, Interview, 6/24/19)

Over and over, Elle heard the message that she could and should not teach science throughout the school year. Despite this, Elle's STEM journey map indicated that there were points throughout the year when her STEM-linked professional agency remained high.

Elle maintained a strong, robust professional vision for science and engineering instruction. In previous interviews, she stated that she believed science to be "more than just experiments and science fair projects" (Elle, Interview, 12/5/18) and to be more about skills and competencies that help students creatively think through and solve problems. Elle was bound and determined to make her instructional practices match her professional vision; she continued to push back against the idea that she "was not allowed" to teach science to her fourth-grade students.

> I knew what science should look like in fourth-grade. I knew that I could still make this work. And STEM is about problem solving and exploration, which I think is important for if you're going to be a well-rounded individual. I just kept looking for some way to make STEM connect in my classroom. I suggested that I run a STEM club or a science elective or coordinate a group of students from one of the universities. In my mind, this was still doable. There had to be a way around this, I just had to figure out what it was that would be acceptable to them [administration]. (Elle, Interview, 6/24/19)

Despite repeatedly being told that she could not integrate science into her classroom interventions or integrate science and engineering into other parts of her students' days, Elle continually tried to do so. As Elle narrated moments of STEM-linked professional agency, she always brought the topic of conversation back to the students and the instruction and experiences they deserved.

> And if we are concerned about the children as a whole, then this doesn't just need to be for fourth-grade, and not just in my room. This is something that perhaps everybody can do, it doesn't necessarily have to be Ms. [Last Name] is taking away time every single day in reading class. But if that's the only place they're going to get science, then it's going to be with me. It's where I can help the child who doesn't like school at least like science. I can find a way to teach science so that the kid who struggles in reading has something, something they're successful with. Science has that power, you know? (Elle, Interview, 6/24/19)

Often discouraged by people and programs at her school, Elle tried to remain positive. Her love for her students and science was evident in the way she spoke with pride about the steps she took to try to integrate science and engineering into her curriculum. "There really shouldn't be any barriers between my students and science, but there are. There are barriers, and their first name is administrative, and their last name is team" (Elle, Interview, 12/4/19).

Elle felt that the administrative and curricular lead team—teams consisting of the principal, assistant principal, curriculum facilitator, instructional coach, and a literacy coach from outside the school—restricted her STEM-linked professional agency and her ability to support the learning of all her students through science and engineering.

> I know I'm kind of a rebel. I guess I'm open-minded and flexible in my thinking about the way I structure my classroom, so I don't really see that it will be hard for me to integrate science so students benefit from it. The integration of subject material, you know, sneaking the science into reading, meets the needs of all my learners. And that keeps the thinkability high. Like, I can figure it out, I can get it in here somewhere. But I would say by January, after the PLCs and after them pulling up data from reading between third, fourth, and fifth grade and looking at what's going on in the classroom and then *them* [her emphasis] trying to readjust things, I kind of felt like STEM was pushed to not even the back burner, maybe the backsplash, like it's not even relevant to these people who seem to have control over my teaching. (Elle, Interview, 6/24/19)

Between October and March, Elle's perceptions of doability were drastically different from her thinkability and professional vision for science and engineering. "I could see what was possible, but you can only be told no so many times before you're kind of like, yeah, this is just not happening" (Elle, Interview, 6/24/19). The pressure to prepare students for achievement on their end-of-grade and to conform to certain instructional practices gave Elle "no wiggle room when it came to teaching what's really important—science" (Elle, Interview, 6/24/19).

Surprisingly, at the end of the school year, in May and June, Elle found science and engineering to be doable again in her classroom. While her professional vision and thinkability had remained high throughout the year, Elle suddenly found herself believing that science instruction would be possible in her classroom. "Suddenly, STEM was a thing! I was really excited about this. Not so much about the reasoning, but they were finally going to let me teach science again!" (Elle, Interview, 6/24/19). At the beginning of May, Pine View Elementary School was in "test mode"; instruction was delayed for a month of test preparation work. Unlike some of her colleagues, Elle was excited about this prospect; the district had just delivered four science kits to be used with students to aid them in preparing for their English language arts, end-of-grade test.

> We were going to be using these kits for test prep and remediation for the [State Test] and I was selected as one of those teachers to remediate students for the test. Everybody else was dreading this, but I was so excited. The materials were already there. There were books, too, for teaching science. I had all of my stuff that I bought last year with my grants. All of this stuff was there, delivered to the schools, the kits and materials were wrapped up in neat packages. And so, I was like, there's no way they can say no. The district supports this. It's not for the best reasons, but it was science and I was going to be the one teaching it! In my mind, there's was no way this could fail. (Elle, Interview, 6/24/19)

Elle's vision of teaching science through literacy integration did not fail, "but there's a reason that my dots [thinkability and doability] aren't all the way up at the blue smiley face, in the end I could only focus on reading. I squeezed some science in, but not the kits" (Elle, Interview, 6/24/19). In the end, Elle's curricular lead team opted to have Elle prepare the fourth-grade students for their end-of-grade test, not with the district-provided science kits, but with more traditional methods of test preparation—reading passages with multiple-choice questions. Elle "made sure that everything they [students] read was tied back to science" and "backed that up with some engaging science stuff during morning meetings" (Elle, Interview, 6/24/19). Elle brought in short, hands-on science explorations to weave into other non-traditional times in her schedule to meet the needs of her students and give them the education she believed they deserved.

Despite the times when Elle felt mandated programs diminished her professional judgment and constant surveillance constrained her STEM-linked professional agency, she still narrated moments of push back. Elle’s STEM-linked professional agency enabled her to integrate science and engineering into the district-mandated literacy program assisting students in accessing and applying inquiry, creative thinking, and problem-solving strategies.

Mount Pleasant Elementary School: Willa. Willa taught at Mount Pleasant Elementary School, a traditional public school in a rural part of a sprawling school district. A smaller school, Mount Pleasant Elementary School had 337 students, 99% of whom qualified for free or reduced lunch, 59% of whom were students of color, and 10% of whom were English language learners. Historically, Mount Pleasant Elementary School had struggled to meet expected growth on state-mandated, end-of-year assessments and always fell well below the state average in proficiency in English language arts, mathematics, and science assessments.

Mount Pleasant Elementary School had a unique partnership with a local university. A grant-funded partnership worked to incorporate emerging technologies and strategies, such as makerspaces, into schools to help prepare teachers and pre-service teachers to meet the needs of students regardless of learning needs and socioeconomic status. This partnership emphasized support for teachers in high need subject areas such as science, technology, math, engineering, and literacy. Despite the extra support from the university partnership, teachers struggled to balance STEM instruction with program and policy demands associated with teaching at a low-performing school in the school district.

Narrative #5: Willa. Willa described herself as a “unicorn” (Willa, Interview, 1/9/19). She told what it was like for her, a White female with 14 years of experience, to be an innovative teacher who pushed boundaries on a staff composed of mostly veteran, traditional teachers, saying:

> I have those professional conversations with colleagues, but sometimes I want more action. I’m just usually the unicorn of the group. I’m the one who’s just got to do more and be more innovative. It’s like I’m the only one doing it [science and engineering]. (Willa, Interview, 1/9/19)

Willa was the first person in her family to finish high school. “I have personally seen what an education can do for a person, and how it benefits a person” (Willa, Interview, 11/22/19). Willa’s vision and beliefs, centered on the premise of quality education, were a driving force for everything she did in the classroom.

> I have siblings who are not great parents. I look at how their children turned out as opposed to my own. That is, partially, a lack of education. I look at my son and at his cousins and think about what would be different if they [siblings] had had a better education. And when I look at the children in my classroom, or any child that my teaching touches during the day, I know that I want them to have the same affordances and advantages that my son had. That comes from having great educational experiences. (Willa, Interview, 11/22/19)

Willa referenced this often during her interview. “It’s why I do what I do” (Willa, Interview, 11/22/19). Her desire to provide rich educational experiences for every student so that all students could have “affordances and advantages” shaped her vision for science and engineering and her pedagogical practices. This commitment made her a "unicorn," the only teacher pushing boundaries and creatively working the system in the name of science and engineering. Figure 5.7 shows Willa's STEM journey map and the STEM-linked professional agency of a "unicorn" teacher committed to teaching science and engineering.

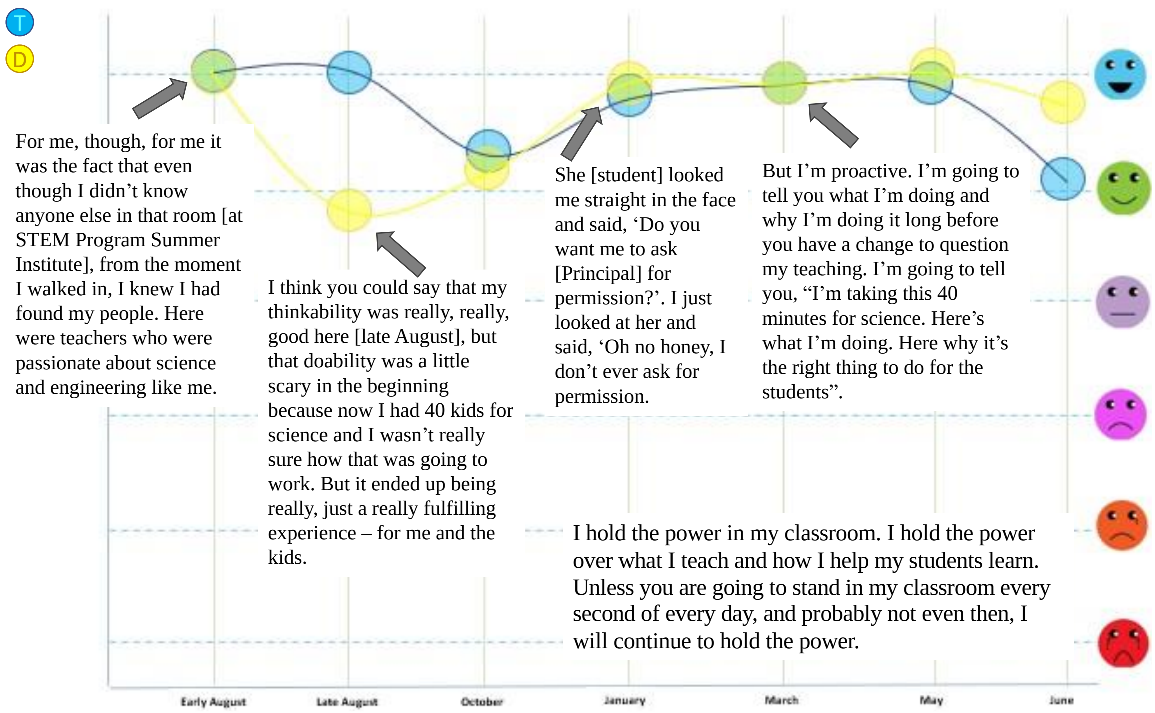


Figure 5.7. Willa's STEM Journey Map. Select Quotes Demonstrate Moments of High and Low STEM-Linked Professional Agency.

Willa consistently believed that science and engineering instruction were both thinkable and doable over the school year leading to her steady enactment of STEM-linked professional agency. A first-grade teacher at Mount Pleasant Elementary School, Willa had been teaching for 14 years and had extensive experience in early childhood education. As a classroom teacher of 16 years, that was obvious to me whenever I walked into her classroom. Baskets of manipulatives, design challenges, and STEM activities lined the shelves, and a building center filled with wooden blocks dominated a corner of the classroom. “Sometimes we forget how foundational building is for children,” Willa said when I referenced how, in this school system, it was rare to find a corner of a first-grade classroom dedicated to block work. “If we’re going to understand a Mesopotamian marketplace, let’s build it. If we’re going to understand how walls are built, let’s explore design concepts and the geometry. But children have to actually do it, not just read about it” (Willa, Interview, 11/22/19).

Willa described her professional vision for science and engineering as creating a learning environment that “allows students to experience concepts and topics in ways where they could make real, lasting, engaged connections” to the content and have “those doors of possibility opened for them” (Willa, Interview, 1/9/19). “I don’t want them to give up on science, which I think we run the risk of doing if we just give students a test in fifth-grade without any real teaching before that” (Willa, Interview, 1/9/19). According to Willa’s STEM journey map, she seemed able to accomplish and live out her vision for science and engineering instruction. As Willa recounted those moments of high STEM-linked professional agency, she described the perception that she was able to teach outside the box, or in other words, that she was able to teach innovatively in the interest of her students.

> Not getting to it [science] is not a choice for me. I have to make time. I make time for my kids to always be engaged in their learning, and usually that means that I make time for the science and engineering. So far, no one has really given me a hard time about that, taking some time here and some time there for science. But, you know, if they did, I wouldn’t change. (Willa, Interview, 11/22/19)

Willa had been a last-minute addition to the roster of the STEM Program Summer Institute participants the summer before. “The day before it started, Roxy called me up out of the blue and said, ‘Girl, what are you doing tomorrow? I’ve got an opportunity that you just have to take me up on!’” (Willa, Interview, 11/22/19). Roxy was a member of the STEM Program team who also worked with Mount Pleasant Elementary School through a university technology and STEM integration grant, and that day she sent multiple messages insisting that Willa attend.

> I’m sure you hear it all the time, what a great PD Summer Institute is. But it’s true. Actually, by the time I came [to Summer Institute], I had been in trainings for about 25 days that summer. I was pretty burnt out.
>
> But you all got me excited again. For me, though, for me it was the fact that even though I didn’t know anyone else in that room, from the moment I walked in, I knew I had found my people. Here were teachers who were passionate about science and engineering like me. (Willa, Interview, 11/22/19)

Twenty-five days of summer professional development is atypical for elementary teachers and showcased Willa’s commitment to lifelong learning. In early August, Willa had “found her people,” and at that moment did not feel as if she were the only unicorn in the room.

Upon returning to Mount Pleasant Elementary School and starting the school year with her first-graders, Willa’s thinkability remained high; she continued to hold a robust vision for science and engineering instruction. As the year began, though, the doability of science and engineering dipped slightly. “I knew what I wanted to do, but it’s the beginning of the school year, it’s hard to go out and get all those resources on your own”

(Willa, Interview, 11/22/19). Yet, it wasn't just the lack of resources that made science and engineering feel less doable for Willa.

> That's when I noticed that the other first grade students weren't getting science. I just don't get it. Why would you not teach science? But the other teachers on my team weren't willing to sit at the table and have the real conversation. They didn't want to hear about how important science is for kids or work on team plans for their science time. (Willa, 11/22/19)

Willa found solutions to those dilemmas. She offered to absorb her teammates' students into her own class during science. Not all the first-graders at once, mind you, but enough at one time that her classroom, which normally hosted 18 students, suddenly found itself filled with 35 or more students for science.

> I mean I was the only one really teaching science, so I knew that I could give some other kids some science experiences too. I think you could say that my thinkability was really, really, good here [August], but that doability was a little scary in the beginning because now I had 40 kids for science and I wasn't really sure how that was going to work. But it ended up being really, just a really fulfilling experience—for me and the kids.
>
> We tried a bunch of things out. We used Legos™ to build, we created things, we went outside to explore. And then one day, what really got me going around here [October], this is when I hit the jackpot. I discovered that all these plans that I had, this vision of engineering from the summer, we already had the kits! Here they were, sitting in the principal's office for the last six months. Brand new and no one was using them. I don't think anyone knew they existed. So I scooped them up and we were off! (Willa, Interview, 11/22/19)

That was the point, in October, on Willa's STEM journey map, where the doability rose to meet the thinkability, and Willa's STEM-linked professional agency remained strong for most of the school year. Willa worked extensively and exhaustively to give all first-graders at Mount Pleasant Elementary School rich science and engineering experiences. She found herself providing extra time for her own students to pursue engineering, design, and science interests—many times by integrating science and engineering with the district-mandated reading and mathematics programs.

> Here? [Pointing to January] Well the story here is that here is where we learn about Mesopotamia. It's a lot of listening and learning and sometimes that historical content is above their heads. You talk about trade. You talk about early civilizations and how the civilization was connected to that trade. And, you know, I'm always thinking about where the science and engineering is. How do I connect this? Because I know that if I can connect it to science or engineering, they'll understand Mesopotamia better. Imagine, first-graders learning about Mesopotamia. So instead of just listening and learning about how these people traded as part of their culture and community, the kids actually had to create something one day to bring to trade. We turned it into a kind of engineering challenge. What would you engineer and create to bring to the marketplace to trade? You just wouldn't believe some of the things they would come up with. We went through the whole engineering design process. They had to write a plan. They drew models. They got feedback and then revised their plan. And then when they got to actually experience a marketplace and trading, they understood the vocabulary and the content so much better. (Willa, Interview, 11/22/19)

Willa often did this—integrated engineering and science into the mandated curriculum, the same curriculum that seemed to limit many other teachers' practices. "It's thinkable because I see the possibilities in my head and it's doable because I just go ahead and do it. I'm not about to ask for permission" (Willa, Interview, 11/22/19).

> One of the little girls from across the hall came up to me one afternoon and said, "Ms. W, science is so fun in your room." I thanked her and asked her what she liked about it. She liked the fact that they didn't have to read out of a book and that it was messy and that they got to work together to build things. Then she wanted to know if we could learn about volcanoes one day. She *really* wanted to make a volcano. I told her that we probably would, but not for a few more months until we learned about Earth materials. She looked me straight in the face and said, "Do you want me to ask [Principal] for permission?" I just looked at her and said, "Oh, no, honey, I don't ever ask for permission." (Willa, Interview, 11/22/19)

Willa enjoyed the support of her administrators, or rather she demanded it. Outside of the fifth-grade teachers who were required to teach a daily science block, on average Willa taught more science and engineering than most teachers in this study. Referencing the March through May portion of her STEM journey map, Willa elaborated.

> I get through everything I have to [reading and mathematics] and make that time for science. My kids are always engaged and we move fast. I've never had a principal come and say, "Well, why are you doing blah, blah, blah?" But I'm proactive. I'm going to tell you what I'm doing and why I'm doing it long before you have a change to question my teaching. I'm going to tell you, "I'm taking this 40 minutes for science. Here's what I'm doing. Here why it's the right thing to do for the students." Nobody usually gives me a hard time for that.
>
> You know, some people are worried about the data. But I worry about the teaching and learning first. My data is great, but there's a reason for that. It supports me in standing up and saying, "I'm going to go ahead and do things my way."
>
> What most teachers don't realize is that we hold the power. I hold the power in my classroom. I hold the power over what I teach and how I help my students learn. Unless you are going to stand in my classroom every second of every day, and probably not even then, I will continue to hold the power. (Willa, Interview, 11/22/19)

Unlike most teachers in the study, Willa's high STEM-linked professional agency continued throughout the year. As she pointed to the part of her STEM journey map representing the weeks around May, Willa began to describe her students' excitement and success with an insect unit focused on designing ant hills. Suddenly, the focus of her story shifted.

> I taught about insects and habitats, but then they created these anthills using junk building. They had to show all the parts and purposes and stuff. It was amazing to see the kids take ownership of their ideas like that.

> Sometimes I think the biggest problem is that there's not accountability for teaching science. There are plenty of people here at this school that don't teach it. They might put it on their schedule, but then half the time we're told, "I don't want to see that being taught unless so and so or such and such is walking in the building." Then they might do some vocabulary. That's what hurts as a teacher, as a professional. I'm held accountable for reading and math, but science? No. I should be held accountable for everything I do that helps a child learn.
>
> Imagine what a beautiful world this would be, or a place the world would be, if we just taught science and social studies the way that we tend to teach reading and math. I feel like when you give kids those real world, realistic, authentic experiences, which is just what happens in science and engineering, then the rest of it, the math and the reading, comes as the tools that you use to teach it. That's the way I envision it. Just imagine if we all had that vision. (Willa, Interview, 11/22/19)

Willa's STEM-linked professional agency was supported by the fact that she had a strong, vivid professional vision for science and engineering instruction—both its purposes and its methods—and she felt empowered to pursue that vision and enact the content and pedagogy that she felt was right for her students. At the end of the year, when most teachers were envisioning the possibilities for the year to come, Willa's STEM-linked professional agency dropped. I pressed Willa to tell me more about this sudden shift since it was the lowest she ever rated the doability on her STEM journey map. Willa explained,

> Well, I'd been asked to change positions next year. I wasn't going to be a first-grade teacher anymore, I was going to be the reading interventionist for Kindergarten and first-grade. I was kind of struggling to figure out what that would look like. I mean, there wasn't any need to worry about me, there was always going to be science and engineering, it was just going to take me a hot second to figure out how to take their [district] reading interventions and fit them in engineering. But, you know I'll do it. (Willa, Interview, 11/22/19)

Haskell Elementary School: Marlene. Haskell Elementary School was a magnet school in the urban center of a small town. Even though it was a magnet school with enrollment open to students from across the district, 78% of Haskell's 545 students were "neighborhood students." Instead of applying from across the school district to attend Haskell Elementary, these were students who lived within the school's region. Eighty percent of the students at Haskell Elementary school were economically disadvantaged and qualified for free or reduced lunch, and 79% of the students were minoritized students. Haskell Elementary School faced similar tensions due to accountability pressures as other high-needs schools in the district. After years of inconsistent growth and falling well below state achievement standards, the school adopted additional reading and mathematics programs in addition to the district-mandated ones. Teachers at Haskell Elementary experienced additional mandates—ancillary professional development, master schedules designed by an outside company, and increased coaching and surveillance by district and program administrators.

A founding teacher at Haskell Elementary School, during her 17-year tenure, Marlene had seen four administrators rotate through the doors of the school. Marlene acknowledged that she missed her previous administrator of 8 years and had a strained relationship with her current principal but said, "I don't have a problem speaking my mind. I keep it within the chain of command, but it's my classroom and my students. I'm in charge" (Marlene, Interview, 12/4/19). The principal at Haskell Elementary School was under immense pressure from the school district. Recent shifts in leadership structures at the district level meant that Haskell's principal now had a supervisor, a former district principal, who routinely stopped by the school to observe both the principal and the teachers—checking to see if teachers were adhering to their schedules, reviewing assessment data, and making leadership and instructional suggestions. The staff at Haskell Elementary school was, at times, a close-knit family. Marlene carried a wealth of social and cultural capital in the school community. Teachers thought of Marlene as a mentor and counselor, not only because of her experience but also because of her caring, supportive, maternal disposition.

Narrative #6: Marlene. “When what we do for students in the classroom is fitting, it’s like a puzzle. And when all the puzzle pieces fit, everything else will fit. That’s when the learning happens” (Marlene, Interview, 1/2/19). Marlene’s teaching came from “a place of caring and advocacy” (Marlene, Interview, 12/4/19). An African American female, Marlene’s 17 of 22 years of experience was spent at Haskell Elementary School advocating for and championing the students. Marlene always thought of the students as her children, shaping the role she played in their lives and how they influenced hers.

> You know my dream was always to be working in a maximum-security prison. I’ve always dreamed of working with the families, children of those who were incarcerated. I care immensely for people and I want to help them to overcome that baggage that, that brings about. And then one day I was like, why not catch them before they get to maximum-security? And so, I became a high school teacher. And then one day I was like, I can catch these children earlier. Let’s try earlier. The children of people who are incarcerated, they just need so much. I can be that for them. If I can help even one child, then I’ve done my job.

This made sense, given the combination of her respect for authority in combination with her deep commitments to the most vulnerable populations. Marlene’s students figured prominently into how she narrated the thinkability and doability of science and engineering in her classroom. “I teach because I care. I make all these changes and I do what I do because I teach as an advocate, but mostly because I teach as a mother” (Marlene, Interview, 12/4/19). Students, of all grades and ages, referred to Marlene as “Ms. Marlene Beatty” rather than “Mrs. Beatty” since she had taught many sets of siblings, cousins, and various familial relationships.

> You know there’s a reason I always get ‘those students’ in my classroom. Everyone knows that I’ll be the one to form the relationship, to give rides, to stay after school and tutor, to do what needs to be done for those children. (Marlene, Interview, 12/4/19)

When Marlene narrated making decisions, changing practices, and taking action, it was nearly always sparked by her students and in service of her students. She was a student-focused, relationship-driven teacher.

Marlene’s focus on her students was a resource for her own STEM-linked professional agency development. Marlene began narrating her STEM journey map by saying, “It [STEM Program Summer Institute] was one of the best professional development things I’ve been to!” (Marlene, interview, 6/12/19). Marlene’s statement was not surprising. Like other teachers, Marlene had truly enjoyed the three-day STEM Program Summer Institute. However, what she said next *was* surprising because, as Marlene chronicled her experience at Summer Institute, she mentioned names unfamiliar to me.

> You know, I like to sit back and observe. I don’t just get right in there. And that’s what I did [during the STEM Program Summer Institute]. I watched everyone

doing their different things, what they said and what they did. After a while I was like, okay, I see, I see how this goes. And then I said, well that's Ja'Niyah right there. And that's how Emanuel would do it. And the way those two women are building things, well that's how Crystal would be. Because, you know, I've got to be able to picture my kids in it. (Marlene, Interview, 1/2/19)

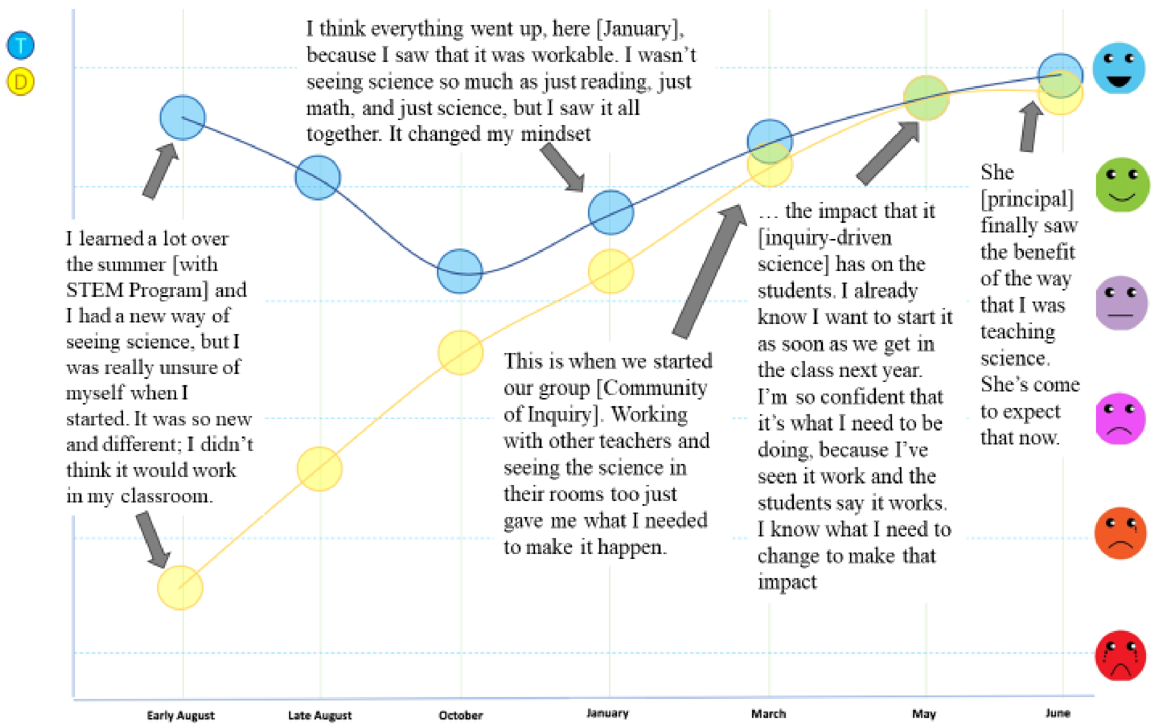


Figure 5.8. Marlene's STEM Journey Map. Select Quotes Demonstrate Moments of High and Low STEM-Linked Professional Agency.

I immediately took note because, to the best of my knowledge, Ja'Niyah, Emanuel, and Crystal were not teachers who had attended the Summer Institute. Actually, Marlene was not referring to fellow teachers attending the Summer Institute; she was referring to her students at Haskell Elementary School. Not one to jump right into the action, at the Summer Institute she watched the other teachers participate, interact, design, and collaborate—envisioning the engineering design challenge from the perspective of her students and picturing her students in similar situations.

Marlene continued to reflect on her Summer Institute participation in early August. "That workshop led to my thinkability being so high. It totally changed the way I thought about STEM. It was all of it. All of that! I was flying!" (Marlene, Interview, 6/12/19). On her STEM journey map, Marlene described the thinkability and doability of science and engineering in vastly different ways. Marlene described her science instruction before the Summer Institute as being, "you know, focused on science, just not hands-on or really even all that interesting. You know, some of the passages we read in reading were about science things" (Marlene, Interview, 6/12/19). Marlene also expressed that engineering was nonexistent in her classroom before becoming involved with STEM Program; the science instruction was didactic and teacher-driven. "I'd like to say everything changed as soon as I got back to my classroom . . . but it was hard" (Marlene, Interview, 6/12/19). Marlene indicated that she struggled with her ability to make changes to her instructional practices and begin to enact her new professional vision.

> You know, after that summer, I had a new way of seeing STEM for my classroom. I just didn't know if I'd be able to do it. I mean, how was it going to fit into my classroom? I was so different than the way we usually taught. How was this going to work with the kids? (Marlene, Interview, 6/12/19)

The STEM Program Summer Institute gave Marlene new ways of seeing science and engineering in her classroom, which contributed to the high sense of thinkability. At the same time, Marlene noted that this "new way of teaching" (e.g., integrating engineering practices into classroom science, unrestricted student exploration, less didactic and vocabulary-driven instruction) conflicted with standard pedagogical practices in her school, making science and engineering instruction seem less than doable.

The thinkability and doability of science and engineering both increased as the months passed. Marlene reflected on her science and engineering instruction in January and on the impact that her foray into engineering had on her students and her practice. Marlene worked with a STEM Program STEM Coach to co-plan the engineering unit, because she was unsure how engineering instruction might change her instructional practices and integrate with her science instruction. “I think everything went up here [January] because I saw that it was workable. I wasn’t seeing science so much as just reading, just math, and just science, but I saw it all together. It changed my mindset” (Marlene, Interview, 6/12/19). Not only did Marlene “[see] it all together,” meaning that she saw a connection between content areas, rather than siloed subjects; Marlene’s students began to see the connection as well.

> I decided to do a lot of referring back, I wanted them to see that it wasn’t just one subject that we’re doing everything in. And then I tried the Knee Brace [Engineering] Kit. And so when we came back to some of the other things we did, we referred back to that. Some of the kids were able to see it, see the connection too. When they made those connections, it started to click for me. (Marlene, Interview, 6/12/19)

Marlene was “a little bit of a rebel” (Marlene, Interview, 6/12/19) and identified most strongly as an advocate for children.

> I teach because I think every child has the ability to learn even though learning looks different for everybody. I want to be part of that process. I want to show

> children the different paths that they can travel down to get to their future. And a want to give them a voice to reach that future, whatever it may be. That's why I teach. It's why I teach the way I do.

Marlene described a professional vision of an engaged classroom that guided students in making connections between science content and their lives. This vision was dynamic, as Marlene explained that it and her pedagogical practices shifted over the school year. As she aspired to invoke student-driven lessons in her science and engineering instruction, it did not come as a surprise that Marlene depicted moments when her STEM-linked professional agency enabled her to use observations and knowledge of students as a catalyst for continued instructional and pedagogical changes. Marlene indicated that, in the past, when her students were not engaged in reading informational passages or textbooks about science topics, she would lecture to them. Now, she drew on her STEM-linked professional agency to make changes to her practice.

> You know I had a student tell me that he thought I was teaching science the way I would have taught high school English. That really got me. So I made a change to how I was teaching. I had to, for my kids. I thought about the connections they made and what they knew, and I made the change. (Marlene, Interview, 6/12/19)

At almost the mid-point of the school year, Marlene seized upon a student's comment and changed how and what she taught. As the year progressed, her STEM-linked professional agency continued to develop.

At the beginning of March, Marlene became involved with the STEM Program's Communities of Inquiry (COI). COI, as described in Chapter III and earlier in this chapter, was a STEM Program professional learning opportunity that brought teachers together in professional learning communities. Marlene joined COI "because I just wanted some kind of connection. I wanted to see how other people were doing science because I knew that I still had to grow" (Marlene, Interview, 6/12/19). Professional learning opportunities and collaborating with a network of like-minded teachers influenced Marlene's sense of STEM-linked professional agency.

> I think just the fact of coming together and talking about it, talking about the lessons, then they are hearing and some of the ideas of the lessons made me think that this kind of science was something I could do. But then, to see those new possibilities for my classroom in action and to see [other teachers'] students doing that, I was like, "hmmm, I might do that in my classroom." I saw it in action [in other teachers' classrooms]. I saw it working, and I knew that I could do it in my classroom too. That was cool. (Marlene, Interview, 6/12/19)

As a reminder, COI groups gathered to collaboratively plan a science lesson, which a teacher would teach in their classroom. The COI group then observed the lesson in action, meeting to debrief and revise the lesson based on their observations. As Marlene observed and reflected on science lessons that she had a hand in planning, and saw the students' success with those lessons, her STEM-linked professional agency increased.

> And then what happens is, we started doing more experiments and more things that were hands-on. I started seeing it working in [my] classroom and seeing [my students] learning how to work together and talk to each other and how to do teamwork. You'd see two of them working together that you've never seen before and just think, 'Yes! That's what it's about.' And you would just think, 'How is this possible?' And now I could easily see how it fits in my classroom and I see it working. And the kids would say that it was working. They talk about what they learn and how excited they are, and I know I'm on to something. (Marlene, Interview, 6/12/19)

When Marlene witnessed her students' success and heard her students talk about their experiences, she exercised her STEM-linked professional agency to shift her pedagogical practices. Marlene took that feedback and transformed her science and engineering instruction, often matching the vision she had held since the summer.

> Marlene: You know it's not just right now. Even thinking forward into next year, my thinkability and doability are high.
>
> Alison: Say more about that. Why do you think that is?
>
> Marlene: Because of what we're doing in the classroom now and the impact that it has on the students. I already know I want to start it as soon as we get in the class next year. I'm so confident that it's what I need to be doing, because I've seen it work, and the students say it works. I know what I need to change to make that impact. (Marlene, interview, 6/12/19)

As Marlene explained, the feedback that she received students, from what they said and did, gave her confidence. This made it possible for her to make teaching decisions that propelled her to leverage her STEM-linked professional agency in making changes in her science instruction.

When Marlene reached the end of her STEM journey map, she began chuckling. "This right here," Marlene said as she pointed at the overlapping yellow and blue dots above June, "It's how I know next year will be different" (Marlene, Interview, 6/12/19). By the end of that school year, Marlene not only exercised her STEM-linked professional agency but leveraged it as a resource to continue charting goals and growing professional agency in her science and engineering instruction. She planned to take that agency into the next school year—already planning how to infuse her instruction with more student-engaged talk, engineering that connected to the science standards the state required her to teach, and pedagogical practices that elicited a variety of students' voices and perspectives. The question remained, though, what had brought on the chuckling?

> You know, right here [June], this is where I sat down for my end of year conference with [Administrator]. She told me that she finally saw the benefit of the way that I was trying to teach science. She's come to expect that now. You know it's been a struggle. Before [Administrator], there was this principal who used to come and say, ya'll do things so unorthodox all the time, but you always get the job done. And my thing was, okay, let us be. And she did. But, then she left. It's been hard to establish a relationship with [Administrator], it's been like going through a divorce or something.
>
> I've been trying to stand on my own this year, especially with science. It's been a transition that's been hard for [Administrator] because she's not like my other principal. She needs to be in control and she needs to say how things are done. But, this year I've been trying to do my own thing. And right here in June, she finally got it. (Marlene, Interview, 6/12/19)

Cross-narrative interpretations. Analysis of teachers' narratives and STEM journey maps demonstrated the nature of their STEM-linked professional agency over the previous school year. At times teachers were able to enact, or at least take steps to try and realize their professional vision for science and engineering instruction. At other times, they felt unable to turn their vision into actionable practice. In moments when science and engineering were both highly thinkable and doable, teachers drew on their STEM-linked professional vision to align their professional vision and practice in innovative and responsive ways. In this cross-narrative interpretation, I make four claims about the nature of teachers' STEM-linked professional agency:

1. STEM-linked professional agency ebbed and flowed throughout the school year—i.e., it was not a final form achievement.

2. Teachers committed to teaching science and engineering were optimistic about science and engineering instruction overall.
3. Teachers committed to teaching science and engineering *needed* community.
4. STEM-linked professional agency was both socially constructed and contextually influenced.

STEM-linked professional agency as dynamic. STEM-linked professional agency was neither a final form of accomplishment, nor could it be captured in a momentary snapshot; it ebbed and flowed over a school year. The STEM-linked professional agency of elementary teachers committed to teaching science and engineering in high-needs schools could not be adequately described, as the literature often describes it, as dichotomous (i.e., as "agentic" or "not agentic") (Wei & Chen, 2019), a final form accomplishment (Biesta et al., 2015), or a snapshot of a moment in time (Eteläpelto et al., 2015). Teachers' STEM-linked professional agency was a dynamic phenomenon of working creatively within the contexts of traditional schooling to create change and align professional vision with practice in innovative and responsive ways.

This was visible in all narratives and STEM journey maps, though some more than others. Take, for example, Holly's STEM journey map. A snapshot of Holly's STEM-linked professional agency in October (see Figure 5.9), would have painted Holly as non-agentic and lacking in STEM-linked professional agency.

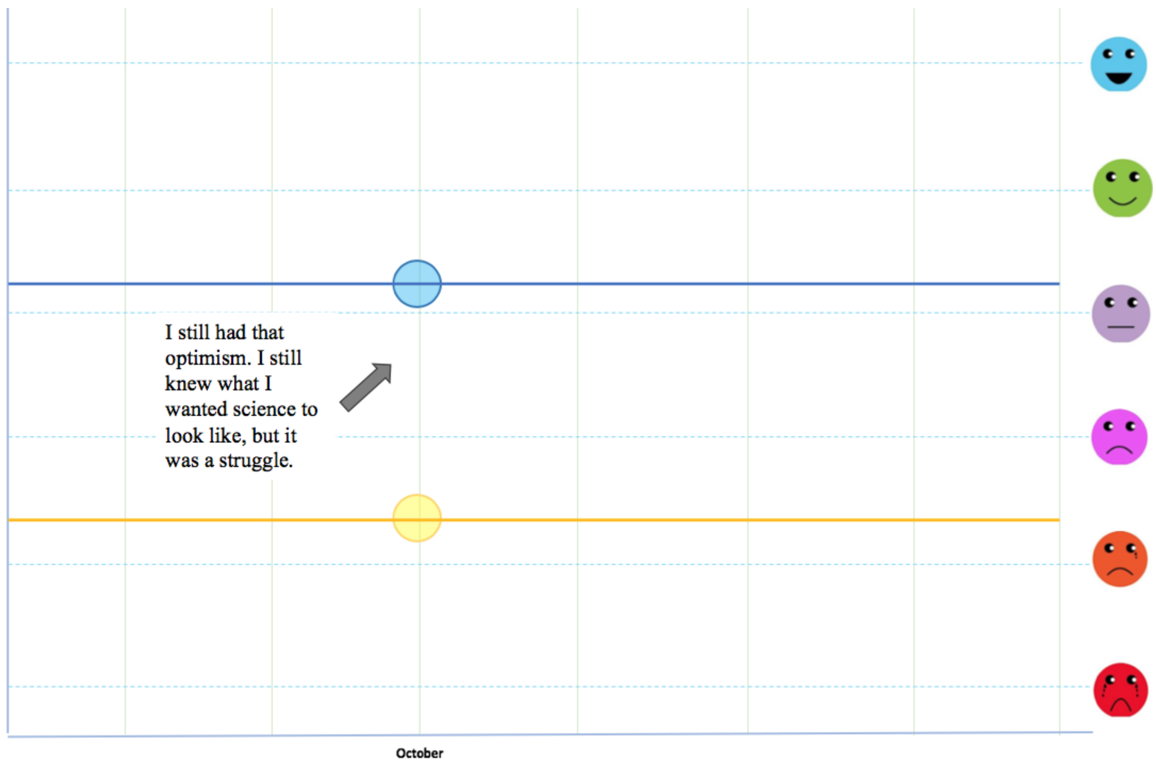


Figure 5.9. A “Snapshot” of Holly’s STEM Journey Map in October.

This STEM journey map is neither in any way representative of Holly’s STEM journey map as a whole, nor a complete picture of her STEM-linked professional agency. Holly’s STEM-linked professional agency fluctuated throughout the school year, from the highly agentic “we’re just going to do this science” (Holly, Interview, 6/12/19) to the “couldn’t do it. No one else was interested in science” (Holly, Interview, 6/12/19) low moments.

STEM-linked professional agency has a temporal aspect, in that people’s life histories and prior experiences influence their agency concerning their contexts (Brodie, 2019; Eteläpelto et al., 2013). I argue that while STEM-linked professional agency is not an accomplishment to be achieved and maintained, nor, due to its dynamic nature, can it be captured by looking at a single moment in time. It is dynamic and changes over time, such as a school year, concerning particular social and material conditions and relations of power that teachers experience in their workplace.

Optimism. All teachers began the year optimistically about their enactment of science and engineering instruction. All but one of the 18 teachers in this study were highly optimistic in early August, all feeling that science and engineering were highly thinkable. Thinkability remained high for many teachers as their year progressed. This indicated that teachers held on to their professional vision for science and engineering throughout the year. Duffy (2002) argued that teachers' visions served as a moral touchstone or compass, directing their actions and initiatives. "If you have an idea why you're teaching, you can hold everything up to that. It's your touchstone. You won't allow things that go against that" (p. 339). Much as Duffy suggested, teachers often worked to match their practices to their vision in moments of STEM-linked professional agency and used that highly thinkable professional vision to exercise STEM-linked professional agency.

While teachers' professional vision for science and engineering remained relatively high and stable, their doability fluctuated throughout the year. Their STEM-linked professional agency similarly fluctuated when they actively navigated school procedures, pressures to conform their practice, high-surveillance practices by administrators, narrowed curriculum, skeptical colleagues, and pressures to raise test scores in other content areas. Science and engineering do not take high priority with these kinds of pressures, and one almost has to be in "screw it" mode (Alina's words) or "honey, I never ask for permission" mode (Willa's words) to teach science or engineering. This is a big ask for a profession based on upholding gendered norms of compliance and politeness (Moreau, 2019).

***Community*.** Teachers' optimism came at a cost. Holding on to their robust professional visions and buoyed by their STEM-linked professional agency, teachers took it upon themselves to create change. Most teachers were left to go it alone and continuously search for support that was not offered or easily found. This was exhausting for some teachers. Teachers like Elle, Marlene, and Willa worked tirelessly to subvert the system and found ways to integrate science and engineering into their practice, but described a mental state of emotional exhaustion bordering on teacher burnout—e.g., "I'm constantly fighting for it," "It's like, what more can I do? I'm just done" (Skaalvik & Skaalvik, 2010). Teachers needed a community; there was a heavy call for support among all the teachers, and STEM-linked professional agency was most visible when teachers had access to support.

Some teachers, such as Holly and Marlene, found that support and community outside of their schools in the form of University STEM Program's Communities of Inquiry. Other teachers, like Elliot, found it in the form of supportive colleagues (i.e., Susan, the teacher down the hall). But even then, most teachers needed more support than they found or received. While Elliot received support from Susan in the form of a recommendation to attend the STEM Program Summer Institute, it was clear that he needed more. His STEM-linked professional agency oscillated wildly throughout the school year. Elliot's agency was at its highest just after Summer Institute, professional learning that Susan suggested he attend. At his lowest point, Elliot said that "It's an entire culture [testing] and it's kind of sad that everybody shifts to those priorities. I was settling rather than working for it. But what could I do?" (Elliot, Interview, 6/12/19), noting a lack of community and cohesiveness between himself and his colleagues.

Although Elliot described the desire to turn his high thinkability and professional vision into actionable steps, his plan of action was vague in comparison to teachers such as Willa who enjoyed more support, from administrators, colleagues, and outside sources like STEM Program. Holly and Marlene were both part of STEM Program COI groups—providing them with much needed and desired support. Ongoing professional learning supported teachers in "see[ing] the new possibilities" (Marlene, Interview, 6/12/19), not "feel[ing] like I was alone," and thinking that they "could do more" (Holly, Interview, 6/12/19). While a supportive community fostered and bolstered teachers' STEM-linked professional agency, what would have happened if this community was removed? Would teachers like Marlene and Holly have faced journeys like Elliot's? Teachers, especially those working on teaching against the status quo by enacting science and engineering instruction, need and thrive off the community. Access to continuing support and collaboration increases professional capital, impacting teachers' STEM-linked professional agency (Hargreaves & Fullan, 2015).

Social and contextual. The ebbing and flowing of teachers' STEM-linked professional agency was a dynamic process and an ongoing negotiation and renegotiation between teachers and their workplace contexts (Lasky, 2005; Sfard & Prusak, 2005). STEM-linked professional agency was socially constructed and also, at times, needed to be socially validated or affirmed through others (Ashforth & Johnson, 2001). Recognition, positioning, roles, discourses, and power dynamics were important to teachers and their STEM-linked professional agency. The recognition Marlene received from her administrator bolstered her STEM-linked professional agency for the upcoming school year. Alina's lack of social capital within certain circles of the faculty played a role in compromising her STEM-linked professional agency.

STEM-linked professional agency also allowed teachers to re-story their conditions within a contentious professional landscape, meaning that teachers did not encounter dilemmas of practice unaided and forlorn; their STEM-linked professional agency strongly shaped those moments (Buchanan, 2015). This meant that teachers were able to construct and re-construct their professional selves and professional context drawing their agency to create a context where they would be better able to align their practice with their professional vision. Elle drew on her STEM-linked professional agency to step up and push back (Buchanan, 2015) against school- and district-mandated curricula and reforms, working to reshape the landscape of science and engineering instruction in her classroom through the integration of subject areas and the implementation of electives and after-school clubs. Alina, too, worked tirelessly to renegotiate the instruction ideals given to her by her school administration. Teachers' STEM-linked professional agency enabled teachers to renegotiate the sociocultural conditions of their educational context, which was no small feat considering the power dynamics and discourses of historic and traditional schooling at play in these schools (Biesta et al., 2017).

CHAPTER VI

DISCUSSION

In this study, I explored the dilemmas elementary teachers encounter as they endeavor to integrate and enact science and engineering instruction in their curricula in high-needs schools, and the nature of their STEM-linked professional agency as they work through those dilemmas in doing so. The research questions that guided this inquiry were:

1. What is the nature of their elementary teachers' professional visions for science and engineering instruction in high-needs schools?
2. What facilitates and/or constrains the enactment of teachers' professional visions for science and engineering?
3. What dilemmas emerge for elementary teachers as they reconcile their professional vision with the ideals and demands of schools?
4. In what ways do teachers respond to those dilemmas?
5. How do teachers who work in high surveillance cultures and have strong commitments to their professional vision for science and engineering narrate the nature of their STEM-linked professional agency over a school year?

In the remainder of this chapter, I highlight central themes concerning the ongoing problem of teachers' de-professionalization and review findings for, connect literature with, and give implications for each research question. After a review of the findings, I re-examine the conceptual framework I used to guide the study, fleshing out changes in my perspectives regarding professional agency since I embarked on the study. My revised framework contributes to the literature on teachers' professional agency and, especially, STEM-linked professional agency. I end the chapter with the limitations of the study and recommendations for future scholarship and efforts to understand and support teachers' STEM-linked professional agency.

A Persisting Problem of De-Professionalization

> Teachers are the gate-keepers of its traditions and culture and facilitators of evolution . . . teachers above all professionals, must, almost by definition, be intellectually active, authoritative, lively, critical, reflective, flexible and ever attentive to the constant and changing demands of the young and the society for which they are being prepared. (Bottery & Wright, 2002, p. 68)

I was motivated to do this study because, as high-stakes accountability measures continue to be the focus of schooling's outcomes, especially in high needs schools, the curriculum narrows, and teachers are not treated as the professionals Bottery and Wright (2002) describe in the quote above. There is no one-size-fits-all instruction that meets the needs of all students, so why do some expect one-size-fits-all teaching and instruction? When curricula and practice are standardized and teachers are told what and how to teach, teachers are sent the message that they are not respected, trusted, or knowledgeable, that their expertise is not valued, and that they are not capable of making decisions in the best interests of their students. This de-professionalization is a problem; it can strip away teachers' agency and their ability to think and do differently. However, this study shows teachers who, despite this de-professionalization, find cracks in which to enact their agency.

High-needs schools in the United States already function at a disadvantage. Historically, there is a disparity in resource allocation, a wider absence of needs that must be met, and a higher rate of staff turnover. Additional to this are additional challenges such as accountability pressures, standardized practices, and scripted, narrow curricula (Milner, 2013). Governmental, institutional, and local demands on teachers promote “teaching to the test” and hinder teachers from fully focusing on teaching to the whole child and perpetuate a heightened culture and sense of surveillance (Gurl et al., 2016; Tanner, 2013). These climates perpetuate narratives that de-professionalize teaching. Elementary teachers in high-needs schools, the teachers who serve some of the most marginalized students in our communities, are being marginalized themselves. Teachers’ professional self-concept and professional agency for teaching in high-needs schools become distorted by lack of autonomy regarding curriculum development and decision-making (Carter-Andrews et al., 2016; Hargreaves & Goodson, 1996). And, despite this, elementary teachers in high-needs schools continue to be resilient and rise above challenging situations that threaten their vision for their students, their agency, and their professionalism. But we still lack fully realized narratives of those teachers in the literature.

I came to understand in the more nuanced interplay between the tensions teachers face and their desires to be professionals, to act with integrity, and at the same time to give every child a chance to succeed. In many high-needs, elementary contexts, teachers are pressured to act in ways they do not think are professional, resulting in instructional environments that teachers do not feel are conducive to student success. And, yet, even amidst this climate of deprofessionalization, most teachers do not merely act as passive recipients of the numerous policies, administrative requests, curricular demands, and pressures from teammates to comply. This study, more than anything, demonstrates the many ways teachers who teach in high-needs schools push back, are intellectually creative, and strive to continually do whatever they can to expand their students' lives and opportunities. The narratives in this study are difficult to read because it is hard to imagine that passionate educators face such a battle just to teach; they were also hard to write. But, at the bottom of this, is a story of hope. The teachers, as facilitators of evolution (Bottery & Wright, 2002), point to the difficulty of doing the right thing for children. That they were often, but not always, able to do so is impressive. Teachers' professional agency gives us a lens to better understand this hope, push back, and action. But, that they had to fight or push back to do so is unjust.

In the next few sections, I summarize the findings for each research question, make connections to the research literature, and outline implications for professional learning, professional development, and educational leadership. I follow those sections with discussions of limitations, future research, and concluding thoughts.

Research Question 1: The Nature of Teachers' Professional Vision

Summary of findings. Elementary teachers' visions for science and engineering in high-needs schools included four themes: (a) an engaged classroom, (b) practices that foster meaningful and relevant connections, (c) instruction that broadens student pathways, and (d) teaching for altruistic reasons. Many of their visions included two or more of these themes, indicating that their visions were robust and multi-faceted. Teachers who were committed to teaching science and engineering in high-needs elementary classrooms envisioned engagement. This was different from simply an *engaging lesson*. Teachers dreamt of teaching science and engineering with *hands-on*, *inquiry-based* methods than engage students in learners in exciting and motivating ways. Teachers also narrated professional visions for science and engineering that created meaningful and relevant connections for students and between subjects. These visions included content and practices creating *real-world* connections between *subject areas*, *realized by students*, often because *you see science and engineering everywhere*. Finally, teachers also described professional visions for instruction that broadened student pathways and provided students with new opportunities. Teachers wanted to teach in ways that went beyond just curriculum and pedagogy, envisioning their role as a teacher as someone who, through their pedagogical choices, helped students to recognize their potential and see that science was for them.

Connections to the literature.

> The best teachers are not followers. They evaluate directives from methods course instructors, inservice speakers, teachers' guides and other authoritative sources; override such directives when, in their judgment, something else will work better; and revise and invent yet again on the basis of instructional results. In short, they adjust, modify, adapt and invent; they do not emulate. They do this because they possess an independent spirit. (Duffy, 2002, p. 333)

Duffy calls this "independent spirit" visioning. By visioning he means a teacher's conscious sense of self, of one's work, and of one's mission, or a personal stand on teaching that rises from deep within the inner teacher and fuels independent thinking (Duffy, 2002). Hammerness (2001, 2006) describes this as a set of images of ideal classroom practice to which teachers strive—or a teacher's professional vision. Both Duffy (2002) and Hammerness's (2001, 2006) vision frameworks helped me to understand the professional visions teachers narrated. The findings pointed to the fact that teachers' visions in this study partly focused on teaching for altruistic reasons, but focused to a much greater extent on what it meant to teach science and engineering in elementary classrooms.

When teachers have a focused professional vision, they assume control over instructional decision-making and pedagogical reasoning to achieve and realize that professional vision. Current research suggests that effective elementary teachers adapt their instruction to meet the needs of their students (Bransford et al., 2005; Duffy et al., 2008). The ability to "speak back" against institutional demands and directives that restrict adaptive teaching requires a clear professional vision for teaching, as this often gives teachers the strength of purpose required to adapt their instruction and to teach responsively in the face of institutional demands (Achinstein & Ogawa, 2006; Vaughn & Faircloth, 2011).

Hammerness's framework allowed me to begin to look at the multifaceted nature of teachers' professional visions for science and engineering. But it was Gess-Newsome et al.'s (2003) conceptualization of teachers' visions as part of personal practical theories that helped me to surface the components of the visions and the meanings they held for teachers. These components included teachers' ideal images of teaching and learning, the roles of teachers, and methods and content for instruction. Considering teachers from this perspective, teachers focused on their ideal image of teaching and learning in an engaged classroom. Their ideal methods and content focused on integration and connecting science and engineering to students' lives, therefore making it relevant for their students. And, they narrated their ideal vision of the role of the teacher as not just a distributor of knowledge or a facilitator of an activity, but as a person who could play a role in a student's life through meaningful science and engineering instruction, thereby opening up opportunities for students who would not have necessarily had access and broadening student pathways, both in the classroom and in their futures.

This takes me back to Duffy's (2002) referral to vision as "independent spirit" (p. 333). When I started to understand the intricate facets of teachers' professional visions, I began to see how multifaceted and powerful these visions were. There is scant literature focusing on elementary teachers' professional vision for science and engineering, and no literature that I am aware of that focused specifically on teachers in high-needs elementary schools. Yet, we know that these teachers—teachers committed to teaching science and engineering in high-needs schools—are some of the most beaten-down teachers in the system. These teachers are under considerably more pressure than their counterparts and teach with fewer resources, but they are also some of the most resilient. This speaks to what Duffy (2002) calls their "independent spirit" (p. 333), and it speaks to the power of their professional vision to sustain and enrich them and to fuel their mission. Teachers embrace their multifaceted professional vision as a personal practical theory (Gess-Newsome et al., 2003). Teachers use their vision to take a personal stand on their teaching and to push back or speak back against institutional demands and directives that are restricting their professionalism and constraining their science and engineering instruction. Amelia demonstrates this when she says, “I know what they want. I know what they say to do. But it’s not right for my students. So, I’ll just put my own spin on it and do it my way” (Amelia, Interview, 1/10/19). Here, when Amelia says “they,” she means her school’s curricular leaders and administration. Amelia teaches science and engineering the way she does because she wants “to reach as many students in some way, shape, or positive form” (Amelia, Interview, 1/10/19). She uses that vision of her role as a teacher and ideal pedagogy to push back against how “they” are asking her to teach.

Teachers’ professional visions are important because teaching is a complex and demanding job. Every day, teachers face dilemmas of practice, unpredictable situations, circumstances out of their control, and tensions from outside their classroom where there is no immediate, clear way to proceed. Researchers have estimated that teachers make hundreds of not-so-trivial decisions every day (Danielson, 2011), making it important to understand what guides and sustains teachers in their complex and demanding job, especially in high-needs school contexts. When teachers have a clear sense of their purpose as educators, conceptualized by a strong, robust, multifaceted professional vision, they are better positioned to speak back to institutional demands and constraints and teach how and what they feel is in the best interest of their students.

Implications. Teachers who hold focused, content-specific, professional visions are powerful teachers, well-positioned to be advocates for their students and for school improvement. A robust professional vision is important for teachers who work as advocates and change agents in service of their students. Their clear, focused, content-specific, professional visions enabled them to navigate significant challenges and dilemmas. These findings can inform the work of teacher educators and professional development providers, as well as school leaders.

Teacher educators and professional development providers are well-positioned to foster teachers' and teacher candidates' development of robust professional visions for science and engineering in the work they do with teachers. Teacher educators should be cautioned, however, against simply providing teachers with a philosophical basis upon which to build their professional vision or asking teachers to take up a uniform, shared vision blindly. A robust professional vision that enables teachers to navigate tensions and dilemmas contains many components and layers. No matter the context, fostering teachers' robust professional visions includes surfacing these components and helping teachers or teacher candidates evolve their vision based on their experiences, beliefs, ideal images, and conceptualizations of the how, why, and what of science and engineering instruction for their classrooms. This work is dynamic, ongoing, situated, and individualized support for teachers and teacher candidates that will enable them to draw upon their professional visions to "sustain them through difficult times" (Hammerness, 2006, p. 78) and speak back to restrictive institutional pressures and demands that threaten both their ability to enact science and engineering and their professionalism.

This study also highlights teachers' professional visions for science and engineering as a potentially overlooked resource for school improvement. School leaders are well-positioned to listen to their teachers and leverage their teachers' professional visions by surfacing teachers' individual visions of the role a teacher could play and ideals of content and pedagogy. This is in contrast to asking or requiring teachers to align their professional vision with an institutional one; at best, this encourages buy-in, and at worst, demands compliance. We saw this with the Weaver Way, where on a school-level, this vision functioned as a primary layer of school improvement, uniting curricula, practice, and mindset and encouraging or expecting commitment and compliance to a shared vision. On a teacher-level, it was re-interpreted as a way to focus the enactment of their professional vision on their students, thus creating tension between teachers and Weaver Elementary School. Organizational visions that do not include the collective voices and visions of its members can inspire general amenability, rather than the passion and drive teachers and schools need as they work to integrate science and engineering into their curricula.

Research Question 2: Facilitating and Constraining Teachers' Professional Visions

Summary of findings. Teachers explained that the enactment of their professional visions for science and engineering in high-needs elementary schools were both facilitated and constrained by the various sociocultural conditions of their educational workplace. Table 6.1 illustrates how teachers perceived these facilitating and constraining influences on the enactment of their professional vision.

Table 6.1

Facilitating and Constraining Enactment of Professional Vision

	Facilitated Enactment of Professional Vision	**Constrained Enactment of Professional Vision**
Strength of Influence	Students and community	School programs and priorities
	Colleagues	School, district, and state policies
	School vision or philosophy	Colleagues
	Outside support	Surveillance culture
		School vision and philosophy

Note. The frequency counts of mentions in the data determined the strength of the influence.

Teachers cited facilitating influences as (a) teachers' students and their community, (b) teachers' colleagues, (c) the vision, structure, or philosophy of teachers' schools, and (d) support from outside of teachers' school community. Teachers drew upon these influences as personal resources for confidence in their vision of how and what to teach and the ability to accomplish their vision. In contrast, influences that teachers cited as constraining their practice included (a) schools' priorities and programs (including testing and curriculum); (b) school, district, and state policies; (c) teachers' colleagues (fellow teachers, coaches, and administrators); (d) constant surveillance of programs and policies; and (e) the vision and philosophy of teachers' schools.

Connections to the literature. Educational policies and programs that aim to control and thereby limit teacher creativity, autonomy, professional judgment, and pedagogical reasoning can stifle teachers' enactment of their professional visions. That is not true of all teachers, because, as the findings pointed out, connection, support, and professional communities can nurture and support teachers in the enactment of their visions. Most often, the literature chronicles the difficulties elementary teachers encounter as they attempt to realize their vision for science and engineering instruction. Southerland et al. (2007) summarized these as internal and external barriers for teachers. Internal barriers include teachers' beliefs about science and students, their understanding of content, and their prior experiences with science and engineering. External barriers relate to the material, human, and cultural resources and institutional requirements for learning and assessment. Similarly, York-Barr and Duke (2004) outlined factors that facilitate not only the implementation of science and engineering, but also how teachers perceive their ability to teach in ways they envision possible as school culture, collegial relationships among faculty, well-defined roles and responsibilities, and shared decision-making (Wenner, 2017; York-Barr & Duke, 2004).

In the context of this study, these teachers were no different, citing similar influences that facilitated and/or constrained the enactment of professional visions for science and engineering. In keeping with the literature, teachers felt the supportive relationships with colleagues and a school's ethos and culture facilitated the enactment of their professional vision for science and engineering. Similarly, they perceived their vision to be constrained by external barriers, especially accountability pressures from school and district administrators, which narrowed the curriculum, pressured teachers to conform to prescribed practices, and often decreased teacher autonomy. These findings continue to be consistent with Lewthwaite's (2006) contention that both personal or internal and contextual or external factors impact the success of teachers working to realize their vision of science and engineering instruction.

But, yet, these teachers *are* different; their contexts and their stories are different. Their perceived constraints and struggles are consistent with the literature, but the magnitude of their struggles and how these constraints affect their professional vision is rarely fully captured. Eslinger (2014) describes teachers teaching in high-needs schools as finding themselves between a "rock and a hard place"; they are navigating an already challenging school context with the additional pressure of reducing already-present achievement gaps. Eslinger (2014) uses the metaphor of a "rock" to describe the dilemmas teachers faced, while using the metaphor of the "hard place" to describe the increasing bureaucratic control of testing, content, and pedagogy. I see this metaphor differently. I think that elementary teachers in high-needs schools find themselves stuck between two different structures—their professional vision for science and engineering, and institutional constraints. "The rock" is teachers' robust professional vision. It serves as their foundation, the place from which they draw strength in the face of constraints, or the "hard place."

High-needs schools in the United States amplify the magnitude of the "hard place." Teachers described having less time and resources for their science and engineering instruction with a casualness that implied a commonplace expectation. However, for these teachers, school policies, programs, and priorities and lack of recognition and support from colleagues (fellow teachers, coaches, and administrators) weighed more heavily. These themes seemed to loom larger than others because of the intensified nature of pressures at high-needs schools. Teachers felt isolated and professionally lonely; when they perceived a disconnect between their professional vision and what others at their school prioritized, teachers described feeling as if they had to go it alone. These feelings and perceptions deepened when teachers perceived a lack of collegial support. Teachers felt this tension, being caught between their robust professional visions and intense pressures and constraints, intensely.

Implications. Context matters; the sociocultural conditions of a teachers' workplace make a difference on whether or not they feel able to enact their professional vision for science and engineering instruction, whether or not they perceive the agency to do so. In the teaching profession, the ability to turn professional vision into practice, this kind of autonomy is necessary for teachers to be able to address the changing needs of students and to respond to any number of situations with action. Teachers need a connection with their students, the educational community, and the larger community to inspire. They need support from colleagues, administrators, and outside actors and agencies (see Table 6.1 presented earlier). It is worth noting, again, that teachers cited colleagues and administrators as people who both facilitated and constrained the enactment of their professional visions. This highlights the importance of a professional community, built on the premise of shared authority, leadership, knowledge, and values for all teachers. Collaboration and active engagement in such a community helps teachers, administrators, and other colleagues to understand one another, cultivate shared respect, and help colleagues see beyond their own experiences.

If school leaders are trying to build a school where professional agency is valued, building a school that builds community is a priority. In many schools, the role of school leaders has emphasized the role of leadership in instruction, responsibility mostly remaining in the hands of administrators or principals who govern hierarchically. These schools function as a chain of command, with the administrator dictating policies and procedures. Instead, in a school community, governance is in the hands of the people who have a vested stake in it—teachers, students, community members, and administrators (Furman & Starratt, 2002). The authority rests not in the bureaucracy, but in the expertise and agency of the participants. A school that embraces a community approach would embrace shared decision-making, increased instructional innovation, shared purposes and goals, and reciprocal and constructivist leadership that dramatically alters the views and positions of teachers (Doyle, 2004).

Teachers narrated a multi-level policy structure in their schools. Federal policy pressures, state reform mandates, political rhetoric, and social perceptions around teaching and learning put many schools and school districts on the defensive, producing sociocultural conditions that constrain teachers' enactment of professional vision and their science and engineering instruction. We know from the literature on educational leadership that effective leadership in schools facing challenging contexts includes models of distributed leadership focused on building positive relationships and empowering others to lead (Harris, 2003). For school- and district-level administrators, examining relationships with teachers, looking toward reciprocal relationships (i.e., recognizing expertise, collective decision making) might ease pressures, increase autonomy, and amplify teachers' voices and visions. The irony here is that the two tensions a school administrator must hold—the need for teacher autonomy and the need for community—are both important.

Research Question 3: Dilemmas Teachers Encountered When Enacting their Professional Visions of Science and Engineering

Summary of findings. Instead of considering constraints on the enactment of teachers' visions as barriers that affect teachers, I choose to consider them as dilemmas, or moments of tension when teachers experience conflicting visions and demands. Teachers experienced dilemmas of practice when they find their professional visions for science and engineering conflicting with institutional ideals and demands. This permeated their lived experiences and involved conflicting visions (their vision versus institutional ideals) of teaching and learning, curricular goals, pedagogical practices, and conceptualizations of positions within the educational community. Teachers narrated this as two dilemmas specific to their experiences and contexts. One dilemma centered on visions they held for their role as a teacher competing with schools' conceptualization of what teachers were meant to do, like when Alice's vision of her role as a teacher (a capable and knowledgeable professional) ran counter to how she felt her school and school district saw her (someone to read a script to deliver instruction). The other dilemma centered on teachers envisioning certain curricular and pedagogical decisions as possible in their classrooms, but found their schools often making those choices in their stead and dictating the curricula and practices for teachers to use. We saw this dilemma when Jemma felt pulled in contradictory directions between the pedagogy she envisioned using to teach science and engineering and the structured, prescribed lessons and units she was given to teach by her school district.

Connections to the literature. These dilemmas challenge teacher autonomy and professionalism by making it difficult for teachers to rely on their expertise and professional judgment when planning and implementing science and engineering. Dilemmas are defined as “aspects of teachers’ intellectual and lived experienced that prevent theoretical ideals of constructivism from being realized in practice in school settings” (Windschitl, 2002, p. 132). As I wrote in Chapter II, Windschitl (2002) defined four dilemmas that teachers need to navigate to be able to teach within a constructivist framework—conceptual, pedagogical, cultural, and political. As a reminder, Table 6.2 gives a detailed explanation of the four types of dilemmas.

Table 6.2

Dilemma Types

Dilemma Type	Explanation
Conceptual	Conceptual dilemmas center on teachers’ understandings of the theoretical and epistemological underpinnings of constructivism and how these beliefs translate into classroom action.
Pedagogical	Pedagogical dilemmas stem from teachers’ implementation of constructivist practices and the difficulties they have managing classroom interactions with students, focusing on student understanding instead of memorization, and assessing student content understanding.
Cultural	Cultural dilemmas evolve from the conflict between constructivist culture and traditional classroom cultures, which emphasize the right answers over thinking skills and prioritize western culture over students’ lived experiences.
Political	Political dilemmas result when constructivist-based practices appear to run counter to the practices that the community and school stakeholders expect to be used for students to succeed academically.

Note. Source: Windschitl (2002).

The simple act of working to implement science and engineering into their elementary curricula is a form of teaching against the grain (Cochran-Smith, 1999, 2001) or teaching against the status quo of expected schooling in high-needs schools, where time and resources for science and engineering instruction are often usurped in favor of subject areas assessed by high-stakes testing. Windschitl (2002) argues that engaging in forms of teaching that disrupt the status quo pedagogies causes teachers to confront competing ideals and demands. This, in turn, provoked deep dilemmas as teachers work to sustain the practice to which they envision and aspire.

The dilemmas expressed by teachers were mostly political tensions that surfaced as teachers attempted to work within and around constraints of systems of accountability, institutional structures, and tumultuous political climates (Upadhyay, 2009; Valli & Chambliss, 2007). To persist with instructional practices counter to the status quo, the teachers had to negotiate dilemmas, pulling them in contradictory directions. This is not to say that teachers did not experience conceptual, pedagogical, and cultural dilemmas in their attempts at science and engineering instruction. I am sure that they did experience dilemmas that fell into those dimensions, but teachers' narratives focused primarily on political dilemmas and tensions. This is both expected and surprising at the same time. This was not surprising, as the sociocultural conditions of high-needs schools intensify how teachers interpret and perceive constraints on the enactment of their professional vision and their science and engineering instruction. But, even given those conditions, I expected to surface a tapestry of dilemmas in teachers' narratives. Instead, political dilemmas—a disconnect with school priorities, institutional hierarchies, and a narrow conception of teaching—figured foremost and prominently at a macrolevel in teachers' instructional lives, and overshadowed other intersecting dilemmas occurring at a microlevel in teachers' classrooms. For example, few teachers brought up classroom-level dilemmas of creating lessons to promote students' sensemaking when so much of the curriculum treated students as passive recipients of knowledge.

Teachers experienced and understood dilemmas at different levels of impact. The localized dilemmas, while all political, impacted teachers at a higher level, leaving some teachers unable to see through "the cloud" of one dilemma to acknowledge or address other dilemmas. Take, for example, Elle, whose main struggle was with the stakeholders at Pine View Elementary telling her that she was not allowed to teach science and demanding that she follow a semi-scripted curriculum that cut science out of her instructional day altogether. That dilemma figured so prominently in Elle's educational context that it was as though she could not see through the cloud of the political tensions and dilemma even to begin to talk about cultural, pedagogical, and conceptual dilemmas. For example, Elle alluded to, but never truly narrated how teaching science and engineering in a way that aligned with her professional vision shifted the cultural norms of her classroom. The tensions with her administration and mandated curricula overshadowed this dilemma, which figured prominently in her narratives. Cultural, pedagogical, and conceptual dilemmas primarily occur at a classroom level and between teachers and themselves or teachers and students. Here, again, is another example of the amplified pressures found in high-needs school contexts significantly weighing on teachers and affecting the enactment of their professional visions and what science and engineering are possible in their classrooms.

Implications. Much inquiry-based science and engineering instruction begins with what students know and is driven by meaningful interactions between the students and their teacher (Windschitl, 2002). This requires a great deal of teacher autonomy to select curriculum and enact envisioned pedagogy. Historically, school- and district-level administrators and policymakers have sought to control curriculum and standardize pedagogical practices rather than allow teachers control over their own curriculum and practice (Apple, 1982). I will admit that this has not always been the case for all levels of schooling. In the more recent past, this level of surveillance has increased dramatically, and it is felt in harsher ways by elementary teachers—especially elementary teachers who teach in high-needs schools. If political dilemmas eclipse pedagogical, conceptual, and cultural dilemmas and dominate teachers' thinking and reasoning, then administrators and policymakers must stop treating teachers like technicians, expected to implement curriculum and objectives that are tightly controlled by someone holding authority and power.

Teachers are capable of exercising professional expertise and demanding new roles for themselves, which include greater autonomy and a larger voice in the school's decision-making process; to meet teachers' needs, schools and school districts need to make changes in organizational and political structures. The autonomous professionalism that teachers value is not complete freedom. In any organization, there are non-negotiables and expectations. While a few teachers in this study did narrate having “complete freedom” of science and engineering content and pedagogy, it is unlikely that any teacher can say, “I’m not really a morning person; I think I’ll start teaching at noon.” Genuine, autonomous professionalism is essential for teacher agency. Top-down approaches to leadership, resulting in treating teachers like technicians, are almost always guaranteed to fail (Seligman, 2012). When teachers are controlled and told what to do, when they are made to feel incompetent, lacking positive relationships, and lacking a measure of control over their professional lives, they feel crushed, de-professionalized, and unmotivated. School- and district-level administrators and leaders must work to change this dynamic by cultivating positive, supportive relationships with teachers and by ensuring that teachers have significant say and choice in what they do, or how and what they teach (Sparks & Malkus, 2015).

Research Question 4: Teachers’ Responses to Dilemmas

Summary of findings. I sought to uncover how teachers navigated and responded to the dilemmas they encountered when working to teach science and engineering. I framed teachers’ responses to dilemmas as ways they spoke truth to power. I found that teachers responded to tensions and conflicts with three general ways of speaking truth to power—compliance, deferential resistance, and tempered radicalism. Teachers’ responses to dilemmas were multidimensional and contextually driven. That is to say that teachers might respond with compliance to one dilemma given a certain set of contextual circumstances but respond with tempered radicalism in another context.

Teachers who responded to dilemmas with compliance cooperated with and conformed their practice to school and school district requirements, demands, and ideals.

This happened because teachers considered themselves “rule followers” and felt that it was not “their place” to question the authority of administrators and supervisors. Responses of compliance do not imply an agreement or alignment of vision and beliefs between the teachers and their institution. Teachers continued to hold an often vivid and robust vision for science and engineering instruction but felt as if they could only respond with compliance to the demands being placed on them by institutions.

Teachers responded to dilemmas with deferential resistance by voicing opinions and ideas but keeping their responses in line with institutional norms and expectations. Teachers described this as being part of the professional conversation, speaking up when they disagreed or felt uncomfortable, but not making waves. For example, Nichelle narrated,

> It’s hard for me to voice my opinions sometimes because I am really dutiful and I am a rule follower. But when I hear something I disagree with, I feel like I always need to speak up. So for me, I’ll do it and be honest, but respectful all at the same time. (Nichelle, Interview, 1/16/19)

Teachers like Nichelle characterized their responses to dilemmas as deferential resistance responses because they indicated that they voiced their opinions and contributed to the conversation but yet spoke up respectfully and with deference to others’ viewpoints.

Responses of tempered radicalism varied from deferential resistance because they included teachers not only speaking back to dilemmas but also included teachers taking action or making changes. Of the teachers who described responses of *tempered radicalism*, all talked about action alongside their words. “If I don’t agree, and I have a good reason for not agreeing and you’re not listening to me, I lead by example. I make the change and do what I know is best for my kids" (Dawn, Interview, 12/20/18). Countering and responding with *tempered radicalism* did not include only *speaking* truth to power, but also putting thoughts, words, and ideas into *action*. Responses of tempered radicalism mostly occurred within the classroom. However, some teachers sought to change structures outside of their classroom, in small, respectful ways that were meant to have a change impact on the environment around them.

Connections to the literature. Schools are social worlds sometimes characterized by unequal power relations and discourses that result in the oppression and silencing of teachers. As discussed in Chapter II, there are three commonly held tension metaphors explaining how teachers respond as tensions and dilemmas arise (Braaten & Sheth, 2017): (a) dilemmas as roadblocks, (b) dilemmas as accommodation, and (c) dilemmas as productive. The roadblock metaphor (Hammerness, 2004) is used to show how the constraints of traditional schooling prompt teachers to abandon certain practices despite desiring to teach in a way aligned with their professional vision. When tensions and dilemmas are sources of accommodation (Smagorinsky, Cook, et al., 2004), teachers do not see them as a complete barrier, but rather as a tension that they can manage. In these cases, teachers make accommodations to their practice to manage the tension and work within it. Productive responses to dilemmas include using the actual source of tension as groundwork for teacher reflection and analysis so that teachers can engage in a reconciliatory process of wrestling with and working through the dilemma (Stillman, 2011).

The common tension metaphors present in the literature do not fully capture the breadth of teachers' responses. When teachers see dilemmas and tensions as roadblocks (Hammerness, 2001), accommodating (Smagorinsky, Cook, et al., 2004), and productive (Stillman, 2011), they react to these dilemmas. However, it is difficult in this study to characterize teachers' responses to dilemmas as *reactions* to tensions. Teachers did not simply react to problems. They responded to dilemmas by navigating the tensions and drawing on their sense of self, or who they want to be, when their professional expertise seemed to collide with policy-related mandates, programs, and, sometimes, the administration implementing them. As mentioned previously, teachers narrated mainly political, or policy-related, dilemmas. Relatively few scholars have explored teachers' responses to policy-related dilemmas in light of their personal self-concept or sense of self (Stillman & Anderson, 2015), even though Lampert (1985) argues that teachers' efforts at managing and responding to dilemmas are often guided as much by a sense of *who I am and want to be* as they are by a sense of *what I need to do*.

Teachers' sense of self and self-concept played into how they responded to dilemmas (Shavelson et al., 1976; Yeung et al., 2014). Earlier examples in the data illustrated how a teacher's self-concept (e.g., "I'm a rule follower") affected their response to dilemmas and how teachers negotiated power differentials. Teachers responding with compliance had their voices diminished (rather than elevated) as political dilemmas undermined their professional vision and professional expertise. In contrast, teachers responding to dilemmas with tempered radicalism drew on professional expertise and identity and worked to re-author policies and policy-related tools. For some teachers, this ultimately empowered them as instructional agents—authors of pedagogy, programs, and policies and curriculum creators rather than curriculum technicians and implementors.

Implications.

> When I watch student teachers learning to teach, I am also witnessing them confront challenges to their identity, beliefs, and values, often at the limits of their knowledge. Some recognize that they are being challenged this way; others do not. Regardless, their private struggles are in full view . . . (Larkin, 2013, p. 9)

Larkin says this about the discomfort he feels watching student-teachers teach. I can sympathize. Over the years, I have shared my classroom with eight student-teachers (and countless preservice teachers); indeed, it is uncomfortable to watch them confront these challenges. I also think about the dilemmas in-service teachers face and wonder how we prepare preservice teachers to respond to these same challenges, knowing that the majority of beginning teachers will find themselves teaching in high-needs schools (Silin, 2010). What could teacher education look like if we took the issue of naming and normalizing dilemmas seriously, helping preservice teachers see that their role is not to simply respond with compliance and cultivating their skills to artfully and tactfully speak truth to power? To prepare teachers for the realities of high-needs schools, teacher educators must instill in their students the resolve to do what is best for children, regardless of instructional context and corresponding mandates. Researchers have suggested that teachers who thrive have a clear professional vision for their teacher (Fairbanks et al., 2010). Ideally, teacher educators could continue to help new preservice teachers identify, explain, build, and maintain their visions as they move from university coursework and into their first few years of teaching (Mascarenhas et al., 2010).

Preservice teachers need experiences where their prior knowledge, personal goals, and conceptions about teaching are the objects of study. When preservice teachers are allowed to interrogate their own ideas, they also develop their abilities to reframe problems and challenges, access different ways of thinking about teaching, identify new solutions to their problems, and, ultimately, respond to dilemmas of practice in productive ways (Larkin, 2013). It is important to prepare teachers as professionals, equipping them with the knowledge, skills, and agency to speak back to dilemmas rather than respond with compliance.

Research Question 5: The Nature of STEM-Linked Professional Agency

Summary of findings. Elementary teachers wrestled with dilemmas of practice because they found their professional vision for science and engineering in high-needs schools competing with institutional ideals and demands on their practice. Teachers who respond to dilemmas of practice centering on science and engineering instruction with deferential resistance and tempered radicalism draw on their STEM-linked professional agency to do so. In addition to the conceptualization of professional agency as a content-specific construct, teachers also narrated six additional key characteristics about the nature of their professional agency: (a) STEM-linked professional agency has a more nuanced definition when grounded in the data, (b) STEM-linked professional agency is visible in moments where science and engineering were both highly thinkable and doable in teachers’ classrooms, (c) STEM-linked professional agency is not a final form accomplishment, (d) teachers began the year with optimism, (e) teachers need community to foster and draw on STEM-linked professional agency, and (f) STEM-linked professional agency is socially and contextually influenced.

As a reminder, I defined teachers' stem-linked professional agency as teachers dynamically and creatively working within the contexts of high-needs schooling to create change and align practice with professional vision in innovative and responsive ways. Teachers described the thinkability and doability of their science and engineering instruction over a school year. Moments of STEM-linked professional agency were visible when teachers described science and engineering as both highly thinkable *and* doable. In those moments, teachers discussed action-oriented changes in their instruction to align practice with their professional vision. Working within the contextual parameters of high-needs schools, teachers created change within their workplace to align practice with vision in ways that were innovative and responsive.

Connections to the literature and implications. Teachers are urged to utilize agency in their professional workplace (Edwards, 2011). They are encouraged to be active professionals (Sachs, 2000) and change agents in the interests of their students (van der Heijden et al., 2015). There have been many studies that define and demonstrate the complexity of teachers' professional agency. This study adds to that body of literature by illustrating the nature of professional agency when specifically focused on science and engineering instruction given the unique contexts of U.S. high-needs elementary schools and by showing the dynamic nature of teachers' STEM-linked professional agency as it oscillates over a school year. This view of professional agency takes into consideration the complex interplay between teachers' professional vision and the sociocultural conditions of high-needs elementary schools and how that interplay functions as dilemmas of practice that teachers confront and work through. It grounds a definition of STEM-linked professional agency for elementary teachers committed to teaching science and engineering in high-needs schools in the data. It provides a more distinct view of this agency as a phenomenon where teachers work to align practice with robust professional visions in innovative and responsive ways.

One implication of this is the idea that professional agency as a broad construct can be seen differently when viewed from a content-specific lens. Exploring teachers' professional agency through a science and engineering lens and as STEM-linked professional agency surfaces the things specific to science and engineering that influence professional agency. For example, school norms, community expectations, teacher beliefs and visions, and teacher support structures vary and function differently between content areas. Focusing professional agency with a content-specific lens allows researchers to see the social, cultural, and historical differences with regards to content areas affect professional agency in small but distinct ways.

Connection: STEM-linked professional agency ebbs and flows. Teachers' STEM-linked professional agency ebbed and flowed over the school year. It was neither a fixed quantity or trajectory, nor was it an achievement to be accomplished and maintained. In contrast to the ways existing literature frames it, STEM-linked professional agency is neither a final form achievement or accomplishment (Biesta et al., 2015), nor is it a binary construct (Wei & Chen, 2019). Teachers' stories point to the problematic nature of defining professional agency in these straightforward ways. Teachers' narratives spoke to the fact that as teachers contended with school procedures, pressures to certain practices, high-surveillance cultures, narrowed or prescribed curricula, skeptical colleagues, and pressures to raise student achievement data in other content areas that their STEM-linked professional agency fluctuated, sometimes a little, and sometimes wildly.

Most teachers narrated the rise and fall of their STEM-linked professional agency. Support, autonomy, trust, and recognition foster teachers' STEM-linked professional agency and facilitated enactment, while institutional constraints, disconnects between teacher and school professional vision, loss of autonomy, and accountability pressures constrained STEM-linked professional agency. Consider the differences between Elliot's and Marlene's STEM journey maps (pp. 167 and 205, respectively); both teachers narrated fluctuation in the thinkability and doability of science and engineering in their classrooms, and therefore their STEM-linked professional agency. However, exploring their narratives and their journeys longitudinally not only allowed me to see this fluctuation but to understand why that ebb and flow occurred. Marlene's struggles with the pedagogical expectations of her school and Elliot's struggles with isolation and professional loneliness run the risk of being obscured by only investigating professionally agentic moments or a single view of teachers' experiences. Different sociocultural conditions of Elliot's and Marlene's schools facilitated and constrained the enactment of their STEM-linked professional agency differently, causing the ebb and flow of professional agency.

There have been calls to examine professional agency using life-history methods (Edwards, 2015). I think this study, its methods, and its findings point to why that is and why this is important. Using Connelly and Clandinin’s (2006) three dimensions of space and narrative—asking teachers to look backward, project forward, and consider their unique context during interviews—allowed teachers to draw on memories and emotions while narrating their lived experience. Retrospective narrative protocols offer teachers a chance to make deep sense out of their journey and make inferences about how they ended up where they did (Kuusela & Pallab, 2000). Along the same lines, teachers’ STEM journey maps allowed me to capture a more comprehensive picture of the fluid and temporal nature of their STEM-linked professional agency, in part because I looked at teachers’ narratives longitudinally. Past studies of teachers’ professional agency have captured snapshots of agency (e.g., Eteläpelto et al., 2015) and chronicled critical incidents and turning points in professionally agentic moments (e.g., Vähäsantanen, 2015). Using a narrative inquiry approach, the three dimensions of space, combined with the STEM journey map, allows a deeper picture of teachers’ professional agency. It helps to get to the heart, emotion, and incidents and their meanings at multiple touchpoints in time. Exploring the longitudinal nature of teachers’ STEM-linked professional agency uncovers not just what professional agency looks like in a moment in time (e.g., Soini et al., 2015), what it enables in teachers (e.g., Eteläpelto et al., 2015), or identifies the factors that support or constrain it (e.g., Long et al., 2017). It enables us to understand teachers’ professional agency in a more robust way, the influences that catalyze their agency and solidify their professional vision, and the choices and decisions that teachers make, but also the outcome of those choices and what inhibited and constrained teachers and why.

Implication: STEM-linked professional agency ebbs and flows. Teachers do not "have" or "not have" STEM-linked professional agency. It is a dynamic phenomenon that changes depending on teachers' contexts. Examining professional agency longitudinally, taking into account its temporal nature, provides a more robust understanding of professional agency. Professional agency is linked to teachers' past, present, and future (Emirbayer & Mishce, 1998), and manifestations of STEM-linked professional agency could remain stable, or unchanged, or change over time and through given situations. It is nearly impossible to capture an accurate portrayal of teachers' STEM-linked professional agency at one moment in time. A snapshot of teachers' STEM-linked professional agency could paint a portrait of an agentic or non-agentic teacher due to the context in which the teacher is at that moment. To consider teachers' STEM-linked professional agency from a singular point of view or as a final form accomplishment fails to take into account the dynamic nature of teacher agency in and of teachers themselves as individuals.

Getting a full picture of the ups and downs of teachers' STEM-linked professional agency enables has two implications for professional development—timing and focus. Structural supports for teachers, such as professional learning opportunities, must be carefully planned in regards to both scheduling and format—the timing of teacher support and professional learning matters. The literature already tells us that effective professional development should be sustained longer than just one or two days (Garet et al., 2001; Guskey, 2002). Similarly, understanding that teachers' professional agency ebbs and flows throughout the year means that school leaders and professional learning coordinators should thoughtfully consider when opportunities are offered. Teachers began the year optimistic about their science and engineering instruction because they had received "just in time" support through professional learning, with some participating in professional learning opportunities throughout the school year. School leaders and professional learning coordinators can look to the oscillating nature of teachers' professional agency to find moments for ongoing support and professional learning throughout the year, targeted at those moments when teachers find their STEM-linked professional agency more difficult to enact.

Teachers' STEM-linked professional agency ebbed and flowed because there were sociocultural influences that facilitated and constrained their enactment of that agency. Well-designed professional learning opportunities will consider this. Understanding not only that teachers' professional agency fluctuates throughout a school year, but also *why* it fluctuates, helps professional development providers situate professional learning in teachers' contexts, making it coherent and meaningful. This connection helps teachers surface contextually specific dilemmas of practice they encounter when working to integrate and enact science and engineering in their classrooms and curricula and provides teachers with exemplars and support in responding to these dilemmas.

Connection: Teachers' optimism. All but one teacher in Phase II of the study began the year quite optimistic about science and engineering instruction. This indicated that teachers began the year with a robust professional vision for science and engineering instruction that served as a foundation for their vision going forward throughout the school year. For the most part, teachers held on to their professional visions throughout the school year. However, a strong professional vision is only one component of teachers' STEM-linked professional agency; as teachers wrestled with dilemmas and worked through constraints, their agency often fluctuated as it was shaped and reshaped by social and contextual influences.

Teachers' STEM-linked professional agency depends upon a relationship among professional vision, current practice, and institutional context. Much of the literature focusing on teachers' professional agency centers the relationship between teachers' actions, personal resources, and the sociocultural conditions of their workplace (Eteläpelto et al., 2013; Toom et al., 2015; Vähäsantanen, 2015). When I began this study, I struggled with understanding the multiple conceptualizations of teachers' *personal resources*. The literature often describes personal resources as a combination of professional identity, commitments, beliefs, ideals, motivations, visions, interests, and goals (e.g., Eteläpelto et al., 2013). However, the literature underestimates the role of vision in the enactment of professional agency. I found that the nature of teachers' professional agency is highly dependent on the relationship between professional vision for science and engineering and institutional context. This complex relationship is much like what Hammerness (2001) terms *distance*—the space between teachers' professional visions and their current practice.

Teachers exercised their STEM-linked professional agency in moments where science and engineering were both highly thinkable and doable, meaning that they found themselves able to align their current pedagogical practices with their professional vision. Teachers who found the distance between their professional vision and their current practice to be small (close) felt that the space between vision and current practice was reasonable; they were able to navigate it (Hammerness, 2001).

When teachers found the distance between their professional vision and current practice to be a wide chasm, the distance provokes feelings of discouragement and despair. Teachers discounted their professional visions as unrealistic or undoable, perceiving that it was more difficult to enact STEM-linked professional agency. Professional vision plays an important role in teachers' professional agency and STEM-linked professional agency. Teachers' robust professional visions served as a foundation from which they made their decisions and choices about their practice.

Implication: Teachers' optimism. But, the question remains: How do we reduce the distance between professional vision and practice, make science and engineering both thinkable and doable, to foster STEM-linked professional agency in elementary teachers? To support professional agency relative to science and engineering instruction in high-needs schools, it is necessary to create professional learning opportunities where agency-promoting principles (e.g., robust professional visions, navigating dilemmas) are acknowledged and fostered. Professional learning settings such as professional learning communities (Stoll et al., 2006) or communities of practice (Wenger, 2011) create social, interactional spaces (Lipponen & Kumpulainen, 2011) that acknowledge teachers as knowledgeable equals positioned to help collectively foster professional agency in the learning community. Fostering STEM-linked professional agency concerning dilemmas and professional vision in such an interactional space is a twofold process. Teachers need a clear professional vision for science and engineering, both individually and collectively, within the learning community. After identifying dilemmas of practice that may be keeping teachers from fully aligning their practice with their professional vision, teachers work together in a collective inquiry approach to diminish these obstacles—fostering STEM-linked professional agency.

STEM Program's Community of Inquiry (COI) groups (previously mentioned in Chapters III and V) are a good example of professional learning opportunities that foster STEM-linked professional agency by addressing the relationship between dilemmas of practice and teachers' professional visions for science and engineering. While not part of this study, COI groups are an implication; the results of this study explain the configurations and successes of STEM Program COI groups well. Using some of the preliminary findings from this study, the second iteration of COI groups established interactional spaces for teacher community and learning. These were based on discourse, dialogue, values, and shared professional visions. Teachers engaged in a collective inquiry process around a problem of practice. Through the teachers' participation and shared discourse, they fostered, negotiated, and re-negotiated STEM-linked professional agency, which they used to bridge the gap between their professional vision and practice as they took initiatives to transform the dilemmas encountered in their own classrooms.

Connection: Social and contextual influences. Sometimes I think the word "community" is at risk of losing its meaning. In education, terms are prevalent such as "communities of learners," "discourse communities," "educational communities,"

"communities of inquiry," "professional learning communities," and "communities of practice." However, all of those iterations of "community" hold an idea of a communal space where meaningful social interactions offer a modicum of support and care and broaden people's sense of self beyond the "me" and "I" into the "we" and "us" (Grossman et al., 2000). Teachers in this study needed community. Social interactions, both formal and informal, that offered support and care shaped teachers' professional visions, enabled teachers to see science and engineering as more thinkable and doable, and emboldened STEM-linked professional agency. The idea that professional communities and teacher communities are important to teachers is not new. Teachers who find connections with colleagues and peers with shared commitments, values, openness, and willingness find themselves supported and more likely to persist in the face of challenges (Riveros et al., 2012). However, narratives such as Elliot's and Holly's add to the literature by illustrating incremental ways that community influences teachers and their professional agency. Elliot's narrative, when Susan recommended he attend the STEM Program Summer Institute, provides an example of how a supportive colleague makes all the difference and impacts professional vision, but also how he desperately needed more access to community as soon as that support was gone. Holly's narrative gives us examples of how finding a professional community and small steps towards finding your place in that community helped her see science and engineering as thinkable and doable.

This study was framed by a subject-centered sociocultural view of agency—implying that professional agency is an individual construct (Eteläpelto et al., 2013). The framework implies that both personal resources and the sociocultural conditions of a teachers' school frame their agency, but does not go far enough into the idea that the development and enactment of professional agency are social and contextual by nature. The teachers in this study constructed and enacted their STEM-linked professional agency in relation to others, including teachers, administrators, students, and the whole community. Not only is STEM-linked professional agency not a fixed quality or an achievement, but it is also interactive; it is something that teachers do in practice and as part of a delicate dance in their context (Lipponen & Kempulainen, 2011).

Implication: Social and contextual influences. Considering that STEM-linked professional agency is interactive and socially and contextually influenced, teachers need (a) ongoing support and community, (b) a way to reflect on their own agency in context, and (c) exemplars of professional agency in action. Giving teachers access to community contexts would provide teachers with a level of support to persist in the face of dilemmas and challenges, understand policies that are driven down from above, and seize power to help shape those policies in ways that make sense in their classroom and localized contexts. Teachers, both novice and seasoned, need to be supported by professional learning and communities of colleagues, immersed in reflective intellectual inquiry into their practice, and given opportunities for leadership development within their professional contexts—classroom, school, or school district—or beyond.

Knowing that STEM-linked professional agency is socially and contextually influenced, teachers need to be able to reflect and see how they drew on their professional agency to successfully navigate social, cultural, and institutional conditions in their quest to teach science and engineering. Teachers can learn from other teachers' narratives about how they successfully navigated those same challenges. In doing so, we provide teachers with a bit of a roadmap, but not a recipe. Professional agency has no formula. Teachers cannot reflect on their experiences or look to another teacher and expect that the same actions are going to function in the same manner—because teachers and their professional agency are continually shaping and being shaped by their context. However, teachers can draw on their lived experiences and other exemplars to understand their own professional agency, what affects it, and how to wield it. These teachers are better positioned to no longer reproduce the status quo within schools and within society. This kind of teacher emancipation happens when teachers understand that with their professional agency, they are capable of disrupting hierarchies and systems that continue to push them down and that continue to push a model of an idealistic view of teaching and learning.

Revising the Conceptual Framework for Teachers' STEM-Linked Professional Agency

The idea of teachers as active agents within their professional workplace, i.e., classrooms and schools, has long been central in educational research as well as practices and policies (Toom et al., 2015). The construct of teachers' professional agency has emerged to describe the active efforts that teachers make to enact choices about their practice and pedagogy and take intentional action to affect change or make a difference. Teachers' professional agency is, in fact, much more than just coping with challenging situations and dilemmas. It involves acting in new and creative ways and resisting external norms mandates when those conflict with professional vision and expertise (Dovemark, 2010; Lasky, 2005).

When I began conceptualizing and operationalizing elementary teachers' professional agency within the context of science and engineering instruction in high-needs schools, Eteläpelto et al.'s (2013) subject-centered sociocultural framework inspired my conceptual framework. I added Windschitl's (2002) framework focusing on the dilemmas teachers encounter as they seek to teach against the status quo of traditional schooling and Archer et al.'s (2012) construct of science as being "thinkable." This framework (see Figure 6.1) guided this study and the exploration of teachers' experiences and narratives.

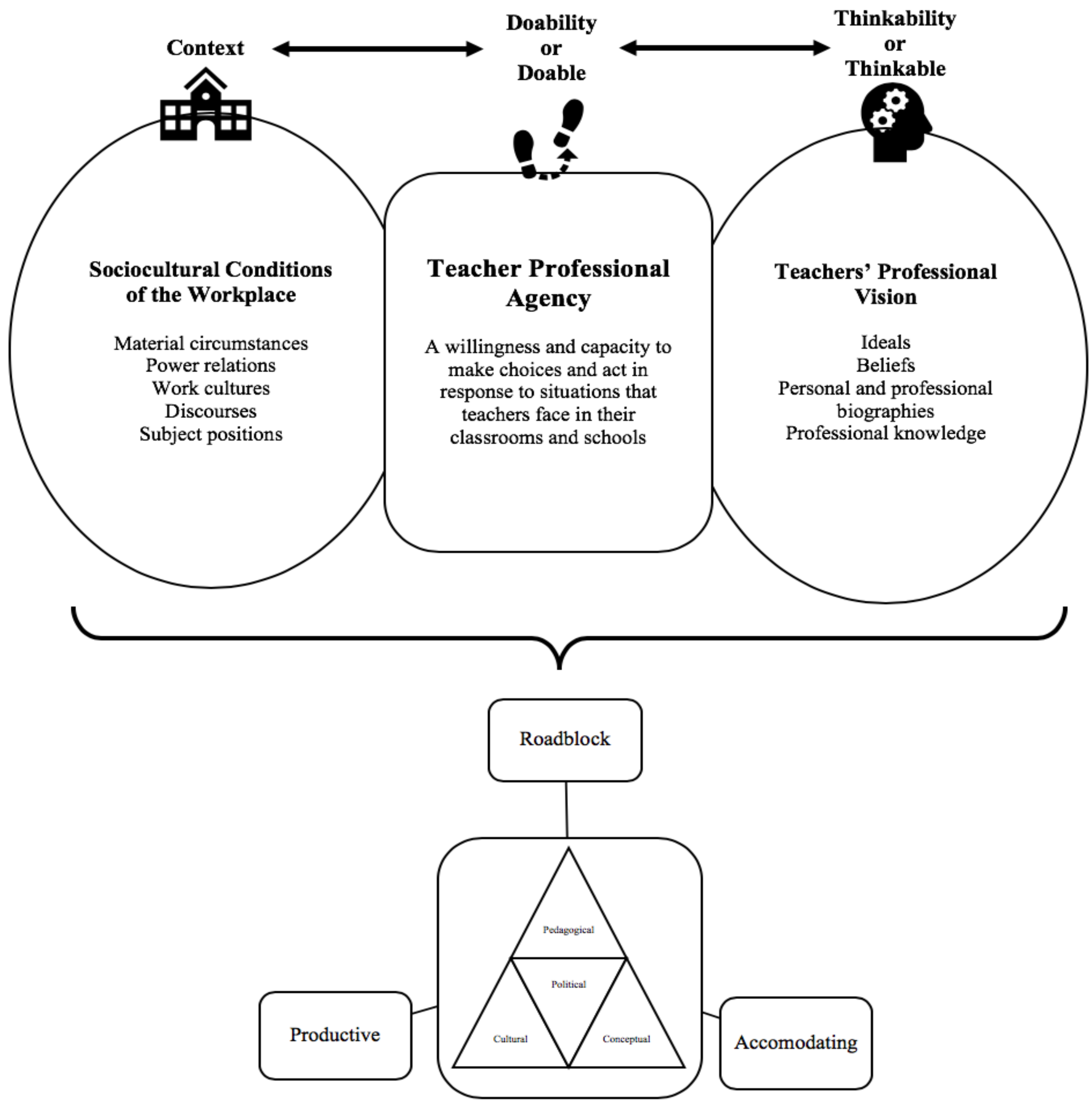


Figure 6.1. Conceptual Framework for Teachers' Professional Agency.

Now, looking back on my findings, my perspective has shifted. Thus, I amended my conceptual framework, the conceptualization of dilemmas, and definition of teachers' professional agency for science and engineering instruction in high-needs school contexts to include a more nuanced explanation—one grounded in the data and findings expounded upon in Chapters IV and V (see Figure 6.2).

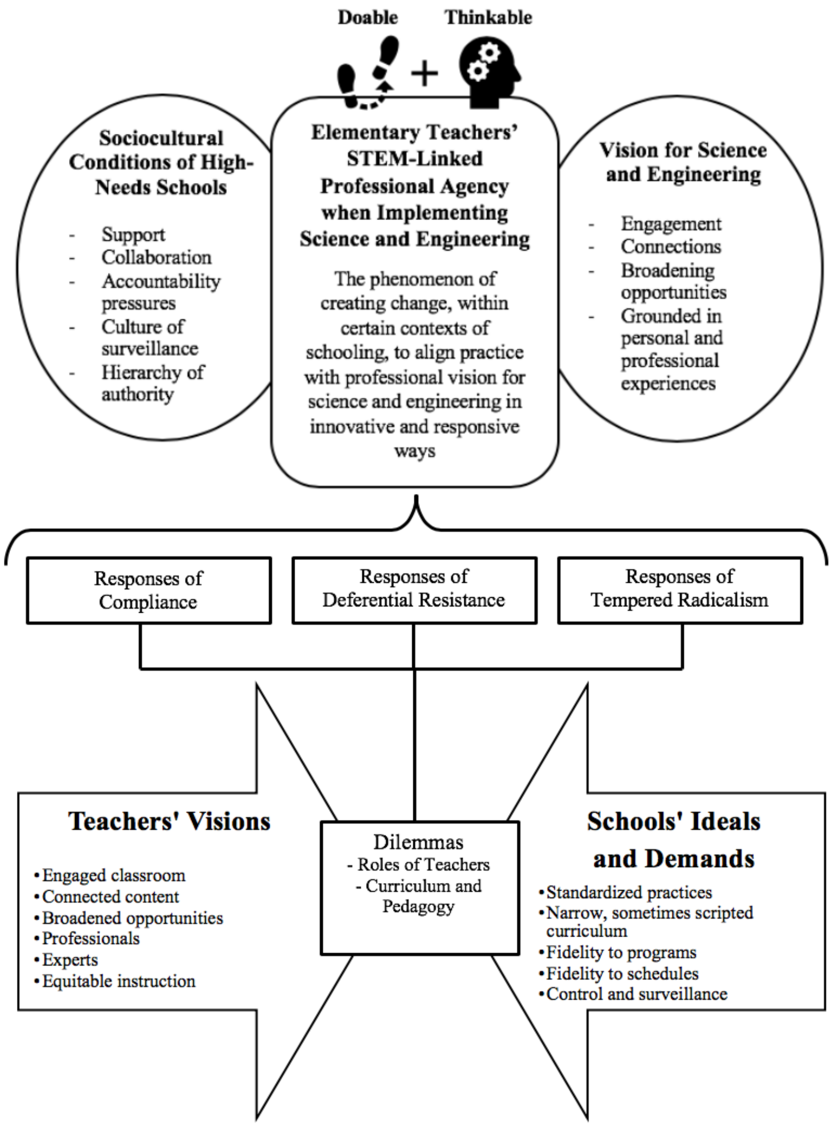


Figure 6.2. Framework for STEM-Linked Professional Agency in High-Needs Elementary Schools.

In the ongoing struggle of teacher deprofessionalization, teachers often hold a professional vision for science and engineering instruction that is often at odds with institutional ideals of and demands on their practice. Teachers experience this conflict as localized dilemmas focused on the role of teachers and visions of curriculum and pedagogy. When teachers respond to these dilemmas, they draw on their STEM-linked professional agency to act as change agents within their educational community to align practice with professional vision in innovative and responsive ways.

> If you have an idea why you're teaching, you can hold everything up to that. It's your touchstone. You won't allow things that go against that. (Duffy, 2002, p. 339)
>
> Sometimes you just have to channel your inner science warrior and go to battle for science in your classroom. (Alice, Interview, 6/10/19)

These two quotes frame this entire study. Duffy (2002) talks about teachers' visions and the process of visioning. This study began with me listening to teachers describe vision and motivations for teaching, but their professional vision for science and engineering instruction. As Duffy suggests, teachers held their visions as touchstones, as the foundation for what they said and did, how they responded to dilemmas, and how they enacted their STEM-linked professional agency. The second quote comes from Alice, a first-grade teacher, who holds a robust professional vision for what and how she teaches science and engineering. It is, in part, her vision that allows her to "channel [her] inner science warrior and go to battle for science" in her classroom. As Duffy (2002) says, her vision is her touchstone, and she will not allow things to stand against it. There is a direct link between teachers' visions and their STEM-linked professional agency. It serves as a touchstone, for almost all teachers and not just for Alice, and frames the enactment of their STEM-linked professional agency in response to dilemmas.

STEM-linked professional agency allows teachers to *re-professionalize* themselves and think and do differently with their science and engineering practices (Beech, 2006). Teachers' STEM-linked professional agency underscores teachers' abilities and efforts to act on the beliefs and convictions that they draw from their professional visions. Holland et al. (1998) contextualize agency as the ability to engage in one's environment actively and respond to one's surroundings. Here, teachers harnessed a sense of their professional agency, used their professional visions, and acted purposefully on their environment to shape and reshape the educational contexts in which they taught. These teachers often persisted in the face of perceived dilemmas. Fueled by their professional visions to "channel your inner science warrior" (Alice, Interview, 3/6/19), teachers harnessed their STEM-linked professional agency to push boundaries creatively and align their practice with their vision in innovative and responsive ways.

Limitations

First, this is a study based on the personal, lived experiences and narratives of teachers in high-needs elementary schools. Their experiences, and therefore their narratives, are limited to certain times and spaces of the individual teachers. While I spent a considerable amount of time with most of these teachers outside of this study through my work with the University STEM Program and inside the study while collecting their experiences and narratives through interviews, I do not have personal insight into teachers' classroom practices, the instructional changes they narrate making, or the impact their science and engineering instruction had on their students. The literature on narrative inquiry acknowledges this as a potential limitation in its design. Clandinin and

Connelly (2000) state that one of the criticisms of narrative inquiry is that it is "essentially a linguistic form of inquiry" (p. 77)—that of story recording and telling. This can also call into question the process of re-storying teachers' narratives and being sure that the narrative is authentic to the teachers' experiences and stories.

I selected the teachers, in part, due to their association and participation with the University STEM Program. No one mandated that teachers participate in professional learning with the STEM Program. While some teachers attended the STEM Program Summer Institute based on the recommendation of a friend or colleague, teachers still *chose* to attend and be associated with the STEM Program. This is to say that the teachers in this study were all committed and motivated to integrating and enacting science and engineering instruction in their classrooms. Some might say that these teachers already possessed and drew upon a certain amount of STEM-linked professional agency to begin with, which would be an accurate assumption. While there were teachers in this study who identified as "not a science person" (Ava, Interview, 1/16/19) or "just not as science-y as everyone else" (Megan, Interview, 1/11/19), this study began with a pool of participants predisposed to working toward integrating science and engineering into their elementary curricula.

Researcher bias is another potential limitation that I acknowledge in this study. I have an admitted closeness to both the teachers in my study and the STEM Program and its many teacher supports. The teachers reported positive experiences with both STEM Program professional learning opportunities and me, as a STEM Program team member and professional learning facilitator. I have been a teacher, and am currently a tutor and consultant, in the same school district as many of the teachers. I had taught in the same school with some of these teachers, been a cooperating teacher when some of these teachers were pre-service teachers, and worked in many of their classrooms as a STEM coach, mentor, and, many times, a classroom volunteer. Some might label me as being "too close" to the research. I know the school districts, their policies, their school- and district-level administrators, and inner workings. While it is the case that this closeness with the teachers in my study established open and trusting relationships that resulted in the sharing of rich narratives, I had to be cautious to ensure that I represented the voices of the participants as they told their stories and not color their lived experiences in a light skewed by my own interpretations and associations.

Future Research

As a beginning researcher, there is much more that I need to learn. At the end of the Phase I interviews and data analysis process, I yearned for a different set of questions. Is it possible that one purpose of research is to learn which questions to ask? I wish I knew how prominently teachers' professional visions would figure into the study as a whole, and I wish I had crafted those questions better—truly to get at the heart of the matter.

> Examining the focus, range and distance of teachers' visions provides a means of understanding the way teachers feel about their teaching, their students and their school; the changes they make or do not make in their classrooms; and even the decisions they make regarding their futures as teachers. (Hammerness, 2001, p. 147)

Beyond crafting more nuanced interview questions that could have explored teachers' professional visions for science and engineering better, future studies need to be conducted focusing on the complex relationship between teachers' visions, their professional agency, and how they act as change agents within their multiple contexts. This study is an attempt to look at small parts of that relationship, but I am convinced that this is only the tip of the iceberg.

Exploring teachers' STEM-linked professional agency surfaced many questions. I am curious about the implications of this research for educational leadership. Leadership and administration made a difference for teachers, their dilemmas, their responses, and their STEM-linked professional agency. It will be important to explore the role of administrators and those holding positions of authority and power over classroom teachers, their professional visions of science and engineering in high-needs schools, and how their actions foster or inhibit STEM-linked professional agency for their teachers and themselves.

Someone recently asked me how my findings might differ in a different context, such as teachers in smaller, rural schools. My answer was that I did not think that size mattered. What I meant by that was that I assume all teachers face some kind of dilemma of practice when they work to enact science and engineering in their elementary classrooms. But what is the nature of that dilemma? And, how does that translate to the nature of STEM-linked professional agency for those teachers? The contexts for research on professional agency, but especially STEM-linked professional agency, are so narrow, that exploring this construct in various contexts would be illuminating.

Teachers often narrated that they “changed their practice” after professional learning opportunities, receiving support from colleagues, and when they felt emboldened as tempered radicals (Meyerson, 2001) to draw on their STEM-linked professional agency and act as change agents. As mentioned before, the fact that no data are corroborating these claims is a limitation of this study, and I was left wondering what, exactly, that change looked like in practice. Therefore, observing teachers’ practices or collecting data specifically about teachers’ practices and changes in those practices could help paint a better picture of the connections between science and engineering’s thinkability and doability and teachers’ STEM-linked professional agency.

Finally, I believe that it is incumbent upon teacher educators to find ways to foster professional agency of all types, but especially STEM-linked professional agency in teachers so that they feel capable of closing the gap between professional vision and practice and persisting in working through dilemmas. I imagine using the findings to create design principles for professional learning experiences. Using those design principles, interactional spaces could be established that would empower teachers and position them as experts and professionals, fostering STEM-linked professional agency that teachers would feel able to transfer to their pedagogical practices and educational environment. No matter what, teachers’ STEM-linked professional agency and teacher professionalization should be further considered and commended. Child psychologist Haim Ginott said it well, “Teachers are expected to reach unattainable goals with inadequate tools. The miracle is that at times they accomplish this impossible task” (1976).

CHAPTER VII

EPILOGUE

I always imagined that I would write the last words of my dissertation alone in a quiet place (it is how I work best). Never, however, did I imagine that my quiet solitude would include being the only person in a building on a university campus devoid of people due to a global pandemic. This is social distancing at its finest. As I write this, our world is in a panic over COVID-19. Just this past week, physical school buildings in the state closed to students, and all instruction has transitioned to virtual learning. We gave educators almost no notice. We asked them to completely redesign the idea of "school" and what it means to "go to school," and in less than 24 to 48 hours, local administrators and classroom teachers functioned like a resourceful, inventive think tank and devised a plan; students' learning, feeding children and families, and needs to be met during a global crisis.

To be clear, the governor closed schools—a difficult but necessary decision. But the plan, the fix, did not come from a state agency or an expert on teaching and learning. Local educators figured out how to meet the needs of their students in a matter of hours. Existing state and federal policies created multiple roadblocks. Educators in local schools and school systems figured out how to creatively manage those roadblocks, too. Yes, there has been a steep learning curve, but our educators dug in, found solutions, and developed creative fixes in the best interest of the children. Teachers have networked with each other, connected with their students, checked in on one another, devised engaging and thoughtful learning activities for students, worried about the health and safety of loved ones (students, families, and communities included), and more over the past few days. Educators may have *redefined* what it means to "teach," but in the meantime, they have *reminded* our communities what it means to be a teacher and an educator.

There are a lot of memes and social media posts circulating from parents joking about how they are ready to retire from teaching after homeschooling their children for a few days and rallying behind teachers saying they deserve extra pay. And while I appreciate them, I think we need to remember this moment the next time someone tries to convince us our schools are better run by programs, policies, and mandates that expect buy-in and compliance than by administrators who, with their own autonomy, trust teachers to act in the best interests of their students and to use their talent, creativity, professional judgment, and agency. It should not take a global pandemic and national crisis for our society to realize that teachers are amazing professionals and that, when we treat them as such, they are capable of so much. We need to support our teachers, invest in them, empower them, and then get out of their way. Teachers are professionals with immense drive and strong visions of what education could be and should be for their students.

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APPENDIX A

STEM PROGRAM POST-INSTITUTE INTERVIEW PROTOCOL

I. Professional Vision

1. Why do you teach?
2. What do you want to accomplish?
3. What indispensable message do you want to share with your students?
4. What do you hope your students will become?

II. Positioning by Others/ Resources

1. Elementary teachers are often seen as dutiful, loyal and people-pleasers. Who are the powerful stakeholders and what are the policies or norms **at your school** that influence your teaching? (Your teaching = how you see yourself as a teacher, how you structure your classroom, how you teach; Influence = enabling and constraining the ways you want to teach)
2. List all stakeholders, policies, and other things that influence their teaching.
3. Go through each one to discuss how those influence their teaching.
4. Who and what are the powerful stakeholders **beyond your school** that influence your teaching. (Your teaching = how you see yourself as a teacher, how you structure your classroom, how you teach; Influence = enabling and constraining the ways you want to teach)
5. List all stakeholders, policies, and other things that influence their teaching.
6. Go through each one to discuss how those influence their teaching.
7. So, given this context, do you speak truth to power? If so, how? If not, why not? How, if at all, do you speak up?

III. STEM Program

1. Now let me ask you about your experiences with STEM Program this past summer. I'd like to start with you thinking back to one experience or activity that was meaningful or enjoyable to you. Tell me about that experience.

   (Probes if necessary: Where were you? Who was with you? What were you doing? What did you especially like about that activity? What did you dislike (about that activity), if anything? What did you learn or take away from that experience? Why do you think this activity/experience resonated with you the most?)

2. If you were to describe STEM Program Summer Institute to a teacher who has not participated, how would you do so?
3. Now let me ask you to think about any changes you see in yourself as a result of participating in this program. (pause) In the 2 or 3 weeks

immediately following the Summer Institute how were you, or your vision for your teaching and classroom, changed by your experience? What happened to these changes in the first 2 to 3 months of school? How did these views evolve?

4. We were just talking about changes that you see in yourself and your teaching as a result of participating in the STEM Program. Are there changes that you would *like* to see in your teaching as a result of the program, but are unable to accomplish?
5. We've had some people say, "This is the best professional learning experience ever!" Do you agree or disagree? Why? What do you mean by professional learning?
6. After 6 years of facilitating these institutes, we think that engineering offers something unique in terms of teachers' professional learning. What do you think? [What, if anything, did the EiE as anchor offer up? Could the learning you describe above be accomplished as well in a different context?]

IV. <u>Vision for Science/Engineering Teaching</u>

We started by reflecting on your professional vision. Let's reflect on this again, but this time foregrounding science and engineering instruction.

1. It can be hard to teach science and engineering in elementary school. What's your opinion on this? (What makes it hard?)
2. Why do you teach science and engineering, if you do?
3. What do you hope to accomplish with your science and engineering instruction? (Hope to accomplish = personal goals regarding science and engineering teaching)
4. What supports and opportunities do you need to meet your goals?
5. Do you have any of these already?

V. <u>Wrap up and thank you</u>

1. Is there anything else you'd like to tell us?

APPENDIX B

PURPOSEFUL SAMPLING

The recruitment of the 47 participating teachers occurred through "convenience sampling" (Patton, 2002, p. 241). Following the STEM Program Summer Institute, all participating teachers were approached through personal contact. Recruiting was not necessarily challenging, with 47 out of 52 teachers agreeing to participate in the study. For Phase II of the study, I narrowed the pool of teachers to 18 using "critical case sampling" (Patton, 2002, p. 236). I noticed commonalities among some teachers that stood out and determined that teachers who narrated working in a high surveillance culture, spoke truth to power, held a robust professional vision for science and engineering, *and* felt capable of enacting pedagogical change in their classrooms were more likely to experienced moments of and enact their professional agency in response to the dilemmas they encountered. This could be considered what Patton (2002) calls critical case sampling because it was designed to select teachers who exemplified particular qualities that could be generalized to a broader teaching population. To complete the critical case sampling, I created two matrices using scored data and then overlapped the two matrices in order to purposefully select the teachers for Phase II.

Four core categories stood out when analyzing the data from Phase I of this study: These core categories included how teachers narrated: (a) their professional vision for science and engineering instruction, (b) how they spoke truth to power, or spoke up when they sensed a tension, (c) the climate and culture of their institution, and (d) perceptions of their ability to enact pedagogical change within their classroom. The taxonomic analysis showed three sub-categories for each core category. I assigned each sub-category a score of one, two, or three (see Table B.1).

Table B.1

Core Categories, Subcategories, and Code Scores

Core Category	**Sub-Category**	**Score**
How teachers narrated their vision for science and engineering instruction	One vision component	1
	Two vision components	2
	Three vision components	3
How teachers respond and speak truth to power	Compliance	1
	Deferential resistance	2
	Tempered radicalism	3
How teachers perceive their workplace environment	Freedom	1
	Some autonomy	2
	High surveillance	3
Amount of pedagogical change present	No change	1
	Some change	2
	More change	3

Using the core categories, sub-categories, and scores, I created two matrices, one comparing professional vision and speaking truth to power and the other comparing climate and culture of teachers' schools to the amount of instructional change which occurred. I considered professional vision and speaking truth to power to be teachers' personal and individual resources, and so, placed those two categories on a matrix together. I considered the amount of autonomy and the amount of pedagogical change teachers perceived to be related to context and structure, and so, placed those two categories on a matrix together.

To determine the subcategories where I would place teachers, I used frequency counts within the coded data. For example, Keira made five mentions of having some autonomy in her classroom and two statements that referenced having total freedom over her instructional and pedagogical practices. I gave Keira a score of 2 in the Amount of Autonomy category since she made more statements referring to some autonomy (Keira, Interview, 1/8/19). I repeated this process for all teachers, assigning scores in the Amount of Change and Speaking Truth to Power core categories. Teachers narrated their professional visions in mainly three ways: (a) engagement, (b) connections, and (c) broadening opportunities. To determine teachers' scores for the Professional Vision category, I used the taxonomic analysis and frequency counts to assess how many components of a robust vision the teacher narrated. I considered a "robust" vision to be strong, rich, and full-bodied; in other words, a robust professional vision would be multifaceted, layered, and consist of more than one component. Therefore, a teacher who described all three components of professional vision received a score of three, while a teacher who described only one component of professional vision, no matter which it was, received a score of one.

Next, I used the core and sub-category scores to place teachers on two matrices—Amount of Change versus Amount of Autonomy and Professional Vision versus Speaking Truth to Power (see Figure B.1 and Figure B.2, respectively). These matrices provided me with a sample of teachers who were especially experienced with desired criteria—a robust professional vision, speaking up and speaking back to tensions, contexts with little to no autonomy, and enacting pedagogical change in the classroom. Matrix #1 (Structure, Ability, Action) allowed me to locate teachers who were able to enact pedagogical change in their classroom and who experienced little to no autonomy for how and what they taught. Matrix #2 (Mindset, Vision, Disposition) allowed me to locate teachers with a robust professional vision for science and engineering instruction and who responded to tensions by speaking up and speaking back to power and authority. In both cases, these were teachers with scores of 2-3, 3-3, and 3-2.

Matrix #1 **(Structure, Ability, Action)**		**Amount of Change** (the amount of change they were able to make to their practice)		
		1 No Change	2 Some Change	3 More Change
Amount of Autonomy (how teachers narrated their environment)	3 High Surveillance	Amelia Sadie Adeena Elle Elliott Karleigh	Holly	Alice Susan Kendall Janice
	2 Some Autonomy	Becca Sylvie Teonna Alina Sophie	Jemma Avery Kate Jayleen Tana Chloe Kayla Keira Collete Emma Jessie Ava Dawn Alanza Zoie	Willa Laura
	1 Freedom	Tibby	Lucy Bridget Maggie Samara Marlene	Arabella Susie Easton Deanna Nichelle Neisha Megan Rhea

Figure B.1. Matrix #1. This Matrix Shows Teachers' Scores for Amounts of Perceived Autonomy Versus Amounts of Pedagogical Change That Was Possible.

<table>
<tr><td colspan="2" rowspan="2">Matrix #2
(Mindset, Vision, Disposition)</td><td colspan="3">Professional Vision for Science & Engineering
(with components including engagement, connections, broadening pathways)</td></tr>
<tr><td>1
One Vision Component</td><td>2
Two Vision Components</td><td>3
Three Vision Components</td></tr>
<tr><td rowspan="3">Speaking Truth to Power
(ways in which teachers respond and speak back to authority)</td><td>3
Tempered Radicalism</td><td></td><td>Kendall
Alina
Susan
Zoie
Samara
Laura</td><td>Alice
Holly
Dawn
Elle
Alanza
Willa
Elliott
Chloe</td></tr>
<tr><td>2
Deferential Resistance</td><td>Nichelle
Sylvie</td><td>Susie
Sophie
Adeena
Lucy
Rhea
Neisha
Megan
Keira
Teonna
Bridget</td><td>Janice
Collete
Jayleen
Jessie
Marlene
Arabella
Tibby
Ava
Kayla
Emma</td></tr>
<tr><td>1
Compliance</td><td>Jemma
Kate
Easton
Deanna</td><td>Amelia
Sadie</td><td>Karleigh
Tana
Avery
Maggie
Becca</td></tr>
</table>

Figure B.2. Matrix #2. This Matrix Shows Teachers' Scores for Components of Professional Vision Versus How Teachers Spoke Truth to Power.

I was searching for teachers who fit all four sampling criteria: (a) a robust professional vision for science and engineering, (b) responding to tensions and dilemmas by speaking up and, sometimes, with action, (c) teaching in what they perceived to be a culture of high surveillance, and (d) despite the context in which they taught, enacting instructional and pedagogical change. To find the final sample of teachers, I layered Matrix #1 and Matrix #2. Layering the two matrices allowed me to isolate teachers who met all the selection criteria (see Figure B.3). Figure B.3 shows the layered matrices, now called Matrix #3. The bolded text in Matrix #3 are labels, scores, and participant names from Matrix #1; the italicized text are the labels, scores, and participant names from Matrix #2. The shaded boxes of Matrix #3 represent the teachers who fell within my desired criteria and, therefore, my purposeful sample.

Matrix #3 (Layered Matrices)		**Amount of Change** *Professional Vision for Science & Engineering*		
		1 **No Change** *One Vision Component*	2 **Some Change** *Two Vision Components*	3 **More Change** *Three Vision Components*
Amount of Autonomy *Speaking Truth to Power*	3 **High Surveillance** *Tempered Radical*	**Amelia** **Sadie** **Adeena** **Elle** **Elliott** **Karleigh**	**Holly** *Kendall* *Alina* *Susan* *Zoie* *Samara* *Laura*	**Alice** *Alice* **Susan** *Holly* **Kendall** *Dawn* **Janice** *Elle* *Alice Alanza* *Holly Willa* *Elliot Chloe*
	2 **Some Autonomy** *Respectful Contributor*	**Becca** **Sylvie** **Teonna** **Alina** **Sophie** *Nichelle* *Sylvie*	**Jemma Dawn** *Susie* **Avery Zoie** *Sophie* **Kate Alanza** *Adeena* **Jayleen Jessie** *Lucy* **Tana Ava** *Rhea* **Chloe** *Neisha* **Kayla** *Megan* **Keira** *Keira* **Collete** *Teonna* **Emma** *Bridget*	**Willa** *Tibby* **Laura** *Ava* *Janice Emma* *Collete Kayla* *Jayleen Ava* *Jessie* *Marlene* *Arabella*
	1 **Freedom** *Compliant Teacher*	**Tibby** *Jemma* *Kate* *Easton* *Deanna*	**Lucy** **Bridget** **Maggie** **Samara** **Marlene** *Amelia* *Sadie*	**Arabella** *Karleigh* **Susie** *Tana* **Easton** *Avery* **Deanna** *Maggie* **Nichelle** *Becca* **Neisha** **Megan** **Rhea**

Figure B.3. Layering Matrix #1 and Matrix #2. This Layered Matrix Helps to Locate a Sample of Teachers Who Fit the Selection Criteria. The Sample is Shown in the Shaded Boxes.

I chose to use teachers who fell in the 2-3, 3-3, or 3-2 sections of Matrix #3 because these were teachers who held a robust vision for science and engineering comprised of two or more vision components, felt able to enact some or many changes to their pedagogical practice, spoke truth to power when encountering a problem or tension, and perceived themselves as working in a culture of high surveillance or with little autonomy. In the end, 24 teachers fit within these selection criteria and I continued Phase II with 18 of these 24 teachers. Six teachers were not intentionally excluded from the sample, one teacher left the teaching profession mid-year (Alanza), four teachers declined to continue with Phase II of the study (Arabella, Jayleen, Laura, and Zoie), and one teacher was not a classroom teacher (Tibby).

APPENDIX C

STEM JOURNEY MAP INTERVIEW PROTOCOL

STEM Journey Map Interview Protocol
Teachers Narrating Their STEM Stories

This interview is meant to work like a map of your science and engineering, or STEM, journey for this past school year. I like to affectionately refer to it as a roller coaster. Beginning in August, how thinkable and doable was science and engineering instruction in your classroom?

I. <u>Mapping STEM's Thinkability and Doability</u>

1. Many elementary teachers find that the thinkability and doability of STEM fluctuates throughout the year. Just to clarify, when I say "thinkability" I mean your STEM mindset, or in other words, do you think STEM is possible or how are you feeling about STEM instruction in your classroom? When I say "doability," I'm referring to actions that you take in your classroom to implement and teach STEM, or in other words, did you take action or were you able to teach STEM?

   You'll notice that this sheet is divided by months along the bottom and smiley faces along the side. I'm going to be asking you to use blue and yellow dots to rank the thinkability and doability of STEM in your classroom at certain points over the last school year.

2. Now, let me ask you to reflect on this past school year. Thinking back to the beginning of August, just before the teacher workdays started, how would you describe STEM's thinkability for your classroom?
   - Have the participant mark STEM's thinkability on the STEM Journey Map with a blue dot.
   - Remind the participant what "thinkability" refers to, if needed.

3. Still thinking about the beginning of this past August, how would you describe STEM's doability for your classroom?
   - Have the participant mark STEM's doability on the journey map with a yellow dot.
   - Remind the participant what "doability" refers to, if needed.

4. Now let me ask you to think about the end of this past August, after the first few weeks of school, how would you describe STEM's thinkability for your

classroom? Still thinking about the end of this past August, after the first few weeks of school, how would you describe STEM's doability for your classroom?

- Have the participant mark STEM's thinkability on the journey map with a blue dot and STEM's doability with a yellow dot.
- Remind the participant what "thinkability" refers to, if needed.

5. (**If the teacher gets the format of the instrument, skip to prompt #6)** Let's fast forward to sometime in October. This would have been somewhere close to the end of the first quarter. How would you describe STEM's thinkability for your classroom? How would you describe STEM's doability for your classroom?
   - Have the participant mark STEM's thinkability with a blue dot and doability with a yellow dot.

6. Now let me ask you to think about STEM's thinkability and doability for the remainder of the map. How would you describe STEM's thinkability for your classroom? How would you describe STEM's doability for your classroom?
   - Have the participant mark STEM's thinkability with a blue dot and doability with a yellow dot.
   - Ask the participant to map the thinkability and doability for each vertical line and point remaining on the STEM journey map.

II. <u>Mapping STEM's Thinkability and Doability</u>

The interviewer will connect the blue thinkability dots and then connect the yellow doability dots on the STEM journey map.

The purpose of this part of the interview is to have the participant narrate the space between two dots, explaining in their own words what may have led to changes, what happened during that time period, why they placed a data point in a certain place, etc.

1. Let's look back at this map of your school year. I'm interested in the stories behind these dots.
   a. Tell me about why this dot is here.
   b. Tell me the story of this part.
   c. What was happening here?
   d. What lead you to feel this way?
   e. Tell me more about what happened here.

- Start all the way back in "early August"
- Ask specifically about both the thinkability and doability dots
- Ask follow up and probing questions to dig deeper and clarify participant statements

III. <u>Mapping STEM's Thinkability and Doability</u>

- If I asked you to think beyond just this past school year, what other "big science teaching moments" stick out in your career?
  - List these "big science moments"
- Tell me about what led up to __________ *(a big science moment from the list).*
- How do you think that impacted what you did next?

IV. <u>Conceptions of Time with STEM's Thinkability and Doability</u>

A lot of times when teachers are asked about science and STEM instruction in their classroom, they say that there isn't enough time. Is that true for you? Can you give me some examples of how that shows up in your classroom?

- Can you think back to a time when time has been central to your science and STEM instruction?
- To what extent do you think it is possible to achieve "enough time" for science and STEM instruction in your classroom or your school.

STEM's <u>Thinkability</u>

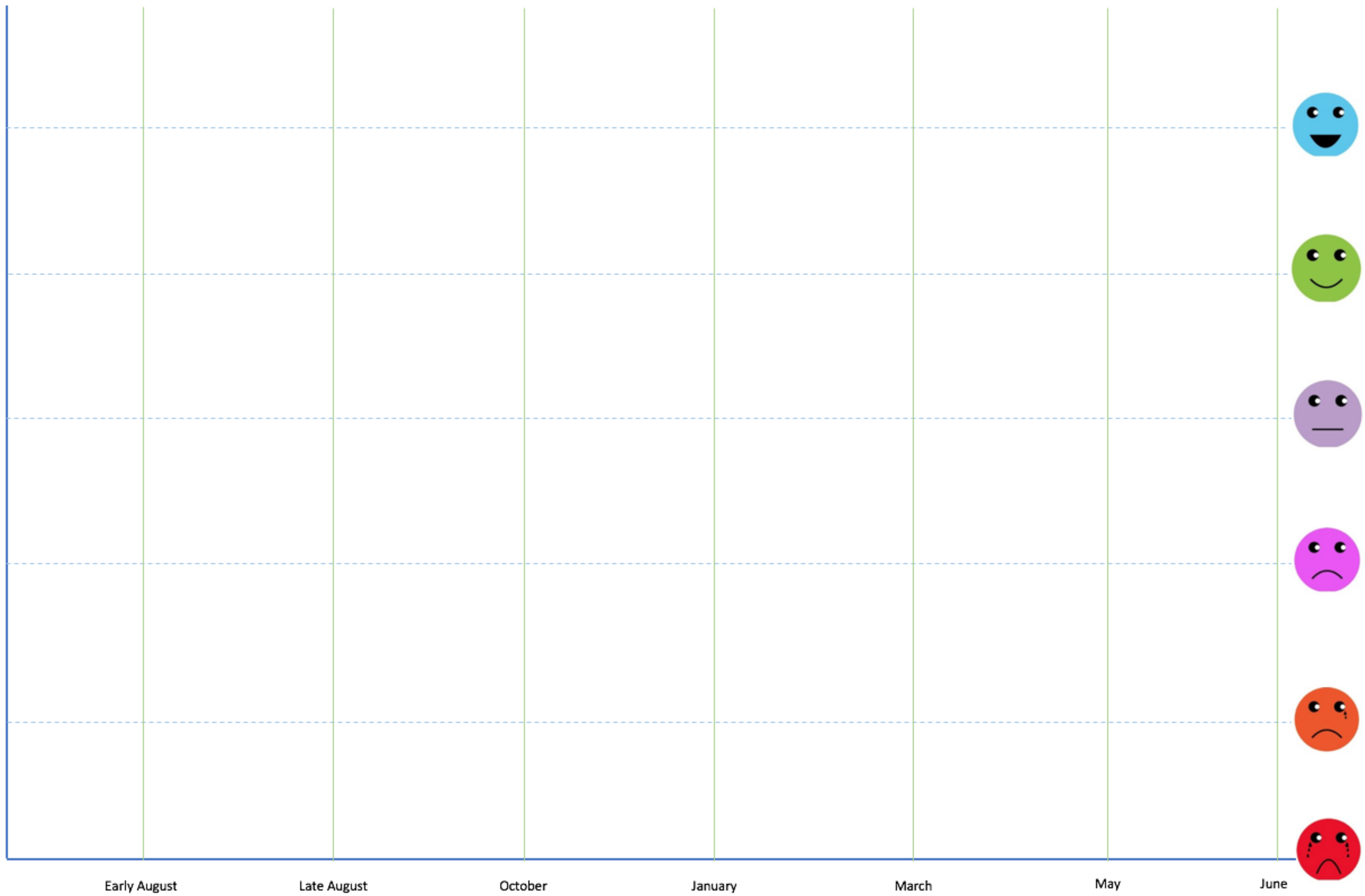
- Your STEM mindset
- Do you think STEM is possible in your classroom?
- How are you feeling about STEM instruction in your classroom?

STEM's <u>Doability</u>

- Actions that you take in your classroom to implement and teach STEM
- Did you take action to implement STEM?
- Were you able to teach STEM?

STEM JOURNEY MAP

Initials: __________ Date: ______________________ Interviewer: _______________



APPENDIX D

SCHOOL DEMOGRAPHIC INFORMATION

Table D.1

Demographics of Teachers' Schools

School	School Type	Staff Population	Student Population	% Free-Reduced Lunch	% Minoritized Students	% English Language Learners
Weaver Elementary School	Traditional Public School	39	511	99%	92%	38%
Pine View Elementary School	Traditional Public School	31	484	99%	90%	51%
Haskell Elementary School	Public Magnet School	32	545	60%	79%	13%
Strauss Elementary School	Traditional Public School	28	404	28%	24%	3%
Clayton Collaborative Elementary School	Public Magnet School with University Connections	25	421	99%	78%	13%
Purnell STEM Academy	Public Magnet School	21	285	98%	99%	6%
Wexford Elementary School	Public Magnet School	23	299	98%	97%	28%
Bradford Elementary School	Traditional Public School	28	447	68%	35%	19%
Cameron Park Elementary School	Public Magnet School	23	306	99%	89%	17%
Mount Pleasant Elementary School	Traditional Public School	22	337	98%	59%	10%