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Agency of in-service Elementary Science Teachers During a Global Pandemic

Anica Miller-Rushing
University of Maine, anica.miller.rushing@maine.edu

AGENCY OF IN-SERVICE ELEMENTARY SCIENCE TEACHERS

DURING A GLOBAL PANDEMIC

By

Anica Miller-Rushing

B.A. Mount Holyoke College, 2000

M.Ed. Boston College, 2004

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Advisory Committee:

Elizabeth Hufnagel, Associate Professor of Science Education, Advisor

Asli Sezen-Barrie, Associate Professor of Curriculum, Assessment, and Instruction

Rebecca Buchanan, Assistant Professor of Curriculum, Assessment, and Instruction

Jade McNamara, Assistant Professor of Human Nutrition

Gail Richmond, Professor of Science and Urban Education

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Thesis Advisor: Dr. Elizabeth Hufnagel

An Abstract of the Thesis Presented
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In-service teachers of science work with unique content and pedagogical experiences. Understanding teacher agency in these circumstances will help researchers understand the actions that these teachers take, actions that are consequential for shaping teaching patterns and supporting the development of students' scientific practices. The purpose of this study was to understand how the agency of six elementary (K–5) in-service teachers was expressed discursively during a global pandemic. The teachers' agency was qualitatively analyzed using a case study approach (Yin, 2012, 2017) that applied discourse analysis to identify the ways in which science teacher agency is conceptualized, afforded, and constrained through consequential saying, being, and doing (Gee, 2010) within elementary classrooms. I found that elementary science teachers conceptualize and operationalize their agency in service to the student, thus, deprioritizing their own needs as teaching professionals. The teachers have a clear sense of agency, primarily framed by a structure-agency dialectic, the scale of expression is their classroom. I also found that centering the teacher voice during the research process increased teachers' reflexivity about their professional agency. Recommendations are addressed including future considerations of in-service K-5 teacher agency in science education research.

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so gracefully modeled for our children how to authentically support a partner's ambitions. To my children, Finley and Harper, you both are the reasons I do this work. I hope in some small way I have contributed to making the world in which you are growing up just a bit better. I hope every student can creatively and whole-heartedly observe and question their world as you do. For those skills and abilities you use so deftly and take for granted today, are ways of orienting to the world that undergird science and are ways of living that I believe every child deserves to have as part of their being. I know you all sacrificed time with me during this process, and I sincerely and deeply thank you for your support to help this project come to completion.

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CHAPTER 1

INTRODUCTION

Foundational Precepts of This Work

This research is based on foundational precepts that (a) elementary science teacher agency affects and is affected by educational structures, (b) that for this research, elementary means teachers that teach in grades K–5, and (c) agency is introductorily defined through an ecological lens (Biesta & Tedder, 2006). Meaning, resources are managed and utilized in ways in which people can achieve overcoming problematic situations and that the "achievement of agency will always result from the interplay of individual efforts, available resources and contextual and structural 'factors' as they come together in particular and, in a sense, always unique situations" (Biesta & Tedder, 2007, p. 137).

Elementary science teacher agency affects and is affected by educational structures. In subsequent chapters I define and unpack what I mean by agency theoretically and operationally for this research. I also explain in what ways this research supports and expands current agency related research, especially for in-service elementary science teachers. Understanding agency is critical to understanding what educators are doing and why they are doing it (Van der Heijden et al., 2015). However, first it is important to convey the critical role of in-service elementary science teachers in achieving those valuable science education goals (Martin, 2017). Through my collaborations with elementary teachers, I have seen teachers that would not consider themselves a science teacher still achieve valuable science education goals. Although these are just a few examples they include, joining professional learning communities to develop new school-based citizen science projects, incorporating science into other subjects

because the school schedule did not allocate discrete science time, creating new curricula using community-based science projects to increase student engagement, asking for help from community partners more knowledgeable about science content, joining district science committees, and using their school yard as a space to make student-led science observations. I have witnessed elementary teachers express their science-related agency and these teachers achieved valuable science learning objectives for their students. Therefore, for this chapter, I focus on setting the stage for this dissertation by elaborating on the foundational argument that underlies this work. Specifically, that *elementary science teachers are unique and essential educational professionals whose agency is enacted in ways that navigate complex structural issues to shape effective, rigorous, and reform-based science education.*

Elementary means K–5. I refer to elementary teachers liberally throughout this work, but who do I mean specifically? Based on the Maine Department of Education (2019)'s licensing parameters, throughout this work I define elementary teachers as teachers that teach within grades K–5. Often teachers within these grades are described as generalists, they teach science as well as the other core disciplines like math, literacy, and social studies (Reys & Fennell, 2003). Therefore, they are uniquely situated to consider science education within the entire educational system including the current reform-based changes taking place in that system today (Davis et al., 2019) (i.e., adoption of the Next Generation Science Standards (NGSS) (NGSS Lead States, 2013)).

Agency definition introduction. This dissertation studies in-service elementary science teacher agency. Agency, or the actions that contribute to the creation, re-creation, and transformation of educational structures and systems (Giddens, 1984), is a critical component to understanding teachers' decisions and actions. Put another way, resources are managed and

utilized in ways in which people can achieve overcoming problematic situations (Biesta & Tedder, 2006); thus, agency is consequential (Pyhältö et al., 2014). Agency is constituted discursively, that discourse is a social action and represents all the ways in which people communicate meaning—meanings which are socially constitutive as well as socially shaped (Fairclough & Wodack, 1997). There are many ways in which people communicate their meaning—spoken word, writing/text, non-verbal communication, actions, social interactions— and since thoughts, beliefs, and emotions are constituted discursively (Hufnagel, 2019), discourse includes these as well. Examples of ways that agency is enacted, specifically within the context of elementary science teaching include using reforms, such as the NGSS (NGSS Lead States, 2013), fulfilling ambitious science teaching goals (Windschitl et al., 2018), increasing competency in science content fluency (Nichols et al., 2016), modifying science curriculum for classroom needs (Goulart & Roth, 2010; Howitt, 2011; Im & Martin, 2015), engaging in science professional development (Martin, 2019; Van Duzor, 2011), attributing agency to others (Oliveira et al., 2015), and including students' agency (Rivera Maulucci et al., 2015).

Elementary science teacher agency is expressed discursively and has outcomes which play a significant role in the classroom learning environments (Kayi-Aydar & Miller, 2018; Martin, 2019). Outcomes that directly affect the teacher themselves include their leadership decisions, their professional reflections, and their professional practice (Allen, 2018; Vanassche & Kelchtermans, 2014). Teacher agency also influences classroom community in significant ways, including class engagement and science-related identity (Hazari et al., 2015). Teacher agency even influences the educational structures in which they work by affecting curricular and pedagogical reforms and educational policy (Leander & Osborne, 2008; Priestley et al., 2012). Teacher agency are the actions teachers take to achieve outcomes, outcomes that affect the

teacher's school context—professionally, their classroom environment and/or the educational system in which they work (Van der Heijden et al., 2015). These actions are constructed to initiate purposeful action and are expressed discursively in a wide variety of ways at different times (Biesta et al., 2015; Impedovo, 2016). Teacher agency affects, and is affected by, the educational system and structures in which they work (Giddens, 1984; Gutiérrez & Calabrese Barton, 2015; Willmott, 1999). Therefore, understanding ways that science teachers express agency is an important part of understanding the ultimate success of our science educational systems (Biesta et al., 2017; Leander & Osborne, 2008).

Teachers' Important Role in Elementary Science Education

Especially since the United States' passing of the *No Child Left Behind Act* (Griffith & Scharmann, 2008; U.S. Department of Education, 2001) challenges to teaching generally have increased. The work done by teachers "has intensified, paperwork and bureaucracy have increased, and teachers have felt increasingly disempowered and professionally marginalized" (Priestley et al., 2012, p. 192). Science teachers not only faces the same challenges as teachers in general education, but science teaching is fraught with additional hurdles and challenges. Elementary science teachers have a particularly difficult set of challenges to contend with to teach science at the highest levels (Zembal-Saul, 2009), because using reform-based science teaching strategies in elementary classrooms requires an almost herculean effort of professional skills and expressions of agency (Martin, 2019).

Reform-based science teaching strategies means switching from teaching that prioritizes how science was created, primarily through the use of the scientific method, to current reforms that call for educators to build students' practices with authentic and ambitious science by using inquiry-based and "three-dimensional" methodologies (NGSS Lead States, 2013). Three

dimensional learning integrates crosscutting concepts, disciplinary core ideas, and science and engineering practices to help students learn to apply new knowledge to other situations which increases 21st century skills including problem solving, critical thinking, communication, collaboration, and self-management (Krajcik, 2015). In classrooms that are practicing reform-based science, students engage in scientific practices—the behaviors and thought processes used by scientists—asking questions, planning and conducting investigations, analyzing and interpreting data, using evidence to engage in argument, and obtaining, evaluating, and communicating information (National Research Council, 2012). By practicing reform-based science, students achieve scientific literacy in which they can explain phenomena scientifically, evaluate and design scientific inquiry, and interpret data and evidence scientifically (Organisation for Economic Co-operation and Development, 2019). To teach reform-based science, elementary science teachers must learn a new way of teaching science focused on the authentic practice of science—a substantial shift in the *what* and *how* science is taught (National Research Council, 2012).

These challenges to teach reform-based science are described as "herculean" because science education is a critical component of today's elementary education (McClure et al., 2017), and elementary teachers who are inadequately prepared to teach reform-based science at the elementary level (Smith & Gess-Newsome, 2004) are at the crux of that instruction (National Research Council, 2007). Elementary science teachers are in the middle of navigating administration, students, student learning, and current sociocultural and sociohistorical contexts (Lemke, 2001). Because of their complex roles at the center of student learning, reform, and social issues, science teachers—and thus their expressions of agency—are critical to the success of students and schools (Johnston et al., 2018; National Research Council, 2007).

The act of elementary science teachers' scientific sensemaking is influencing students' science education sensemaking (Davis et al., 2019). Sensemaking that occurs during the elementary grades is a foundational science experience (McClure et al., 2017). When elementary teachers shape the science education of their classrooms with rigorous and reform-minded practices, they are building scientific experiences that increase student outcomes—such as enhanced language, logic, and problem-solving skills (Michaels et al., 2008; National Research Council, 2012) and increased intellectual risk taking (Beghetto, 2009). Learning builds on learning (National Academy of Sciences, 2018), so the stronger the science education foundation is for a student's academic career, the more choices and opportunities that student has for future science literacy (National Research Council, 2005) and potential for a career in Science, Technology, Engineering, and Mathematics (STEM) (National Science and Technology Council, 2018). It is a moral and ethical imperative to provide all students with the experience of practicing rigorous and reform-minded science (Calabrese Barton et al., 2013). By making sure all citizens (even the youngest students) are represented in the scientific practices, all citizens will be able to have a voice in the science discourses that take place today, and the questions that science asks in the future will be better informed and more creative (Metz, 2008). It is elementary science teachers who are critical for providing a foundation for a student's experience with science practices (McClure et al., 2017). Elementary teachers are the agents of these desired changes in elementary science education (Leander & Osborne, 2008), yet, it is often these same teachers who are currently challenged to teach reform-based science practices in their elementary school classroom if science is being taught at all (Banilower et al., 2018; Tilgner, 1990; Veloo et al., 2013).

Achieving Science-Literate Elementary Students Depends on Elementary Teachers

Science educators play a central role in educating, inspiring, and guiding students to become responsible, scientifically literate citizens (Council of State Science Supervisors, 2017). Science educators are critical to achieving science education goals—improving student skills, fostering science literacy, developing a science workforce, and fulfilling a moral and ethical imperative (National Research Council, 2012). Teachers of science must also uphold the highest ethical standards of the profession (National Science Teaching Association, 2010); a profession which the Teaching Commission (2004) termed "our nation's most valuable profession" (p. 12).

In the influential text, *A Framework for K–12 Science Education* key components of science education are outlined that include science curriculum, student instruction, teacher development, and learning assessment (National Research Council, 2012). Additionally, the Council of State Science Supervisors (2017) also included that science standards, science materials, and individual teacher knowledge and practices also influence science education. These critical components to science education are all intimately connected to teachers and how they teach science. Teacher agency is expressed in part in how they prioritize those classroom activities; thus teachers, and their agency, are at the heart of the practice of science education (National Research Council, 2012). "Ultimately, the interactions between teachers and students in individual classrooms are the determining factor in whether students learn science successfully" (National Research Council, 2012, p. 255). Teachers are the lynchpin to any effort to enact or reform high-quality science education (Cuban, 1995; National Research Council, 2012). Although there are many influences on student learning outcomes, teachers are the single most important determinant of those outcomes (Ingersoll et al., 2017).

It is clear elementary teachers are playing a critical role in elementary science education (Burton & Frazier, 2012; Lumpe et al., 2012). Teachers are expressing their agency by

positioning themselves and others in discursive ways to work out moral and social consequences of these structures in which they engage through their professional practice (Martin, 2017, 2019), so what are those structures?

Structural Contexts Elementary Science Teachers Engage With

Science education researchers find that elementary teachers negotiate interwoven layers of structures every day (National Research Council, 2007). Educationally-related social structures include—but are not limited to—school buildings and materials, budgets, governance, reforms, curricula, policies, organizations, associations, companies, communities, districts and states (Carlone et al., 2015). Some aspects of the structures are more static (location of school, school funding processes), while others are more fluid (political climate, standards, administration and staff). All structures are in constant flux and make teaching science at the elementary level complex (Duschl et al., 2007). Meaning, these structures are more or less engendered at different times and under different circumstances (Wahlberg, 2014). Because structures affect and are affected by agency (Archer, 2003), understanding the structures, their layering, and their contextual inter- and intra-actions is critical to understanding elementary science teacher agency—that is, how the teachers positioning themselves and others in discursive ways to work out moral and social consequences of these structures (Harré, 2012; Harré & van Langenhove, 1999). The structures, along with a myriad of individual factors including identity, values, beliefs (Richmond, 2016), and emotions (Hökkä et al., 2019) influence how and why elementary science teachers do what they do. Thus, it is important to understand these structures and what they afford and constrain in relation to elementary science teaching. The challenging components of these structures on elementary science teaching focused on in this chapter include, (a) science teachers are at the confluence, yet not the priority, of multiple layered

structures in constant flux; (b) a global health pandemic is disrupting education making it more difficult to prioritize science; (c) a current political climate affords and constrains science education; (d) constantly evolving science content; and (e) recently evolved science standards.

Elementary science teachers are at the confluence of science education contexts.
Elementary science teachers are at the confluence of multiple layered structures. These structures are outlined into structural domains within a science education setting by Carlone et al. (2015) and include institutional, disciplinary, cultural, and interpersonal structural domains.

The institutional structures include educational policies, school science traditions, and reform initiatives. The disciplinary domain includes the organizational structures that govern the rules and regulations of everyday life, a category that includes classroom structures like normative scientific practices (Carlone, Haun-Frank, & Webb, 2011). The cultural domain is the structure of ideas and ideologies. And, the interpersonal structures consist of 'ordinary social interactions' between individuals and in communities; e.g., how students interact with one another and their teachers (Carlone et al., 2015, p. 474).

When considering these multiple structural domains that afford and constrain elementary science education, the teacher is the unifying thread connecting them all. Elementary science education is influenced by and influences the sociocultural and sociopolitical impacts of these structures (Tolbert & Bazzul, 2017), and yet it is the teacher that expresses agency by positioning themselves and others in ways to work out the moral and social consequences of these structures (Anderson, 2009; Leander & Osborne, 2008). Even structures that might not be aimed at science education specifically, including sweeping policy reforms like No Child Left Behind (U.S. Department of Education, 2001), influence the kinds of elementary science education proposed, enacted, and supported (Griffith & Scharmann, 2008); all of which greatly affect the teacher and

thus the science education that they enact (Spillane & Callahan, 2000). The nature of the structure-agent dialectic is especially complex because each structure is not equally challenging or supportive for every agent (teacher). Some elementary science teachers are more or less challenged by some structures depending on many professional and personal factors (Schwirian, 1969).

      Science teachers are not the priority. Perhaps most insidious for elementary science teachers' agency is that education's structural intent overall is to ultimately support student learning outcomes, not teacher learning or teacher practices, as evidenced by direction of funding. Although staff salaries make up the majority of elementary school budgets (Sable & Hill, 2006), supporting teacher learning and professional development is not provided or organized within teachers' work to provide professional learning programs or the time and the opportunities for collaboration with other teachers needed to best support their learning (Council et al., 2016). Not that increased funding to any educational sector automatically and directly equates to academic achievement, but how budgets are allocated (often reported as per pupil expenditures) does suggest the aspects of education that are being prioritized (Lips et al., 2008). School districts are funding the staff, but not funding the necessary on-going educational and learning opportunities for that staff to teach reform-based science in the elementary classroom (Council et al., 2016).

      Each educational structure necessitates teachers to navigate, adopt, learn, create, and support actions and ideals for their students' overall academic and socioemotional success (National Research Council, 2012). Perhaps if elementary educational structures better represented the needs of elementary science teachers directly, and shifted to prioritizing the teacher in science education, teachers would in turn feel more prepared and motivated to

navigate, adopt, learn, create and support student learning outcomes in science education. Instead, teaching reform-based science education in elementary schools requires teachers constituting their agency in ways that transform these structures to meet their needs (Rivera Maulucci et al., 2015), which is challenging (Plonczak, 2008).

Contexts are in constant flux. Each of the structural layers are each deeply contextualized, yet, are also in constant flux making them even trickier for elementary science teachers to navigate. Structures are constantly mutating, influenced by and influencing agents (i.e., elementary science teachers themselves) (Archer, 2003; Giddens, 1984), which makes understanding teachers' science-related agency especially interesting (Martin, 2017). Elementary teachers in general are challenged by so many nuances within each possible educationally-related structure it is impossible to describe each structure individually and in detail. Instead, I focus on aspects of these structures that most challenge elementary science educators specifically in this research as they teach science in reform-based, rigorous, and ambitious ways.

The current global health pandemic is challenging. A rare and recent structural context emerged that proceeded to challenge elementary science teachers to teach reform-based science, a global health pandemic. As 2020 began, a global health crisis concerning the corona virus disease 2019 'COVID-19' was starting to emerge (World Health Organization, 2020). By March 11, 2020 the virus had spread around the globe and was officially a global health pandemic (World Health Organization, 2020). During February and March the World Health Organization (WHO) took the rare, but precedented step to recommend a non-pharmaceutical option that up until now had only been commonly suggested for mitigating influenza pandemics—closing schools (Cauchemez et al., 2009)—which meant that most students never returned to their elementary classrooms for the remainder of the 2019–2020 school year,

potentially reshaping the structure of education (Tam & El-Azar, 2020). "Health officials taking the decision to close schools must weigh the potential health benefits of reducing transmission and thus case numbers against high economic and social costs, difficult ethical issues, and the possible disruption of key services" (Cauchemez et al., 2009, p. 473). Schools were closed, and all people were encouraged to social distance (and if necessary, strictly quarantine) which affected every type of education, even the education of essential medical providers that would help combat the effects of COVID-19 (Chick et al., 2020).

The global health pandemic changed every facet of education, a new structure emerged quickly and dramatically that teachers negotiated largely through expressions of agency (UNESCO, 2020). Students were sent home and teachers and administrators worked frantically to maintain community connections; monitor the physical, social, and emotional health of their students; and even create remote learning environments (Markus, 2020). Each school, district, and state pivoted to this new reality in vastly different ways, but the entire elementary educational system experienced a seismic level disruption due to the global health pandemic (Collins & Steele, 2020). Structures were disrupted almost overnight; every single teacher has been affected by this pandemic. Teachers had to navigate new policies, new modalities of teaching, new expectations and learning goals, new community-led priorities (Markus, 2020). This new structure affected every part of the educational system including science education, and elementary science teachers had to position themselves and others in ways that tried to work out the moral and social structures in which they work during this unprecedented time in educational history. This makes studying their agency during this time a rare and important priority.

From my personal experience, science education in elementary schools has been particularly hard hit during the global health pandemic. Based on my on-going work with

elementary teachers across the nation, as schools abruptly reprioritized what they would be teaching during their limited student contact time via online platforms it seems, anecdotally at least, that science often took a back seat to the subjects commonly associated with elementary—reading, writing, and arithmetic. It is my conjecture that the structural challenges already facing teaching science education in elementary schools became magnified and starkly apparent during the pandemic. Thus, this is a unique and opportune moment in time to ask teachers about their science teaching agency. The ways in which teachers critically and creatively solve problems during this seismic shift in those same structures, will give insight into their expressions of agency, of which I analyze and describe. A global health pandemic of this level is a structure that emerges rarely. However, in addition to the pandemic, there are additional structures simultaneously affecting how elementary science teachers are constituting their agency with significant outcomes for elementary science education (Calvert, 2016) these additional structures are discussed next.

The current political climate affords and constrains elementary science education.
In addition to a global health pandemic, the political climate around the nature of science affords and constrains elementary science education (Tobin, 2012). Currently, in some ways our political climate affords science education; there is a desire to actively include all people in science (Travis, 2017), including all elementary teachers (Plonczak, 2008). However, at the same time, the current lack of actualized equity and diversity in science is a challenge that many organizations, groups, governments, and funders are still trying to tackle (Intemann, 2009; Katzenmeyer & Lawrenz, 2006; Medin & Lee, 2012). The current sociopolitical climate, including its desire to include more diverse representation within science, is yet another structural component for elementary science teachers to try and work out through their

expressions of agency. Not only must teachers teach science, but they are also confronted with the moral responsibilities to make science more equitable and diverse (Douglas, 2003). Elementary teachers influence the moral and ethical foundations for many of their students, and are generally the first models students see practicing science (Plonczak, 2008). Thus, the ways in which elementary science teachers express their agency in ways that address the moral and ethical issues of science education can provide a foundation on which students' science is practiced (National Research Council, 2007).

  The current political climate challenges certain science topics more than others. There are additional political constraints besides just how elementary science teachers are addressing equity and diversity issues. There is a political "war on science" that stems from a larger anti-intellectualism campaign which consequently produces a powerful context for science educators (Bolsen & Druckman, 2015; Hardy et al., 2019). This "war on science" highlights a faction of people that challenge the practices of science and question scientific claims often regarding them as inaccurate especially when it is not laboratory-based science (Hardy et al., 2019), thus challenging a public understanding of that science (Sinatra et al., 2014). However, for elementary science teachers who already often feel uncomfortable addressing the science content of topics that are often questioned by the public (e.g., climate change and evolution), the structure of the current political climate provides an additional structural challenge for elementary science teachers to work out (Liu et al., 2015; Sezen-Barrie, 2018). For elementary science teachers not confident in their science knowledge, it is particularly challenging to negotiate the current political climate that often communicates a mistrust of science (National Academies of Sciences & Medicine, 2017).

Science content is constantly evolving. Another structure that elementary science teachers are negotiating is the content of science itself. Science is a socially-created and mediated construct that influences and challenges elementary science teachers (Metz, 2008). Teachers must negotiate a continually growing body of content knowledge. The depth and breadth of the content knowledge that a teacher wields often influences their pedagogical content knowledge, or how they feel it is most effective to teach that content (Magnusson et al., 1999). Often teachers cite not knowing much about science as a reason for not prioritizing teaching it. In other words, teachers' content knowledge influences their engagement and confidence in promoting science education within their elementary classrooms (Gerretson et al., 2008). Science produces content at an astonishing rate; global scientific output doubles every nine years (Van Noorden, 2014). Therefore, without proper support or training to gain the necessary skills to confidently handle changing content knowledge, it can become overwhelming for elementary science educators to feel that they have the knowledge and understanding of science necessary to teach the reform-based practices of science (Luera et al., 2005). Thus, in what ways elementary science teachers express their agency to handle a tension in which they must teach a subject with an ever-shifting content, which they often feel underprepared to teach (Banilower et al., 2018; Bohning et al., 1999), is of great relevance to understanding how elementary science education can ultimately be supported and encouraged.

Science education standards have recently evolved. Not only is science content changing, but the policies and standards outlined to teach that content is also changing. In the United States, the No Child Left Behind Act (NCLB) (U.S. Department of Education, 2001) heavily prioritized math and reading accountability measures which eroded instructional time spent on science (Miller, 2010). Since the passing of the NCLB the pressure has increased to find

ways of including science in the elementary school classroom (Center on Educational Policy,

2008; Rentner et al., 2006). Given that NCLB has "placed science on the backburner in the face

of other curricular demands" (Levy et al., 2008, p. 3), there is a compelling need for supports that

address and mitigate such erosion of science instructional time.

At the same time NCLB prioritizes English and mathematics above other disciplines,

NCLB encourages the alignment of elementary curriculum and instruction with state science

standards and the use of standardized test data to inform instructional improvements at every

grade level. This desired alignment creates a need for an effective and wide spread approach to

science curriculum management (Miller, 2010). As much as it seems like this is a useful goal—

to align NCLB standards, science standards, and standard assessments—the reality is that with

no mandated national science standards, and with state science standards also in flux, national

alignment is almost impossible and continues to be an evolving structure that elementary science

teachers must work out.

How elementary science teachers navigate the pressures and consequences from the

NCLB, is an important role of their expressions of agency. Those expressions of agency,

therefore, should be analyzed and described to more deeply to understand future expressions of

agency when structures shift—like policy or legislative ratifications.

Standards influence science teaching. In addition to the NCLB policy, the United States

national and state governments influence the day-to-day lives of elementary science teachers

through the science standards they produce (Keller, 2012; National Science and Technology

Council, 2018; Spillane & Callahan, 2000). Standards chosen have a major influence on science

education and teachers' practices (Connolly et al., 2018). For example, 79% or more of program

representatives sampled in Banilower et al. (2018)'s survey that examined 1,273 schools across

all fifty states, agreed that teachers in the school teach directly to complete science (and math) standards. This National Science Foundation supported survey was the sixth such survey since 1977 to assess science and mathematics education within the United States and became known as the National Survey of Science and Mathematics Education (NSSME+). The survey was designed to provide up-to-date information and to identify trends in the areas of teacher background and experience, curriculum and instruction, and the availability and use of instructional resources. This publication, which consisted of a comprehensive review of the literature; case studies of 11 districts throughout the United States; and a national survey of teachers, principals, and district and state personnel was a useful tool for this dissertation research to be able to consider elementary science teaching as part of the teaching profession more broadly.

     Recent U.S. science standards, the NGSS. Other publications that also helped to establish broad strokes of the current state of science education are the science standards published in the United States. In 1994, the *Benchmarks for Science Literacy* (American Association for the Advancement of Science, 1994) were announced but were criticized for being too numerous and for lacking coherence and discipline specificity (Donmoyer, 1995). In 1996, the National Science Education Standards (National Research Council, 1996) were released; again many experts believed they were too numerous and did not define "inquiry" well (DeBoer, 2000). In 2013, the Next Generation Science Standards (NGSS Lead States, 2013) were released in an attempt to fill gaps left by previous standards and to support implementation of reforms called for in reports, such as *How Students Learn Science in the Classroom* (National Research Council, 2005)*, Successful K–12 STEM education: Identifying effective approaches in science, technology, engineering, and mathematics* (National Research Council, 2011;

Rodriguez, 2015), and *A framework for K–12 science education: Practices, crosscutting concepts, and core ideas (National Research Council, 2012).*

NGSS presents a shift in what and how science is taught. The adoption by many states of the most recently produced science standards, the NGSS, means that science educators must build students' practices with authentic and ambitious science by using "three-dimensional" methodologies (NGSS Lead States, 2013). Three-dimensional (3D) science instruction called on in the NGSS specifies what is meant by scientific inquiry and the nature of science. These 3D ideas include the use of science and engineering practices to actively engage students in science learning, the integration of these practices with disciplinary core ideas and crosscutting concepts, and student learning to be driven by the need to explain phenomena and/or design solutions to problems

Previous standards focused on the process of how science was created, prioritizing the facts of science. Elementary science teachers now must learn a new way of teaching science focused on students practicing authentic science—a substantial shift in *what* and *how* science is taught (National Research Council, 2012).

Standards are being implemented inequitably. Importantly, each state, and in some cases each district within that state, chooses what standards to adopt and how to adopt them (Spillane & Callahan, 2000). Giving states increased flexibility leaves some ambiguity about how to best teach science, an impactful consequence from a lack of national standards (DeBoer, 1991; McKenzie & Ritter, 2014). Whether standards help or hinder, "there is considerable evidence that, although well-intentioned, standards-based education has the potential to inhibit the autonomy and creativity of classroom teachers and their students" (DeBoer, 2000, p. 599); thus, creating another structure elementary science educators have to navigate and negotiate.

NGSS difficult to effectively implement. Elementary teachers are educational professionals, and the NGSS documents are available to teachers free of charge on the internet. However, it is difficult to effectively implement and/or critique standards that require epistemic shifts in science teaching without deep and on-going training or support (Avalos, 2011). Instituting the difficult-to-adapt teaching strategies that accompany the NGSS requires an interconnected model of professional growth that takes into account the complexity underlying the NGSS and the complexity of instructional change necessary to meet the recommendations in the NGSS (McFadden, 2019). Understanding how and why teachers shift their practices, a shift largely necessary to meet the recommendations of the NGSS, is more complex than just aligning a professional learning environment topic with the NGSS, and instead requires a multipart shift in teacher beliefs, expectations, justifications, and supportive resources (Hayes et al., 2019). Instead of professional learning that meets these complexities and challenges, rather, professional learning is an ad hoc process largely left up to districts, educational organizations, and the teachers themselves to find teacher learning opportunities to help them critique, understand, and utilize these newly adopted standards (Burton & Frazier, 2012). Therefore, understanding elementary science teacher agency is a critical component to understanding those teacher moves that are made to critique, understand, and utilize the newly adopted standards in their elementary school classrooms.

Elementary Science Teachers' Attributes

Just as the structures elementary teachers work out as they are teaching science are complex and deeply contextual, so too are elementary teachers themselves. The agents in the commonly referred to "structure-agency dialectic" are, of course, deeply individualistic. Yet, there are some common attributes across the elementary teaching profession that are important to

highlight in order to become acquainted to the ways in which agency is achieved and expressed in an elementary science teacher context. Throughout the next sections I will outline what is known about elementary science educators in broad ways. However, not all elementary science teachers fit these broad generalities. Instead, initially attending to these generalities helps us to deeply understand the rich complexity of the specific research participants within this research.

Elementary teachers are typically subject generalists, meaning they are assigned to teach multiple subjects to a single group of students, including reading, writing, mathematics, social studies, and science (Maine Department of Education, 2019). There are few science content specialists in elementary classrooms, although there are some in the upper grades (Gerretson et al., 2008). Some elementary teachers teach more science than others, and thus have differing levels of *science* teacher identity, but all elementary teachers provide students with sensemaking science experiences (Davis et al., 2019). Elementary teachers routinely make decisions about when, how much, and in what ways to teach science (National Research Council, 2007). These decisions set the foundation of how students experience the practices of science in schools, and set the foundation for cultivating their own science identity (Smith et al., 2013). Teachers are the crux of achieving quality science instruction, they are between the structures and student outcomes (Lukacs & Galluzzo, 2014). The attributes that I mention highlight that elementary science teachers are unique professionals that enact agency in combination with their own personal attributes. These attributes include; (a) being from a narrowly diverse background; (b) having beliefs that determine barriers or success to elementary science education; (c) feeling underprepared and ineffectual to teach elementary science; (d) experiencing inconsistent professional learning experiences; (e) working with changing administrations underprepared to support reform-based elementary science education; and, (f) if teaching in a rural district, they

face additional challenges to teaching reform-based elementary science education. These various attributes play a part of an elementary teachers' negotiations and expressions of their agency and thus their contextuality and complexity need to be understood to be able to ultimately understand the expressions of agency that come partly from those attributes.

Teachers' Beliefs Determine a Barrier or a Success to Elementary Science Education

Evidence shows that students, even in the primary grades, can carry out scientific investigations, weigh evidence, and propose explanations for their findings; they can participate in authentic inquiry (Magnusson & Sullivan Palincsar, 2005; Metz, 2011). However, student success in inquiry-based learning environments is dependent upon skilled and thoughtful guidance from teachers, including the teachers' *beliefs* in their students' ability to learn science (Ramey-Gassert et al., 1996). A teachers' beliefs about the expected outcome of their science teaching can be an affordance or a constraint to having science be taught within their elementary classroom (Wallace, 2014).

For example, when teachers' believe that their science teaching will be ineffectual even when tried, combines with pervasive cultural beliefs that science is a priority only for older students, then multiple levels and types of barriers must be overcome to accomplish reform-based science education in the elementary classroom (Ramey-Gassert et al., 1996). Teachers trying to implement reform-based science face tremendous complexity and must overcome these perceived beliefs and misconceptions at the same time that they are expected to manage the curriculum, science content, instructional materials, tasks, and the overall classroom community in order to help their students develop sophisticated understandings of and experience with scientific practices (Harris & Rooks, 2010).

Teachers' Opinion on What Inhibits and Promotes Elementary Science Education

Science teachers themselves have been vocal about what they believe is inhibiting or promoting science education. Their professional experiences, trying to actually teach the science that is being called for in the recent reforms, means that their perspective is important to consider (Edwards, 2015). Stating those beliefs briefly, teachers asserted that (a) inadequate teacher background in science, (b) inadequate science equipment, and (c) inadequate time and space inhibit elementary teachers from teaching science. The factors that promote elementary teachers to teach science include (a) students' motivation, interest, and effort; (b) the amount of time provided to plan individually and with colleagues; principal support; and (c) current state standards. All of these factors are stated by teachers themselves as promoting effective science instruction (Banilower et al., 2018).

In some ways these factors are currently out of teachers' ability to control. Although teachers can certainly be policy advocates and lobbyists (Ryder et al., 2018)—which standards get adopted by their state and their district are in some ways not wholly in their control (Haag & Megowan, 2015). How instructional and planning time is partitioned and prioritized, how schedules are reformed within districts and schools is, again, a factor for which teachers can advocate for their beliefs, but the ultimate decision about time and schedules is often not entirely within their control (Datnow, 2012). And, although teachers are tremendous determinants of students' engagement and motivation within the science classroom (Hazari et al., 2015), teachers still must work out how they teach science with the unique students they were assigned.

An example of a structure that significantly affects teacher agency is the teaching schedule. Inadequate time available for science instruction at the K–5 grade level is seen by teachers as one of the biggest inhibitors of teaching science (Banilower et al., 2018). Often the school schedule is determined not by the teacher but at the district and administrative level. How

time is allocated across the day, week, and year is a powerful force in the school's productivity and effectiveness (Pope, 2016). A school's schedule is "far more important than the simple mechanical assignment of students to teachers, spaces, and time periods. Within the school schedule resides power: the power to address problems and the power to facilitate the successful implementation of effective instructional practices" (Canady & Rettig, 2008, p. xvii). Nationally, science is taught on average for 18 minutes a day, totaling 54 hours over a 180-day school year (Banilower et al., 2018). The time spent on science instruction is approximately 20% that spent on ELA or math. There are clearly many reasons why time spent teaching science in elementary schools is on average, much lower than ELA and math, and there are historical practices that have divvied up the school day in ways that makes it more challenging to enact practices based in long term inquiry (Donaldson, 2014). But, no matter how administrators and districts ultimately choose to prioritize and divide up the school day, elementary teachers are confronted by this structural consideration and must navigate it along with the many other structural elements at play in their professional work life.

   Nothing about me, without me. Elementary science education can successfully be implemented when the teachers' learning and practicing of these reforms can be autonomously-driven (Cheon et al., 2018; Skaalvik & Skaalvik, 2014). It is also critical that teachers, who are already known to be crucial to any successful reform implementation (Datnow, 2012; Leander & Osborne, 2008), are working in environments that promote their own effective learning and practicing of reforms. The kinds of factors that enable teachers to become learners themselves is necessary to consider when trying to encourage reform-based science practice implementation in schools (Driel et al., 2000). Teachers themselves have commented on the kinds of learning environments that make it easier for them to learn how to teach reform-based science education

including; (a) staff development that utilizes constructivist underpinnings; (b) need for regular interactions with colleagues and support personnel; (c) decision making structures that encourage development of teacher knowledge and expertise; (d) a common science vision; and (e) incorporating prior teacher knowledge (Davis, 2003). How professional learning environments are designed are another factor to bear in mind when considering what teachers express as inhibiting or promoting science education; because, student science learning is consequently mitigated by a teachers' belief in and learning of these reform-based practices (Lewis et al., 2015).

Understanding the ways in which elementary science teachers make, or want to make, autonomously driven decisions to act is an integral part of understanding teacher agency. Elementary science teacher agency is a critical piece of understanding the ways in which teachers work out the moral and social structures that afford and constrain science in the elementary classroom. By understanding elementary science teacher agency, those at the crux of elementary science education can ultimately be better supported and encouraged to then teach reform-based elementary science education in autonomously driven ways.

Elementary Science Educators Have Reform-orientated Beliefs Overall

Elementary teachers report wanting to teach reform-based science, even wanting to teach science in a more prioritized way than what is currently being taught (Dougherty & Moore, 2019). Elementary teachers might often feel, and be, challenged to implement reform-orientated science practices (Duschl et al., 2007) but these teachers, even at the primary K–3 grades, feel that science is too important to put off to teach in rigorous ways until later elementary grades (Dougherty & Moore, 2019). Across the K–12 grade span, at least 90% of teachers in each grade range agree that reform-based science practice instruction is important including the specific

reform-based beliefs that: (a) teachers should ask students to support their conclusions about a science concept with evidence; (b) students learn best when instruction is connected to their everyday lives; (c) students should learn science by doing science; and (d) most class periods should provide opportunities for students to apply scientific ideas to real-world contexts (Banilower et al., 2018). A similarly large proportion, 89%, of science teachers in each grade range not only believe that these practices should be in place, but they also believe that this kind of reform-based instruction encouraging argumentation based on claims and evidence should be prioritized across the educational day; that *most* class periods should provide opportunities for students to share their thinking and reasoning (Banilower et al., 2018).

Even though there are inconsistencies in how teachers believe they should teach reform-based science versus how they are actually teaching reform-based science (discussed next), when considering the overall composite variables—"traditional teaching beliefs" compared to "reform-oriented teaching beliefs" the results from those composite scores suggest that elementary science teachers have relatively strong reform-oriented beliefs (86%) although traditional beliefs are also still fairly prevalent (55%) across the elementary grades (Banilower et al., 2018).

Elementary Science Educators are From a Narrowly Diverse Background

Elementary educators are not a diverse group of people—94% of the elementary science educators are women, and the percent of overall female educators decreases as grade taught increases (Banilower et al., 2018). Eighty-eight percent of the elementary science educators in Banilower et al. (2018)'s survey identified as having a White or Caucasian racial background, which maps onto the national K–12 average of 83% almost identically (McVey & Trinidad, 2019). K–5 educators are also primarily over the age of 30; fewer than 25% were 30 or younger (Banilower et al., 2018), which again aligns with recent national K–12 trends of a greyer teacher

workforce over time (Ingersoll et al., 2018). Elementary science educators are also relatively inexperienced; one-third have less than five years of experience teaching in elementary schools (Smith et al., 2013) and the national K–12 trend towards a greener workforce is similar with a modal elementary public school teacher being a woman within their first three years as a teacher (Ingersoll et al., 2018). Simply stated, it is highly probable that when a student is being taught science education at the elementary level, that student is being taught by a female, White, older, yet relatively inexperienced, educator.

Elementary science educators' background is not deeply based in science. In order to help students learn, teachers must themselves have a firm grasp of important ideas in the discipline they are teaching (Veal & Allan, 2014). The greater depth in understanding of one's content area, the better the teacher can teach, ask questions, answer questions, develop connections, and identify misconceptions (Hill et al., 2005). In addition, Brophy et al. (2008) found that (a) teachers are uncomfortable teaching what they do not know or are unfamiliar with, and (b) many K–8 grade teachers have limited STEM content knowledge, which results in (c) many K–8 teachers avoiding teaching STEM topics. This finding, that teachers feel uncomfortable teaching science, is a finding that has not dissipated since Weiss et al. (2001) work when they found that less than one-third of elementary teachers feel "very well qualified" to teach science.

Elementary science teacher agency is constituted discursively based on complex contextualizations; however, one aspect of those contexts is the teacher's perceptions of their self-efficacy and autonomy, perceptions undergirded by feelings of qualification and competence, and perceptions that play an important role in how agency is expressed (Skaalvik & Skaalvik, 2014). With less than a third of elementary teacher's reporting feeling well qualified to

teach elementary science, these teachers would then relatedly report low perceptions of their science teaching-related self-efficacy and autonomy (Ramey-Gassert et al., 1996), and thus feel more constrained and challenged to discursively express their agency in more transformative ways (Dikilitaş & Mumford, 2019).

To measure elementary teachers' content knowledge, Banilower et al. (2018)'s national survey used proxy measures, including teachers' major areas of study and courses completed during college or graduate school (a focus on previous academic experiences). What Banilower et al. (2018) found was that the likelihood of having a college or graduate degree in science or mathematics depends largely on the grade teaching. Only 3% of K–5 teachers have science, engineering, or science educational degrees, whereas, when teachers teach in grades 6–8 that percentage goes up to 54% (Banilower et al., 2018). The percentage of teachers with one or more degrees in science or mathematics continues to increase with increasing grade range—91% of high school science teachers and 79% of high school mathematics teachers have majored in science, mathematics, and/or science/mathematics education (Banilower et al., 2018). These findings have not changed since Weiss et al. (2001) findings that very few (2%) grade K–4 teachers had undergraduate majors in science or science education fields; instead roughly 80% majored in elementary education. While science and mathematics teachers in grades 5–8 were more likely than their grade K–4 colleagues to have undergraduate majors in science or mathematics (11%), a majority (72%) still had majors in education.

Overall, elementary science educators are not coming from previous science careers, they are not majoring in the sciences in college or graduate work, but the majority have taken at least one life science course while in college. This limited science content knowledge makes it more difficult for elementary science teachers to create the types of inquiry-based lesson plans called

for in the recent reforms (Luera et al., 2005), and forces teachers to generate the content and pedagogic knowledge needed to teach science effectively during their teaching experience (Heywood, 2007).

Elementary teachers' lack of science content knowledge can be ascribed to the limited number of required science courses they take during their undergraduate training. However, increasing the number of science classes pre-service teachers take is not predictive of success at teaching reform-based science. Often other factors, such as previous career experience in STEM and general interest in science, largely influence how teachers present science to their elementary level students. Therefore, for elementary science teachers to teach science in effective reform-based ways, they must discursively construct their agency in ways that help to address their limited content knowledge. Agency is understood, in a basic sense, as the relatively flexible wielding of means toward ends (Kockelman et al., 2007), therefore, having less science content knowledge to wield, makes attaining the desired ends of effectively teaching that content even more challenging.

Elementary Science Educators' Professional Learning Experiences are Inconsistent

Quality professional learning experiences (often referred to as professional development) within science is a necessity but not a constant for elementary educators (Loucks-Horsley, Stiles, Mundry, & Hewson, 2009). When elementary teachers choose to engage in professional learning experiences focused on science, there is a relative paucity of professional development opportunities in science or science teaching compared to other disciplines (Luft & Hewson, 2014), which has resulted in comparatively reduced professional development time devoted towards the discipline of science (Driel et al., 2000). For example, in Banilower et al. (2018) recent assessment, teachers were asked about the total amount of time they have spent on

science-focused professional development in the last three years—only 4% of K–5 teachers participated in 36 hours or more of science professional development in the last three years (Banilower et al., 2018). Most elementary teachers teaching in grades K–5 have less than 6 hours total of science professional development in the last three years and 43% of teachers had none (Banilower et al., 2018). Weiss et al. (2001) states that, "elementary teachers are the most in need of science-related professional development, and the least likely to participate in it" (p. 37). As elementary teachers tend to be less well prepared in science, choosing rigorous and on-going professional learning experiences in science is imperative (Loucks-Horsley, Stiles, Mundry, Love, et al., 2009; Lumpe et al., 2012).

When elementary teachers do participate in professional learning experiences, they are not consistently based in learning the pedagogical content knowledge. Instead, most professional learning experiences are focused on acquiring or deepening content knowledge (van Driel et al., 2012). Learning the science content without addressing the distinct yet indispensable ways of specifically teaching that science content can create teachers who feel less effective at being able to teach that science content successfully (Luft & Hewson, 2014). For example, only 23% of elementary teachers have had substantial opportunities to rehearse reform and inquiry-based instructional practices during professional development (Banilower et al., 2018).

Although it is critical to develop professional learning experiences in ways that encourage teacher agency, it is also something to be careful of because at this time elementary science teacher agency is still undertheorized; thus, how to encourage elementary science teacher agency is unclear. Currently, "teacher agency is often conceived as a slogan to support school-based reform, despite attempts to locate it in wider theoretical discussions of agency" (Priestley et al., 2012, p. 5). Precisely because elementary teacher agency is critical to achieving the

elementary science education reforms and ambitious science teaching goals vital for student science literacy success (Davis, 2003), agency must be more than a slogan and must be effectively understood to be supported. Those that design professional learning experiences for elementary science teachers must be careful not to wield the under-developed concept of agency as yet another expectation for teachers to practice and master during these experiences. Before this happens, the science education research field must work with elementary science teachers to advance the understanding of this critical concept.

Elementary Science Educators Do Not Feel Autonomous, a Consequential Feeling

Autonomy when thinking about teachers specifically is the "freedom to choose goals, teaching methods, and educational strategies that are concordant with the teacher's personal educational beliefs and values" (Skaalvik & Skaalvik, 2014, p. 69). According to self-determination theory, autonomy and self-perceived competence are fundamental universal psychological needs that are important for motivation and psychological well-being (Deci & Ryan, 2000). At its most foundational, this theory postulates that self-efficacy and autonomy are basic needs that nourish intrinsic motivation; people need to feel competent and autonomous to maintain their intrinsic motivation (Gagné & Deci, 2005). Many in education believe that classroom teachers are in the best position to know their students' needs and interests and, therefore, should be the ones making autonomously-driven decisions about tailoring instruction to a particular group of students (Cheon et al., 2018; Skaalvik & Skaalvik, 2014).

In the Banilower et al. (2018) survey that examined 1,273 schools across all fifty states, teachers were asked the extent to which they felt they had control over a number of curricular and instructional decisions for their classes; they found that it depends. In classes across all grade levels, teachers tend to perceive themselves as having strong control over some pedagogical

decisions such as determining the amount of homework to be assigned (59% of elementary versus 74% of high school), selecting teaching techniques (48% of elementary versus 68% of high school), and choosing criteria for grading student performance (41% of elementary versus 59% of high school) (Banilower et al., 2018). In contrast, especially in the elementary grades, teachers are less likely to feel strong control in determining course goals and objectives (17% of elementary versus 36% of high school); selecting textbooks/modules/programs (15% of elementary versus 36% of high school); and selecting content, topics, and skills to be taught (13% of elementary versus 34% of high school) (Banilower et al., 2018). In fact, in about a third of elementary classes, teachers report having *no* control over these decisions (Banilower et al., 2018), contributing to teachers' perceptions of not being prepared to teach science since they do not feel they have the influence to make autonomously-driven decisions about the science curricula they engage with in their classrooms (Johnston et al., 2018). These findings are similar to Gibbs (2018)'s research that found that currently there is an assault on teachers' identities, autonomies, and efficacies that is eroding the nature of professional relationships amongst teachers and schools, consequently harming K–12 education writ large and science education specifically.

Teachers reporting decreased feelings of autonomy is not an inconsequential issue. Research from Skaalvik and Skaalvik (2014) finds that teacher self-efficacy and teacher autonomy are associated with increased adaptive, motivational, and emotional outcomes for teaching professionals.

In order to work out an educational system that sets up elementary science teachers to largely feel underprepared and ineffectual, thus decreasing their motivation and engagement with

that educational system, requires constituting their agency in a myriad of discursive ways (Den Hartog & Belschak, 2012; Dikilitaş & Mumford, 2019).

Elementary science educators express their autonomy largely through material modification. When elementary teachers do enact their autonomy, it is through modification of the materials to design and support instruction. In roughly half or more of classes, teachers substantially incorporate activities from other sources, "pick and choose" from the material, and modify activities from the materials (Banilower et al., 2018). Teachers were then asked to rate several factors that may have contributed to their decision to modify the materials. Four contributing factors stand out: (a) teachers do not have enough time to implement the activities as designed (74% of teachers K–12), (b) teachers have different activities for those science ideas they feel fit better (69% of elementary versus 77% of high school), (c) the science ideas addressed in the activities skipped are not included in the pacing guide/standards (63% of elementary versus 73% of high school), and (d) in science, teachers are also likely to cite not having the necessary materials or supplies for the original activities (62% of elementary versus 54% of high school) (Banilower et al., 2018).

Elementary Science Teachers' Administrators Priorities Are Constantly Evolving

Administrators play an influential role in determining the kind of science education that is enacted in elementary schools (Neuman & Mohr, 2001). An administration's priorities and policies determine budget allocation, curricular choices, staffing, and professional development choices (Ediger, 1999). Constructive instructional leadership in elementary science has been found to be essential to supporting and encouraging some of the critical pieces needed to be in place for effective science education including (a) collaboration, (b) alignment of the curriculum, (c) implementing modes of teaching science that complement teacher strengths through staff

organization, and (d) providing professional development (Casey et al., 2012). The prioritized policies, decisions, and actions administrators enact, often evolve as administrators change positions (Lanier et al., 2009), present substantial structural challenges that elementary science educators must work out through their agential positioning (Lewthwaite, 2004; Miller, 2013).

Administrators are underprepared to support reform-based elementary science education. Although principals play a vital role in the science curriculum, most administrators have no content knowledge or pedagogical content knowledge concerning science (Lochmiller, 2016). This lack of preparedness to support reform-based science by the administrators of elementary schools (Lanier et al., 2009) means that elementary teachers must position themselves and others to work out the moral and social structure of this additionally challenging context to enact reform-based science in their elementary school classroom without effective support from their principals.

Elementary school budgets do not prioritize elementary science education. The district administrators also decide how most school resources are allocated (Griffith & Scharmann, 2008). The budgets for curricular and material resources such as lab materials, textbooks, and curriculum kits are usually determined at the district level. Generally, elementary science educators lack adequate funding to prepare and use materials for three-dimensional and inquiry-based learning, let alone funding to attend high-quality professional trainings, conferences, or professional development opportunities (Banilower et al., 2018). Most elementary science educators struggle to find funding to teach science, or struggle to find ways to teach science without using consumable supplies, and without needing special materials or space (Griffith & Scharmann, 2008).

For example Banilower et al. (2018)'s survey found that in science, per-pupil spending on equipment and supplies increases sharply from elementary school ($1.98) to high school ($6.88). In elementary grades, teachers of fewer than half of classes rate the availability of resources as adequate, compared to two-thirds or more at the high school level (Banilower et al., 2018). Obviously, these initiatives represent a substantial, yet specific type of investment and more generally represent the priorities of administrators that elementary teachers must negotiate and work out in order to teach science in their elementary classrooms.

Elementary Science Educators in Rural Areas Face Additional Challenges

Another structure that many elementary science teachers face, especially many elementary educators in Maine (where this research project originated), is the rural nature of the state. Of Maine's state education funds, 60% go to rural districts—the highest rate in the country (National Center for Education Statistics, 2013). The physical distance between elementary science educators makes it difficult to work with colleagues to share information, resources, or develop professional learning communities (Goodpaster et al., 2012). Although there are multiple ways that many districts are attempting to bring staff together remotely it is still challenging to enact rigorous reform-based teachers' education needs at a distance (Annetta & Shymansky, 2006).

Often only a minimal number of staff across a district or region will focus on the needs that are specific to science education at the elementary level (Goodpaster et al., 2012), versus at the secondary level where discipline specific science education is the norm and science teachers focus on one discipline. Therefore, meeting teachers' professional learning needs is a challenge when the professional development opportunities, resources, and colleagues are limited and spread out physically from one another (Sandholtz & Ringstaff, 2013). Rural educators, like

urban educators, are critically important to instilling science practices and motivation for science in their students, they are often teaching rigorous science practices to those students (often from low socioeconomic backgrounds), and yet, when trying to foster their own teaching and learning of science they have additional professional development challenges to negotiate (Veloo et al., 2013).

Conclusions

Elementary science education is a foundational educational experience (National Research Council, 2007, 2012). Learning builds on learning, so the stronger the science education foundation is of a student's academic career, the more choices and opportunities that student has for future science literacy and even a potential for a career in STEM (National Science and Technology Council, 2018). Science education, when done with rigorous and reform-minded practices, builds scientific sensemaking (Davis et al., 2019) that increases outcomes such as enhanced language, logic, and problem-solving skills (Michaels et al., 2008; National Research Council, 2012) and leads to increased intellectual rick taking (Beghetto, 2009). It is a moral and ethical imperative to provide all students with the experiences and skills necessary to completing rigorous and reform-minded science practices (Calabrese Barton et al., 2013).

Teachers are essential to achieving this desired rigorous, and reform-based science education (Duschl et al., 2007; National Research Council, 2012) but are underprepared to teach that science necessitating in expressions of teacher agency. Elementary science teacher agency is part of what drives knowledge production within the classroom (Miller et al., 2018). Students must be epistemic agents to actually practice authentic science, but that kind of ambitious practice is led by teachers' agency to design science classrooms that encourage their students'

epistemic agency, agency generally not encouraged in traditional science classrooms (Windschitl et al., 2018).

Professional expressions of agency to teach science in the K–5 educational setting occur within individual attributes, and even larger structural contexts (Pyhältö et al., 2014). Often the structural contexts teachers work within are engendered structures within contradictory sociocultural times and spaces (Toom et al., 2015). Elementary science teachers are working diligently under challenging professional structural circumstances to position themselves to achieve reform-based, effective, and equity-based science outcomes (Martin, 2019).

One of the structural contexts that increased the challenges elementary science teachers work within was the global pandemic of the COVID-19 virus. The global pandemic increased teachers fears and frustrations in that they were trying to teach during a physical and mental health crisis that upended almost every aspect of education (Bushweller, 2020; Collins & Steele, 2020). However, in many ways the pandemic also increased teachers' freedoms to express their agency because structures and expectations were in flux. Teachers needed to enact their agency creatively and critically in ways that worked to achieve their desired goals even amidst the complicated realities of the pandemic.

Elementary science teacher agency is a powerful force for systems-level change (Van der Heijden et al., 2015) because understanding agency is critical to understanding how people discursively position themselves and others in ways to work out the moral and social systems in which they work (Arnold & Clarke, 2014; Harré, 2012; Harré & van Langenhove, 1999). How and in what ways elementary science teachers express their agency can have ripple effects throughout their classrooms, schools, and communities (Pyhältö et al., 2014).

Currently there are gaps in the literature in that agency is undertheorized (King & Nomikou, 2018). This dissertation is part of the increasing studies of science teacher agency (Miller-Rushing & Hufnagel, in press), which could help administrators and researchers support elementary science teachers to ultimately make autonomously-driven actions that transform their practices, places, and spaces. This area of research will take time to develop and impact teaching practices, but it grows each year addressing, conceptualizing, and understanding specific areas of agency (Bandura, 2018; Biesta et al., 2017; Eteläpelto, 2017; Hökkä et al., 2019; Martin, 2019; Stroupe et al., 2018; Vähäsantanen et al., 2020). I hope that this work will add to the field.

CHAPTER 2

LITERATURE REVIEW

Agency is critical as a phenomenon because it contributes to the creation, recreation, and transformation of social structures (Hays, 1994), such as the educational system in which elementary teachers are situated (Plonczak, 2008). A person's agency affects and is affected by the systems they are part of—the structure-agency dialectic (Giddens, 1984). Educators can be powerful forces for systems-level change through their enactment of agency (Van der Heijden et al., 2015). How and in what ways they express their agency can have ripple effects throughout their classrooms, schools, and communities (Pyhältö et al., 2014). Educators are professionals who discursively position themselves and others in ways that navigate the structures in which they engage every day (Martin, 2019). Teacher actions to navigate these systems provide a potentially rich space for education researchers to study agency and learn how to support and encourage it (Eteläpelto et al., 2013). Thus, potentially increasing teacher resiliency and persistence in the face of the challenges facing elementary science teachers.

Within this chapter I describe what is known about agency concerning in-service elementary science educators so that I can then make it clear why this research makes an important contribution in science education research, specifically in the narrow context of teachers teaching science in an elementary school setting. I will describe what is currently known about agency within the context of in-service elementary science teachers, in what ways these conceptualizations have contributed to my own understanding of agency and this research, and I describe how these conceptualizations come together to determine the research questions that undergird this work.

Conceptualizations of Agency Across the Social Science Literature

Understanding agency—the discursive actions of individuals and groups—to position themselves to mediate systems-level change (Harré, 2012), are made within education (Englund & Price, 2018) and science educational contexts (Martin, 2019). Understanding these enactments of agency provides researchers with an awareness of how teachers position themselves and others to navigate the structures in which they work in order to work out the moral and sociocultural consequences of those structures (Harré & van Langenhove, 1999; Martin, 2019). Positioning is a social action that takes place within shared systems of belief about the moral standards in use in a community and about the distribution of rights and duties to think, speak, and act in certain ways (Harré, 2015). Agency is expressed through one's positioning of themselves and others, and yet this positioning is being expressed within what is being determined (by the positioner) to be socially constructed moral constrains to real life (Harré, 2012). Teacher agency shapes and is shaped by the historical, sociocultural, and geographical aspects (Biesta et al., 2015) but also the constructed moral aspect of the system in which the teacher engages (Harré, 2012).

Although this work will highlight how agency is an important component to understanding science teaching in elementary school settings, agency is important to understand at all stages throughout a teacher's professional career, within all subjects, and within all grades. However, there are challenges associated with the study of agency within an education and a science education context which has ultimately affected the current conceptualizations of agency. I describe these current conceptualizations (through general epistemological foundations and then specifically within science education), and describe how these conceptualizations stem in part from the complexity of researching agency and common confusions concerning agency as a useful term.

Epistemological Roots of Agency

Agency has utilized various theoretical traditions across social science fields, including psychology, sociology, anthropology, and education. Differences in the conceptualizations of agency are related to the epistemological foundations of the scholars who employ it (Hitlin & Elder Jr, 2007). The term agency originated in the mid-seventeenth century, from medieval Latin *agentia*, which became *agent-*, meaning 'doing.' In social science, however, agency is generally used to mean, "action embodied or personified; a being or thing that acts to produce a particular effect or result" (Oxford, 2009). Within these definitions of agency, there is a clear sense of doing, of action, and of effect. Agency also contains the *desire* to produce a particular result or effect with a social application (Snibbe & Markus, 2005). There is an intentionality to enacting agency (Bang & Marin, 2015; Harré & van Langenhove, 1999; Paris & Lung, 2008); a "purposeful reconstruction in response to those (life) situations in which existing identities are no longer 'functional'" (Biesta & Tedder, 2006, pp. 26, emphasis in original).

These social practices can be carried out individually, organizationally, or institutionally (Bandura, 2018). The desired effect of our actions can be directed at every level of our constructed systems, but enactments of agency are working to reproduce or transform the system or structures in which the actor lives and works (Rivera Maulucci et al., 2015). These enactments of agency can be seen through a variety of forms and expressions—through exerting influence, making choices, and taking stances (Eteläpelto et al., 2013) and those actions stem from a socially constructed capacity to act. In what ways social forces constrain, shape, and influence those acts is often at the center of research concerning agency (Archer, 2003; Giddens, 1984; Holland et al., 1998).

Even though the term agency is quite slippery and is used differently (Hitlin & Elder Jr, 2007) agency is conceptualized along some similar epistemological constructs that help to understand the affordances and constraints of the foundational aspects of this research.

The role of discourse in agency. Discourse is a 'turn to language' that has a bewildering amount of philosophical frameworks, so many in fact that it is difficult to speak of discourse as a single uniting entity (Burman, 1991). "Discourse" has become one of the most popular and least defined terms in Anglo-American academics; difficult to define because of the wide variety of ways in which it is used (Lutz & Abu-Lughod, 1990). However, discourse is "united by a common attention to the significance and structuring effects of language, and are associated with interpretive and reflexive styles of analysis" (Burman, 1991, p. 326). The theoretical framing of discourse as part of agency is an important initial theoretical framing to consider because discourse and agency are inexorably linked (Arnold & Clarke, 2014; Davies & Harré, 1999); agency is a form of discursive practice in which persons can be positioned as relatively responsible for action (Martin, 2019). Through this 'turn to language,' one becomes interested in the ways language produces and constrains meaning, meaning that resides within the individual as well as within the social conditions that give rise to the forms of talk available to make this meaning (Burman, 1991). In chapter three of this work, I describe the various frameworks of discourse analysis I use to underscore that discourse is itself agency, and provides a way to reveal agency, including a desire to reveal the spectrum of expressed agency. But first it is necessary to describe what is meant by discourse itself when conceptualizing agency for this research.

This research highlights that discourse is the saying, being, and doing (Gee, 2010), an in-the-moment meaning making in which language produces reality (Kockelman et al., 2007). This

research frames discourse as negotiation of meaning in social acts, meaning that discourse is a social practice and constitutive of the construction and shifting grounds undergirding the frameworks of meaning (e.g., Foucault (1979). Linguists often study language as a formal set of structures set apart from everyday interactions (Ahearn, 2001). Instead of taking a linguists approach to discourse, I take an interactional sociolinguistic approach (Gumperz, 2001; Gumperz & Cook-Gumperz, 2008) which examines how the social actions accomplished through linguistic interaction "takes a broad view of language as communicating both content and metapragmatic or indexical information about content" (Gumperz & Cook-Gumperz, 2008, p. 537). An interactional sociolinguistics approach such as this considers that people do things with words (Austin, 1975); and that language is a form of social action, a kind of cultural resource, a sociocultural practice (Foucault, 2019). Language is not just a vehicle by which referential meanings are delivered, language is a process that is constantly being co-constructed by the participants emerging from the social interactions in which they engage (Ahearn, 2001). In other words, considering discourse in this research means considering all the ways in which people communicate meaning (i.e., spoken word, writing/text, non-verbal communication, paralinguistics, actions, social interactions) as well as considering how these meanings are socially constitutive as well as socially shaped (Fairclough & Wodack, 1997).

Discourse, for this research, is not a focus on someone's pronunciation, or a focus on the thoughts inside their head. Instead, this research attends to discourse as all the ways in which meaning is made across moment-to-moment interactions (Ahearn, 2001), and that meaning is co-constructed by the sociocultural influences in which it is situated (Gee, 2010). Discourse, as seen through this interactional sociolinguistic lens (Gumperz, 2001; Gumperz & Cook-Gumperz, 2008) makes meaning, and that meaning is made within a context in which one is an active part

of (Brown et al., 1989). Unshared thoughts and beliefs (thoughts and beliefs that potentially act as an impetus to agency such as self-efficacy, autonomy (Bandura, 2018), identity, values, beliefs (Richmond, 2016), or emotions (Hökkä et al., 2019)) become discourse when they are shared, expressed, enacted or in any way acted upon (Martin & Carter, 2015). How people know what they know about agency is expressed discursively through positioning (Arnold & Clarke, 2014; Martin, 2016, 2019). Discourse doesn't just function as a process of revealing agency, discourse is an expression of agency witnessed through one's positioning of themselves and others (Harré & van Langenhove, 1999). Thus, analyzing discourse makes agency, in all its forms and expressions, salient within and across the cases as research participants position themselves and others in ways to work out the moral and social structures in which they engage.

The very nature of determining what counts as discourse to be analyzed often is connected to the way in which that discourse is analyzed. The process by which the discourse is to be analyzed theoretically determines the nature of what will be analyzed (Sawyer, 2002). The ways in which people position themselves and their 'underlying' ideologies is a naturally discursive act (Van Dijk, 2006), and the way they share that positioning is also discursive (Martin, 2019), but the way they position and share that positioning shapes and is shaped by the contexts in which that discourse is occurring (Davies, 2000) which makes an interactional sociolinguistic approach (Gumperz, 2001; Gumperz & Cook-Gumperz, 2008) fitting for this research. Discourse and agency are therefore deeply linked, but there are other theoretical schools of thought that inform how agency is conceptualized.

Transformation factors into agency conceptualization in education. Education, like most other social science fields, does not routinely report the theoretical and epistemological underpinnings on which they conceptualize agency (Miller-Rushing & Hufnagel, in press).

Instead of a strong singular theoretical lineage concerning how agency is conceptualized, education research conceptualizes agency along multiple factors (Miller-Rushing & Hufnagel, in press). These factors generally depend strongly on individually-oriented concepts like identity, values, and beliefs (Richmond, 2016); the self-perceptions of autonomy and self-efficacy (Gagné & Deci, 2005); often orientated within a sociocultural framework (Tobin, 2012) to highlight transformation (Robertson, 2008).

Although transformation is not a philosophical or theoretical tradition with its own epistemological roots, it does often appear as part of a framework in education-related conceptualizations of agency. Transformation factors into how agency is conceptualized within education because learning, a desired outcome of education, requires on-going progression and transformation for that learning to take place (National Academy of Sciences, 2018). As people learn they change, they are created again and again as they engage with the new knowledge they are being exposed to (Duschl et al., 2011). "One way to think of learning is as the historical production transformation, and change of persons" (Lave & Wenger, 1991, p. 51). This idea of transformation is central to education (Robertson, 2008). Educators hope to design transformative experiences, create learning spaces open to transformative ideas, generate transformative action from their students (Beachum & Dentith, 2004).

Considering education's focus on transformation, it is therefore not surprising that teacher agency has developed with a common theme of researching agency utilizing a transformative or its antonym—reproductive—binary (Rivera Maulucci et al., 2015). Although this research pushes against this binary and considers a spectrum of nuanced ways in which agency is expressed discursively (Ahearn, 2001), there is a tradition to consider within education

that often orientates to agency as a transformative or reproductive act (Engeström, 1999; Pantić, 2015; Rivera Maulucci et al., 2015; Sannino et al., 2016; Sewell Jr, 1992).

It is not that transformative or reproductive acts are inherently inconsequential when considering agency. Quite the opposite in fact. Part of my reason for being interested in researching agency is because I ultimately aspire to support teachers to be autonomously-driven change agents. Therefore, how teachers transform structures and express their transformative agency through their positioning of themselves and others is an important concept to consider (Pantić, 2015; Rivera Maulucci et al., 2015). However, if a transformative/reproductive binary is prioritized, and inversely if the assumptions and contextualizations concerning agency are underappreciated and not deeply deconstructed (encouraged through theoretical traditions such as post-structuralist or post-human perspective) than it is likely that agency will continue to be misconstrued and underdeveloped. If agency continues to be misconstrued and underdeveloped, ultimately understanding how to support a teacher's transformative agency becomes an even harder task to achieve (Purdy, 2013). Although this binary understandably exists in the literature, this research project seeks to utilize a theoretical tradition (e.g., post-structural) with aligned research questions that encourage a description of agency along more of a spectrum (instead of a binary) to highlight, and more deeply understand, the myriad of consequential contextualizations concerning agency.

Theoretical traditions afford and constrain conceptualizations of agency. Agency in science education has common confusions and difficulties which I will address in the following section. Yet before moving on, it is important to consider that many of these confusions and difficulties are due to agency's highly complicated and contextualized nature but also that there are no clear schools of thought theorizing agency in similar ways within any discipline.

Conceptualizations of agency within science education are being drawn from across the theoretical traditions described above, although often not explicitly or coherently communicated (Miller-Rushing & Hufnagel, in press). When considering agency within a science education context, like in this research, it is important to remember these theoretical traditions, but also how these theoretical traditions afford and constrain conceptualizations of agency. Without recognizing and being critical of the (often assumed yet not overtly communicated) theoretical tradition(s) that is being used to conceptualize agency, agency will continue to be researched with unexamined assumptions and thus will continue to have restricted explicit and coherent theorization and operationalization.

For example, Pantić (2015) in her review of the literature on agency and social justice, interestingly demonstrates how different approaches to agency use language in beguilingly similar ways, masking some quite marked theoretically conceptual differences. There are no "perfect" ways to conceptualize or study agency, and that in fact the diversity of conceptualizations can be seen as a strength when studying agency (Eteläpelto, 2017). Yet, current conceptualizations are pulling from many theoretical, and thus epistemological roots, without being explicit about what theoretical traditions are being invoked which adds to the confusion and difficulty in researching, and ultimately understanding and supporting agency.

Common Confusions Across Agency Conceptualizations

Agency is such a complex and contexualized term that there are often common confusions that are evoked when using the term. I will describe the confusions that stem from difficulties in studying agency and conflations with related yet distinct terms.

Confusions stem from difficulties in studying agency. As mentioned earlier, the term agency is quite slippery and is used differently due to the various epistemological roots and goals

of the scholars who employ it (Hitlin & Elder Jr, 2007). Emirbayer and Mische (1998) conclude that "the concept of agency has become a source of increasing strain and confusion in social thought" (p. 962). One way that these confusions have continued to develop stems from how difficult agency is to research. The variation in conceptualizations (and associated epistemologies undergirding those theories) means that it is not always clear what researchers mean by agency, and that it is difficult to build on existing research (Miller-Rushing & Hufnagel, in press).

In addition, existing studies frequently fail to provide enough detail describing their epistemological framing conceptualizing and/or operationalizing agency (Miller-Rushing & Hufnagel, in press). This lack of communication makes it difficult to interpret and build on previous work effectively. Agency has lacked explicit operationalization and there has been a lack of coherence in its research usage (Arnold & Clarke, 2014).

The heavy reliance on qualitative research approaches (across the social science disciplines) allows researchers to dig deep into the multiple dimensions affording and constraining agency of individual teachers, but qualitative conceptualizations of teacher agency are challenged to capture enough comparative data that would help give a more validated construct of teacher agency (Vähäsantanen et al., 2018). Additionally, many of the studies that do consider the multitude of lived experiences that influence teacher agency, often fail to attend to these factors in their analyses (Miller-Rushing & Hufnagel, in press). On the whole, what counts as agency is still largely delineated researcher-by-researcher. These discrepancies make researching agency difficult, but an exciting research space to contribute to.

Confusions stem from conflation with related yet distinct terms. Autonomy, self-efficacy, along with additional terms like leadership, empowerment, personality, identity, and

motivation are terms often conflated with agency. As seen in the extensive explanations that Den

Hartog and Belschak (2012) put forth in their work, trying to make sense of these related, yet

distinct, terms is no easy feat. These terms can therefore sometimes be inaccurately used, as if

they are synonymous with agency. Each term has a specific, complex, and interrelated meaning

which needs to be considered by researchers before invoking within a framing of agency (Huang,

2011).

     Autonomy. According to Deci and Ryan (2000) autonomy is a self-perceived competence

and a universal psychological need for motivation and psychological well-being. "Autonomy

refers to volition- the organismic desire to self-organize experience and behavior and to have

activity be concordant with one's integrated sense of self" (Deci & Ryan, 2000, p. 231).

Autonomy when thinking about teachers specifically is the "freedom to choose goals, teaching

methods, and educational strategies that are concordant with the teacher's personal educational

beliefs and values" (Skaalvik & Skaalvik, 2014, p. 69). In other words, autonomy is the belief in

your right to make your own decisions. A teacher's perceived autonomy is connected to their

teaching engagement, job satisfaction, and emotional exhaustion (Skaalvik & Skaalvik, 2014). In

comparison, agency focuses not on the volition highlighted in autonomy, but instead on the act

stemming from that volition (Deci & Ryan, 2000). Autonomy helps to motivate the agent to

make enactments of agency, although ultimately that enactment might not always meet one's

personal beliefs and values, autonomy is the belief that you have the self-determination to keep

trying to express agency (Gagné & Deci, 2005).

     Self-efficacy. Another example of a term often used in inaccurate and confusing ways

when discussed with agency is self-efficacy. Perceived self-efficacy, is a person's belief in their

ability to influence events (Bandura, 1994)—i.e., a person's perception that if they try something

they will achieve their desired outcome. This perceived self-efficacy "determines how people feel, think, motivate themselves and behave" (Bandura, 1994, p. 1). The feeling of self-efficacy is a motivating and determining factor in the expression of agency, but it is not agency in and of itself (Bandura, 2018).

Agency's Complexity from Contributing Factors (Identity, Values, and Emotions)

Agency is expressed in a range of ways at different times due to the nature of its deep complexity (Biesta & Tedder, 2006; Emirbayer & Mische, 1998). Across modern research literature agency is seen to have a temporal aspect (Emirbayer & Mische, 1998; Hitlin & Elder Jr, 2007; Lipponen & Kumpulainen, 2011). This temporal component to agency means that agency is not a hard-wired and fixed disposition of one's personality (Toom et al., 2015). Instead, agency is expressed in a variety of ways at different times in part because of the ways in which one's identity, values, beliefs, (Buchanan, 2015; Richmond, 2016) and emotions (Hökkä et al., 2019) are forever being reprioritized and reconfigured (Biesta & Tedder, 2007). This constant reconfiguring of identity, values, beliefs, and emotions, which play a role in how agency is expressed, means agency is a difficult, yet intriguing, concept to research.

Teacher identity and agency. Identity is an important component to consider when researching teacher agency because part of a teacher's identity (which plays a role in how agency is expressed) is their professional identity (Edwards, 2015; Eteläpelto, 2017; Eteläpelto et al., 2013; Martin, 2017). Professional identity is constructed through their professionally-related lived experiences within the contexts in which teachers work (Avraamidou, 2018). In this construction, it is helpful to think of the context as the outside boundaries or reality in which teachers work (i.e., structures), and a teacher's identity as the "kind of person [the teacher] is seeking to be and enact in the here and now" (Gee, 2010, p. 13). For example, the school system

is one part of the context in which they work—they have to contend with the policies, culture, and requirements of that school system (Lasky, 2005; Shilling, 1992).

A teacher's identity is positional and personal to each teacher (Avraamidou, 2014a). For example, in the case of science education, some teachers identify as "teachers" and teach science as part of the system in which they teach (these are often elementary teachers) (Avraamidou, 2014b; Davis et al., 2019), while other teachers see the discipline of science in "*science* teacher" as more core to their identities, this is more often secondary teachers who teach limited subjects (Cess-Newsome, 1999).

Secondary science teachers' stories illustrate the dynamic processes and interplay between multiple discourses, such as the 'proper,' 'good,' 'science' teacher, and the cultural norms, resources, and subject positions available to them, as they take up and explain their own and others' meanings and subject positions in science education. (Hwang, 2009, p. 697)

Yet, these secondary science teachers are being oversampled in agency research relative to elementary or middle school teachers (who also teach science); thus, the agency of high school teachers is more prominently represented than teachers at other grades in the K–12 system (Miller-Rushing & Hufnagel, in press). What key elements might be missed about the agency of elementary teachers, where they tend not to identify as strongly as teachers of *science*? The answer is not clear, but, given that we know identity plays an important role in agency, it is an important question to ask.

Teacher values and agency. Richmond (2016) notes that agency is made up of identity, values, and beliefs. "Values refer to those processes, acts, interactions or goals that an individual privileges more than others at a specific point in time" (Richmond, 2016, p. 222). Teachers' values are shaped by their beliefs concerning their discipline, subject matter, to whom and with

whom they teach, and the multiple communities to which they belong (Richmond, 2016). Values explain what a teacher privileges or prioritizes at a given moment, thus creating part of the complex context that contributes to expressions of agency (Akerson et al., 2012). Tappolet (2016) stated the connection between values and agency when they described that one responds to one's values by acting (i.e., expressing agency) on the basis of one's emotions. One's emotions trigger an action (agency), but that sequence is based on one's values. Therefore, to understand science teacher agency, we must also consider the values that teachers are privileging.

Teacher emotions and agency. Tappolet (2016)'s book mentioned above is one of the few published explicitly linking agency with associated concepts like values and emotions. Researchers are now only starting to study the potentially critical links between emotions and professional agency (Hökkä et al., 2019; White, 2016). Sometimes researchers study emotions and agency together with another concept like identity (Rivera Maulucci, 2013). These researchers contend that exploring the links between emotions and identity is particularly suited for exploring issues of social justice in science education because it captures the ways in which our beliefs about how the world, our school, our classroom, and the way in which science ought to be, may conflict with how they are (Moore, 2008; Pantić, 2015).

What people feel emotionally "serves as a crucial resource in negotiating and assigning meaning to these processes as a further dimension of their agency as teachers" (White, 2016, p. 596). Emotions play an important role in the expression of that teachers' agency (Hökkä et al., 2019). Although Hufnagel and Kelly (2018) were not setting out to study the connections between agency and emotion in science education, they found agency being expressed across multiple features of emotional discourse throughout their research. Whether or not researchers

start out seeking to further understand the particular connections between agency and emotions, current researchers are starting to acknowledge and encourage agency to be reconceptualized in such a way as to acknowledge the importance of emotions in expressing agency even within organizational contexts like education (Hökkä et al., 2019).

Confusions and Complexity Affect Conceptualizations of Agency Within Education

Part of the complex and contextual nature of agency is in part from the role that identity, values, and emotion play in how and in what ways agency is expressed (Buchanan, 2015; Richmond, 2016; Rivera Maulucci, 2013); concepts also deeply complex and contextual themselves (Holland et al., 1998; Hufnagel, 2019; Lave & Wenger, 1991). When the concept of agency is known to be confused and complex, and when research is limited as it is currently (how much research being done is limited; who is being researched is limited; and how agency is being researched is limited), there is a natural consequence in that the clarity and coherence of the conceptualization of agency is thus limited.

How much research is being done on agency in an educational context. Even though Vähäsantanen et al. (2020) say that the current research on agency in educational contexts is "intensive," and total numbers are increasing (Allen, 2018; Bartell et al., 2019; Biesta et al., 2015), research on agency is still very much limited in amount and scope. Current conceptualizations being considered are based on a relatively small amount of data. Even as recently as 2015, Toom et al. (2015) note, "Despite extensive interest in the topic, the concept of agency is still vague and only few empirical studies have examined teacher or student teacher agency" (p. 617). Although agency is widely discussed across many fields, there is still little empirical data about agency specifically within educational settings, severely limiting its current understanding.

Whose agency is being studied in an educational context. Educational research writ large is interested in researching the teachers, students, administrators, and community in which the education is centered (Lodico et al., 2010). Including all these parties as research participants allows their experiences to contribute to the foundation of how agency is conceptualized in educational contexts. Although agency is still relatively understudied across the field of education research (Priestley et al., 2012; Vongalis-Macrow, 2007), teachers who are the critical components to effective educational transformation (Tran, 2019; Van der Heijden et al., 2015) are currently understudied and underrepresented (King & Nomikou, 2018; Leijen et al., 2019; Toom et al., 2015). When educational participants are not represented equitably in educational research on agency, the conceptualizations that undergird agency are thus incomplete.

How agency is being studied in an educational context. The data collected in education research concerning agency show a preponderance toward qualitative paradigm research choices. Agency is being principally conceptualized through the lens of descriptive (not quantitative) data and an interpretivist paradigm. This preponderance of qualitatively-generated data in education research to conceptualize agency could be a natural consequence of the strong dependence of agency on context (Biesta & Tedder, 2006; Priestley et al., 2011). Therefore, qualitative research *may* be more effective at addressing most research questions. However, there are so few studies of agency that use ordinal/quantitative data that it is difficult to assess the potential utility and insights that quantitative data might provide to how agency is conceptualized in education.

Agency Within Science Education Affected by Additional Complexities

For science education researchers, agency has recently grown as an area of study, just like in education generally, but it too is currently under-theorized, used inconsistently, and is in need of further investigation and analysis (King & Nomikou, 2018). The same confusions around

agency and the complexity with which agency needs to be considered still exist in science education. Yet, when an additional educational layer is included in consideration, as is done when *science* education is considered, conceptualizing agency becomes even more challenging.

The specific science education-related challenges I discuss here include (a) the underlying, yet unexamined assumption of cognitive psychology (and thus an epistemological connection to rationalist and structural functionalist theory) within much of science education agency-related research; (b) restricted explicit and coherent theorization and operationalization of agency in science education research; and (c) science education's research commonly emphasizing the transformative potential of agency.

Cognitive psychology underlies agency conceptualizations in science education. The cognitive model in psychology that underlies much of the research assumptions in science education has consequential and long lasting effects on how agency is conceptualized (Arnold & Clarke, 2014). Cognitive psychology commonly draws on epistemological beliefs outlined in such theoretical traditions such as rationalist and structural functionalism (Corsini & Ozaki, 1994). In cognitive psychology there is a desire to prioritize the agents internal mental process, remember Descartes' dictum, "I think, therefore I am." There is also a desire in cognitive psychology to find distinct and clear-cut organizational processes, definitions, and categories; research desires also prioritized in the structural functionalism theoretical tradition which ultimately established positivism—an epistemological belief underpinning much of science research continuing to this today.

The contemporary interest in researching agency in science education reflects a shift in science education towards understanding science learning as a complex social activity (Brickhouse, 2001; Lemke, 2001). Yet, there is a deep legacy of cognitive psychology within

science education that cannot be ignored. As Lemke (2001) put it, "science education research has embraced cognitive psychology with almost unseemly haste" (p. 300). The long standing affiliation between science education and cognitive psychology, therefore, has ongoing consequences for how agency is conceptualized (Arnold & Clarke, 2014). For example, researchers have constructed research participants as responsible for action and, in this way, attributed agency, but the constitutive force of language in social interaction has not been widely acknowledged, and the meaning of participants' language in use has not been adequately taken into account when considering agency in a science education context (Martin, 2016). It is still common practice in science education to, in essence, underscore that the research participants affect the discourse instead of embracing Foucault's notion that discourse affects the research participant. What is difficult though is not this belief, but that the belief is so implicitly assumed, that even though it limits how agency is conceptualized, the belief is not acknowledged or made explicit when discussing conceptualizations of agency in science education contexts (Arnold & Clarke, 2014).

Transformation is emphasized within science education's conceptualization of agency. Science teacher agency has the potential to be transformative for the agents (i.e., the science teachers) and the structures (i.e., policies and educational communities) in which they work (Gutiérrez & Calabrese Barton, 2015; Rivera Maulucci et al., 2015). The study of science teacher agency is critical because of its connections to teacher actions and how those actions can at times can lead to transformations for the teacher themselves but also for the classroom community and larger educational system in which they work.

Understanding how agency, especially transformative agency, functions in science education contexts, is particularly important given the pace and level of change in science

education (Windschitl et al., 2018). An understanding of agency, and its complexity, is critical for researchers to support teachers who want to take reform-inspired science actions, administrators who desire to encourage science teacher agency, and policymakers who look to science teacher leaders to determine and enact science education policy and reform efforts. Understanding science teacher agency, especially the transformative potential of agency, can help researchers and administrators support agentive teachers who are open to moving from engagement to enactment (Buxton et al., 2015).

What is Known About Elementary (K–5) In-Service Science Teacher Agency

Within science education research, in-service elementary teachers (K–5) are currently understudied (Miller-Rushing & Hufnagel, in press). Yet, elementary teachers have a particularly difficult set of challenges to contend with to teach science at the highest levels (Zembal-Saul, 2009). Because using reform-based science teaching strategies in elementary classrooms, which teach all subject areas, requires an almost herculean effort of professional skills and negotiation of expressions of agency (Martin, 2019) understanding the agency of those particular K–5 science teachers is worthy of increased study.

How we know what we know. What is known about in-service elementary (K–5) science teacher agency is being derived from studies using similar methodologies and analytical decisions as other studies across education. For example, agency is being researched through a qualitative research lens, the theoretical and/or operationalization of agency is often not explicit, and the framework that is being utilized is largely a structure-agency dialectic lens based on structuration theory (Miller-Rushing & Hufnagel, in press). Therefore, how we know what we know about in-service elementary science teacher agency is largely formulated along similar research designs as agency in general educational contexts.

Elementary in-service science teacher agency is consequential. The role of an in-service elementary science teachers' agency is a consequential topic to consider when interested in science education. Goulart and Roth (2010) explained this significance of science teacher agency when they described that the actions of teachers determine the lived experiences within the classroom and that those experiences then arise to create a "collective consciousness" (p. 533). Goulart and Roth (2010) describe this social interaction within a classroom along a structure-agency dialectic thus highlighting that teachers and students affect and are affected by one another's agency and affect and are affected by the structures in which they are associated.

Howitt (2011) directly calls out the importance of understanding the teachers' role in the structure-agency dialectic of the classroom when they comment that teachers are professionals that know their classroom context best. Teachers' expressions of agency affect and are affected by the classroom community, and teachers' actions within that classroom are actions that are undergirded by their knowledge concerning the students and their interests, the teaching context, the environment, and the outcomes they wish to achieve (Howitt, 2011). Knowing that science teachers are critical at shaping the classroom's context, environment, and outcomes, understanding science teacher expressions of agency are therefore an important component to the ultimate success of science being an integral part of our educational system, (Biesta et al., 2017; Leander & Osborne, 2008) including the K–5 grades (Martin, 2017).

Expressions of agency have outcomes. When in-service elementary science teachers express agency there are consequences stemming from those expressions. But what direct outcomes have been found in the research related to teacher's expressions of agency? Although the data is scant, there are a few research-based findings related to outcomes from in-service science teacher agency including—increased competency in content fluency (Nichols et al.,

2016); modification of curriculum (Goulart & Roth, 2010; Howitt, 2011; Im & Martin, 2015) and professional development (Martin, 2019; Van Duzor, 2011); attributing agency to others (Oliveira et al., 2015); and an increase in students' agency when teachers exhibit more structurally transformative agency (Rivera Maulucci et al., 2015). Elementary in-service science teacher agency is a consequential expression resulting in direct outcomes affecting themselves, the classroom community, and the educational structures in which they work. Not only what outcomes stem from agency, but how agency is expressed and what types of settings encourage expressions of agency are also important considerations I discuss next.

Discursive practices in social settings encourages agency. Elementary teachers are engaged in a day-to-day social practice in which they belong, simultaneously, to multiple professional communities, communities often revolving around different school subjects (Hayton & Spillane, 2005). Teachers are engaging with a variety of students, administrators, community members with a constant steadiness throughout their professional day. The discursive practices that occur in social settings can encourage elementary in-service science teacher agency if the dialogue is cogenerative (Im & Martin, 2015), and the learning process is invested in searching for solutions while they create schemas and rearrange resources to evolve a new structure (Goulart & Roth, 2010).

Cogenerative dialogues are conversations between teachers, students, and researchers that are designed to support the teaching and learning that takes place in a classroom (Tobin, 2006). By engaging in co-planning and co-enactment of science lessons, followed by co-reflection using a structured discourse method called cogenerative dialogue, the process of participating in the cogenerative dialogue "expands teachers' agency to adapt curriculum and implement instructional strategies that can better meet the needs of their students" (Im & Martin, 2015, p.

355). By engaging discursively with others (including students, co-teachers, administrators, and researchers) about how lessons impact student learning, the teacher has an opportunity to express agency to then make teacher-led decisions that can meet the articulated needs of the community. Cogenerative dialogues are one particular discursive practice that has shown to increase expressions of teacher agency within elementary in-service science teachers, but this finding points to the worth of considering the role that the process of discourse plays in agency.

Another part of the discursive process that has been found to support elementary in-service science teacher agency is when the discourse is orientated within a group learning environment that is invested in searching for solutions while they create schemas and rearrange resources to evolve a new structure (Goulart & Roth, 2010). A socially engaged discourse that encourages critical creativity is an effective approach to use the process of discourse to support teacher agency. By creating schemas and rearranging resources teachers are showing creativity (a trait discussed in depth later on in my personal conceptualization of agency). A teacher working within a group that encourages creativity, not just for creativity's sake, but with a willingness to allow that creativity to evolve into a new structure, is a way to conceptualize agency that has been described within in-service elementary science teachers (Goulart & Roth, 2010). The creative expressions of agency must also be wielded critically. In order to look for new solutions there needs to be critical considerations for the possible solutions. The critical nature of agency is discussed later on in my personal conceptualization of agency, but Goulart and Roth (2010)'s research found an ability to be critical of the resources available and the context in which the solutions are trying to be found is an important part of conceptualizing agency within elementary in-service science teachers. Being critically creative in a socially engaged dialogue has been found to be a potential way that agency can be supported in in-service

elementary science teachers (Goulart & Roth, 2010). Research utilizing discursive practices in social settings like elementary classrooms have potential for furthering our understanding of the complexity of in-service teacher agency.

What is attended to. Thus far in science education research, what we know about in-service elementary science teacher agency is relatively limited, but what is being attended to is informative for understanding how this knowledge is conceived but it also gives a richer sense for spaces that might be generative for future research endeavors.

Structure-agency dialectic. One of the ways that in-service elementary science teacher agency is being attended to is through the use of the structure-agency dialectic as outlined in structuration theory (Giddens, 1984). Just like across the rest of the social sciences, the structure-agency dialectic is being well attended to in elementary science education (Goulart & Roth, 2010; Im & Martin, 2015; Martin, 2019; Oliveira et al., 2015; Rivera Maulucci et al., 2015). In these pieces of research the agent under investigation is the elementary science teacher and the structures are a myriad of school-related contexts that influence and are influenced by the agency of the teacher, including the policies and standards at play in a science classroom (Rivera Maulucci et al., 2015). There is a mutually constitutive relationship between structures and agency outlined in structuration theory (Giddens, 1984); the structure-agency dialectic is clearly an essential part of how the current conceptualization for agency is being attended to, including within in-service elementary science teacher agency research.

Transformative agency. Another way in which agency is frequently being attended to within science education research that is specifically researching in-service elementary science teachers, is through a conceptualization that highlights the transformative potential of agency. Although the transformative nature of agency is also commonly attended to in education and

science education more generally (discussed earlier), this transformative potential of agency is also included in current research on agency of in-service elementary science teachers (Goulart & Roth, 2010; Rivera Maulucci et al., 2015).

Many of the consequential outcomes discussed in this research is actually calling out the transformative potential of agency for elementary science teachers. For example, elementary science teachers are often portrayed from a deficit perspective concerning their content knowledge and their fluency to work with that knowledge (Epstein & Miller, 2011; Gerretson et al., 2008; Kumar & Morris, 2005); one way the recent research has found to combat this content knowledge deficiency, and transform elementary teachers' engagement with science content, is by encouraging teachers' representational agency (Nichols et al., 2016). Representational agency means that teachers (in this case) "have command over the various representations of content in science, and the ability to reason, argue, or explain what is being represented, how it is being represented and in how many ways it can be represented" (Nichols et al., 2016, p. 510). By understanding the transformative potential of representational agency that, in turn, influences one's content fluency (Nichols et al., 2016). For example, Nichols et al. (2016) described that a meaningful experience in science at some fundamental level requires that teachers and students possess representational agency. Representational agency can be thought of as enacting an enhanced fluency over the science content, and that by using this fluency, a teacher's understanding of science can better enable them to make expressions of agency with consequential outcomes on the classroom community (Nichols et al., 2016).

It makes sense that the transformative potential of agency is still considered an important part of in-service elementary science teacher agency, just like it is also considered an important part of agency within education and science education more generally. These in-service

elementary science teachers are also working in an educational context that sees learning as a transformative process, a transformative process of sensemaking that is consequential and yet highly contextualized to the elementary science classroom environment (Davis et al., 2019).

Within a professional development context. In-service elementary science teacher agency is often being attended to through a professional development or a professional learning context (Howitt, 2011; Nichols et al., 2016; Rivera Maulucci et al., 2015). Professional development, or a professional learning experience commonly aims to support teacher learning and/or teacher leadership development (Darling-Hammond et al., 2009; Luft & Hewson, 2014). Recently the trend has been to try to design these experiences to occur iteratively throughout a professional career and to encourage teacher's autonomy and/or agency as part of a whole school community (Niemi, 2015).

Therefore, by researching in-service elementary science teachers' agency within a professional development context, the current research is highlighting the ability of professional development learning spaces as contexts that can push teachers to new ways of actively critiquing the systems and structures currently in place in science education (Longhurst et al., 2016). Professional development often asks teachers to work collectively in groups, potentially providing additional insights into shared epistemic agency (Stroupe, 2014). Thus, situating teachers as research participants in more socially-based and intrapersonal contingent research contexts, such as the discursive environments of professional development experiences, might allow researchers to view expressions of agency.

What is not being attended to. Just as there are some principal aspects of in-service elementary teacher agency that are currently being attended to in the science education research, there are some principal aspects not being attended to including—the elementary teacher

population as an important subset of teachers within science education research, how elementary teachers conceptualize their own professional teacher agency, utilization of a variety of research methodologies, and inclusion of structural changes including the recent policy shifts to adoption of the Next Generation Science Standards (NGSS Lead States, 2013).

In-service elementary science teachers are understudied. What research is known about the agency of in-service elementary science teachers is extremely limited if one considers all those contexts—in-service teacher, teaching in the elementary grades, and teaching science. If a researcher is interested in researching in-service elementary science teacher agency there are currently no common schools of thought, no coherent and explicit theorization on which to use as a starting point. Because the research that prioritizes in-service elementary teachers as the research participants is so limited, researchers instead are looking across the social science disciplines to build a conceptualization of agency that is valuable within this specific combination of contexts.

In-service elementary science teachers are critical to effective science education occurring at the elementary level (Bintz et al., 2017; McClure et al., 2017) and yet researching their agency still seems to be a side effect of the research agenda, not the main priority. Across these few recent articles that focused on researching the agency of in-service elementary science teachers mentioned above, agency is used as more of a tool to get at understanding other interests in science education instead of understanding the teachers' actions themselves as powerful components to examine on their own. For example, instead of the research goals being explicitly about understanding in-service elementary teacher agency, the research goals prioritized understanding how teachers assign agency to others within science literature (Oliveira, 2015); how teachers modified lesson experiences for overall curriculum development (Howitt, 2011);

teachers' understanding across multiple representations of science content (Nichols, 2016); how language is co-generated between teacher and student (Im, 2015); how curriculum is collectively designed between teacher and students (Goulart & Roth, 2010); and how teachers transfer knowledge gained in a professional development experience to the classroom (Van Duzor, 2011). Rivera Maulucci (2015) was the only exception. Her research directly prioritized considering teacher agency development and conceptualizations including a focus on transformative and reproductive agency (Rivera Maulucci et al., 2015).

The specificity given to conceptualizing agency within *science* elementary teachers, as opposed to considering the agency of teachers writ large, or even considering elementary teachers more specifically is an important contribution to the overall conceptualization of agency because that specificity helps to add to the body of literature that can ultimately unpack the deep complexity and contextualization that is a natural part of agency. In addition, the discourse these teachers use are enactments of agency in and of themselves, and their discursive practices communicates not only their positioning of themselves and others, but also the ways in which structures position them. Science has unique linguistic features that differ from the ways of being, speaking, and interaction common among students' other discourse communities (Brown, Reveles, & Kelly, 2005), different than what is considered the typical discourse community in an elementary classroom that is generally focused on early literacy in reading, writing, and mathematics. Research on discourse processes in science education has examined that knowledge and practice are communicated in different settings, including different content settings (Kelly, 2014). Typically, discussion in science classrooms is directed by teacher talk (interactional discourse), and framed on the science textbooks utilized (intertextual discourse) (Kelly, 2014). The content setting of science is a discursive event in elementary schools that is a

unique practice. Therefore, analyzing elementary teachers' discourse within a science content context, provides understanding about how teachers are expressing their agency in ways that position science in their classrooms which is a consequential discursive practice that informs how scientific knowledge and practice are communicated in the formative elementary years.

Studying teachers' professional agency in currently understudied contexts (like elementary science teachers) ultimately leads to a more accurate and richer conceptualization of agency because the conceptualizations will then reflect the contexts that teachers are currently experiencing across their professional lives.

Conceptualization of agency currently defined by researchers. Although researchers agree that teachers play a critical role in educational reforms and change (National Research Council, 2012; Windschitl et al., 2018), and that their opinions need to be considered as principal voices within the educational system (Beachum & Dentith, 2004; Zoellick et al., 2018), their voices are not currently being heard in relation to how they conceptualize their own agency (Miller-Rushing & Hufnagel, in press). Instead of defining what counts for teacher agency based on what the teachers say should be counted as their agency, agency is currently being defined by science education researchers who then use their researcher-defined conceptualization of agency to research teacher agency. Just as student voice and choice is being heralded as an important component of learning in science education classrooms (Basu, 2008; Laux, 2018), I hypothesize that teacher voice and choice for what counts as agency to *them* should also be a prioritized component of how agency is being conceptualized in science education research.

Utilized research methodologies and traditions limited. Just as in education research more generally, the agency of in-service elementary science teachers is also largely being researched through a qualitative research paradigm utilizing narrative (Rivera Maulucci et al.,

2015), ethnography (Goulart & Roth, 2010; Im & Martin, 2015), case study (Howitt, 2011; Oliveira et al., 2015; Van Duzor, 2011) and positioning theory (Martin, 2019) methodologies. One research project utilized mixed methods (Nichols et al., 2016). I do not want to restate the earlier discussion that agency is largely being studied through a restricted methodological lens. However, I do want to make clear that this restricted methodological lens could be limiting the scope of how agency is conceptualized including the agency of in-service elementary science teachers.

Theoretical Framework—Personal Conceptualization of Agency

My conceptualization of agency is informed by research across the disciplines and my own reflexivity and positionality in this research. Although I will go on to explain and unpack what I mean by each component listed below (see Figure 1), I utilize a post-structural epistemological framing to support my conceptualization of agency as the capacity of actors to critically shape responses to problematic situations (Biesta & Tedder, 2006, 2007; Emirbayer & Mische, 1998). These actions are primarily framed as ecological (Biesta & Tedder, 2006; Bronfenbrenner, 1979; Priestley et al., 2011), but I also highlight the creativity (Emirbayer & Mische, 1998; Willis et al., 2019), criticality (Charteris & Smith, 2017; Willis et al., 2019), influence of individual's lived experiences (Buchanan, 2015; Hökkä et al., 2019; Richmond, 2016), and the discursiveness of agency (Ahearn, 2001; Al Zidjaly, 2009; Gee, 2010; Hufnagel & Kelly, 2018); attributes that are imbued but not made salient in a standard ecological framing of agency.

As mentioned previously, there are no "perfect" ways to conceptualize or study agency, and the diversity of conceptualizations can be seen as a strength when studying agency (Eteläpelto, 2017). My onto-epistemological belief is that there can be more than one "truth," or

more than one way of supporting your knowledge (Bates & Jenkins, 2007). Therefore, my way of conceptualizing agency is not necessarily the "right" way. Depending on a researcher's experiences and influences, other conceptualizations might resonate more. Eteläpelto (2017) says, "rather than implying a need to find a single way of understanding agency, the differing conceptualizations can be seen as a richness" (p. 4). This belief also afforded me the ability to deeply listen to the research participants' conceptualizations of agency to make sure I accurately gathered, analyzed, and described their conceptualizations which is helpful in determining how we come to know what we know (Duschl, 2008).

Just as other researchers interested in researching agency have historically been prone to do, I am utilizing my agency as I consider what counts as agency for this research. These choices are consequential in framing in what ways and how I consider agency. Therefore, I must not only clarify how I conceptualize agency, but I need to explicitly and coherently explain the theoretical beliefs from which this conceptualization stems (explained within this chapter) and how I will then utilize this conceptualization of agency operationally (explained within chapter three). By being explicit about my own conceptualization theoretically and operationally, I hope this research can play a role in addressing one of the concerns brought up earlier that hinders agency—that is the often-limited explicit communication of the theoretical schools of thought underpinning the research on agency within science education research.

Figure 1

Personal Conceptualization of Agency
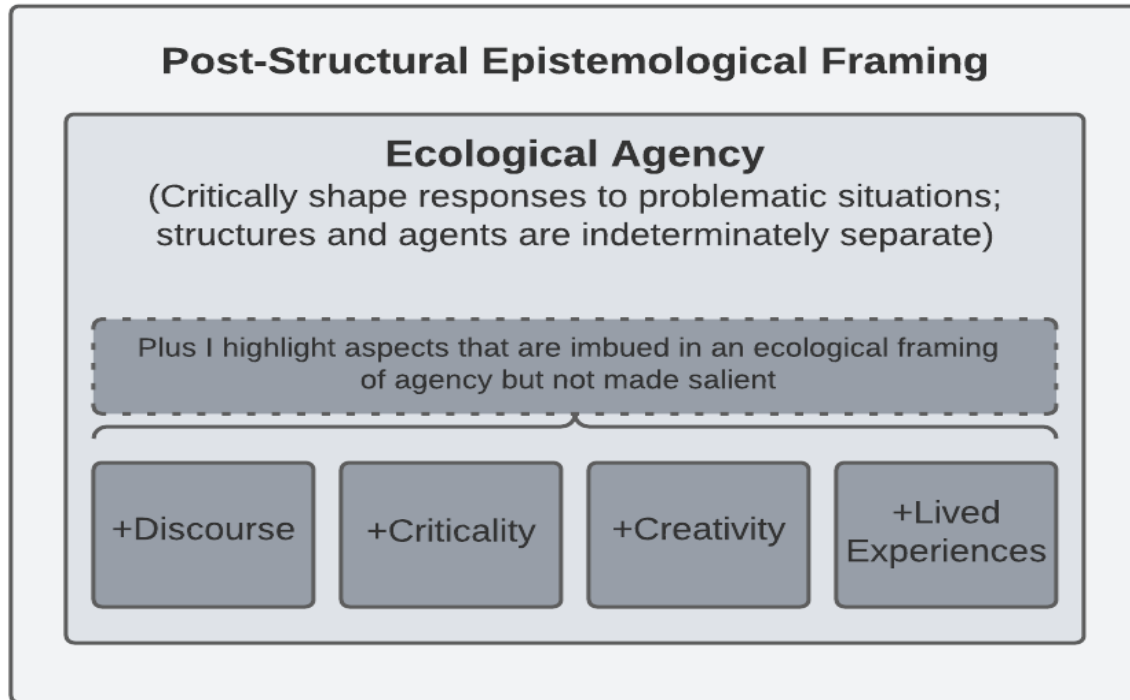
My personal conceptualization of agency draws on epistemology from post-structural theory. Undergirding the components of my conceptualization of agency is an orientation to post-structural theory. My epistemological stance (which aligns closely with post-structural theory) informs my theoretical and thus methodological research choices to prioritize, (a) the research participant's subjective experience (Bourdieu, 1977); (b) that those experiences are discursive and build meaning and knowledge (Foucault, 2019); (c) deconstruct the significance of those experiences to understand the concealments, assumptions, and contextualization that inform the significance (Derrida & Caputo, 1997); and, (d) an understanding that these meanings can never be completely understood by way of narrowly

defined and delineated categories, definitions, and rigid processes (i.e., positivism) (Agger, 1991).

This epistemological orientation allowed me to deconstruct a surface level understanding in order to deeply describe the research participants subjective experience, experience that is made significant through their discursive practice (Caldwell, 2007). At the same time I seek to deconstruct these assumptions, concealments, and contextualization I accept that this deconstruction naturally leads to more understanding in some ways and yet also to less defined clarity in other ways (Agger, 1991). I do not assume that this research will create results that can be delineated and categorized. Instead, I accept the complexity that comes from this qualitative deconstruction adds richer understanding and findings, yet findings that at this point cannot be extrapolated or generalized to large swaths of the teacher population (Patton, 2015).

This epistemology accepts that part of the complexity this research seeks to problematize is how agent and structure are indeterminate from one another. Although it is common practice across sociological research to consider agent and structure as individual entities intertwined and reciprocally consequential (i.e., structuration theory) (Smart, 1982), I continue to build on this understanding by further deconstructing that agent and structure are never wholly separate from one another, they are not indeterminate from one another (Doty, 1997). In other words, the agent never leaves their structural "baggage" at the research door, it is forever tied to their experiences and thus their discursive practice.

I also realize that through this epistemological stance I am continuing to center the human experience, perhaps ignoring potentially consequential conceptualizations if I instead allowed myself to utilize a post-human (Deleuze & Guattari, 1987; Pickering, 1995) or new-materialist (Barad, 2007; Braidotti, 2011) theoretical stance. My epistemological stance is also perhaps

missing an opportunity to profess a needed political agenda by not using a critical theoretical stance (Gutiérrez, 2013; Luke, 2002). However, my epistemological stance, largely informed by a post-structural theory, is where I can orient at this time in my research and my current interest in these particular research questions. My epistemological stance also informs the components that lead to my personal conceptualization of agency which I describe next.

Ecological component of my personal conceptualization of agency. Just as in an ocean ecology where there are interactions between organisms (i.e., phytoplankton, fish, coral, squid, whales, etc.) and their environment (i.e., water, underwater landforms, shipping traffic, pollution, etc.) there is a school ecology where the organisms (i.e., teachers, students, administrators, community members, etc.) interact with their environment (i.e., educational systems, policy structures, buildings and materials, sociocultural contexts, etc.). The organisms are making constant adjustments (expressions of agency) as to how resources are managed and utilized within their environment. In an ecological understanding of agency, resources are managed and utilized in ways in which people can achieve overcoming problematic situations (Biesta & Tedder, 2006).

This ecological understanding of agency first described by Biesta and Tedder (2006) based their ecological framework largely on the work of Emirbayer and Mische (1998), who highlight the iterative orientation of agency between actors and temporal-relational contexts. By including an ecological orientation to my conceptualization of agency I am positing that agency is expressed differently within different contexts and at different times within those contexts (Biesta & Tedder, 2006). There is a relationship that is highly mutable between and amongst the individual, the social group with which they are a part, the environment in which they are living and working, and the time and place in which they are engaged. Orientations and expressions of

agency can change over time depending on the principles and process at work (Emirbayer & Mische, 1998).

Since my earliest training as an ecologist, I cannot help but to see the inter-reliance of living and non-living things in ecological systems. When I think about agency, my ecological basis for understanding the world means I am also influenced by Bronfenbrenner (1979)'s learning theory that states that individuals and their development are interdependent with the ecological systems in which they engage, from the micro- to the macro-scales. I also consider, but do not centralize to my epistemological beliefs, the non-human, or other-than-human, influences on agency when using an ecological perspective (Bang & Marin, 2015; Barad, 2003). Just as the non-living rocks in the trail influence how I use that trail, how teachers use and manipulate the non-living parts of their environments by rearranging classroom curricular materials (for example) affect decisions they and thus their students make with each other and the curricula. Part of my conceptualization of agency "requires an understanding of the nature of the relationship between discursive practices and material phenomena, an accounting of 'nonhuman' as well as 'human' forms of agency, and an understanding of the precise causal nature of productive practices that takes account of the fullness of matter's implication in its ongoing historicity" (Barad, 2003, p. 810).

By drawing on an ecologically based theoretical perspective of agency I am including a multi-layered and contextual understanding of agency so that I stayed open to seeing the nuanced and diverse ways that agency can be categorized and interpreted. The ecological perspective encourages a conceptualization of agency that emphasizes interactions between actors and their environments, which works well for my research of teachers interacting with school systems (Biesta & Tedder, 2006). Through this work I am also highlighting that the ecological

perspective includes attributes that are imbued but I call out and make salient. The attributes I am making salient include the aspects of agency that are discursive, critical, creative, and the full range of one's lived experiences.

The discursive process is included in my conceptualization of agency. Agency can be conceptualized through discursive practices, because "language is a form of social action… these language practices can either reproduce or transform the very structures that shape them" (Ahearn, 2001, p. 110). How one enacts their agency (Biesta & Tedder, 2007) can be examined through how they participate discursively about that agency. Their logic about how and why they are engaging, enacting, and expressing their agency can be examined through their discourse. Agency is a social action that is co-constructed (Ahearn, 2001), and is a central tenant of the type of data-generating interviewing style that occurred throughout this research (see chapter three for explanation between the discourse analysis chosen for this research and the interviewing methodology utilized). In a discursive practice there is an epistemic belief that together we construct and reconstruct norms and expectations of interacting; every interaction has the opportunity to reconstruct or reconceptualize the actors and the practices of those actors (Leipold & Winkel, 2017). Fairclough and Wodack (1997) explained this dialectical relationship between a discursive event and social situations, institutions, and structures when they said, "discourse is socially *constitutive* as well as socially shaped" (p. 10 emphasis in original). Thus, the discursive interactions we participate in are expressions of agency themselves as well as affect our expressions of agency in consequential ways (Kelly et al., 2001; Martin & Carter, 2015).

It is important to point out that the discourse of teachers is not just in the words which they speak. Discourse includes words audibly spoken, of course, but it also includes the non-verbal and paralinguistic methods of moment-to-moment social communication (Al Zidjaly,

2009; Woldemariam & Lanza, 2014). Discourse can also be generated through artifacts generated during the day-to-day practice of teaching. For example, the actions a teacher makes, the curriculum they prioritize, the professional development they choose may be discussed or may be inscribed in a calendar or daily journal and can communicate a teachers' enactments of agency. Discourse is at its heart—saying (informing), being (identity), and doing (action) (Gee, 2010). Including the discursive process as part of the conceptualization of agency posits that discourse is an enactment of agency and can be witnessed and analyzed through the myriad of ways teachers put their world into words (Strauss & Feiz, 2013).

The discursive process is interactional. It is also important to point out that I was informed by (Hufnagel & Kelly, 2018)'s work concerning discourse that considers the interactional, contextual, intertextual, *and* consequential aspects of the discursive process and that consideration colors my conceptualization of agency.

For example, agency is expressed discursively through the interactional ways in which teachers come together in various social groupings (with other teachers and administrators as well as students) to work through the day-to-day needs of their profession. By coming together, interacting together, discursive processes are being enacted and expressed. When teachers make meaning with others, like they will do in interview settings for this research, there is discursive work being performed. Hufnagel and Kelly (2018) pointed out that this discursive work influences the science education of the school community when they noted that the "discursive work of the teacher and her colleagues influenced the emotional work she performed when teaching science to her students" (p. 909). The enactments of agency to teach science in certain ways were influenced by the discourse that teachers participated in with their colleagues. Thus, I include saying, being, and doing of discourse as part of my framing of the discursive process.

The discursive process is contextual. The discourse occurs in deeply contextual ways, that is, the discourse "occurs in time and space that is in a situation imbued with meaning for participants" (Hufnagel & Kelly, 2018, p. 913). These discourse events are constructed through interaction and have histories that may invoke emotions in participants, which as discussed previously can act as a catalyst for expressions of agency (Hufnagel & Kelly, 2018). Goodwin (1994) explains that understanding these contextual features is an important part of understanding how people within the same profession communicate about their work, such as teachers do about the system of education they work within. The professional vision Goodwin (1994) describes consists of "socially organized ways of seeing and understanding events that are answerable to the distinctive interests of a particular social group" (p. 606). These socially organized ways of seeing and understanding a profession, and for this research, one's role in it, is deeply contextual and must be considered as part of the discursive processing across time and scale (Wortham, 2012).

The discursive process is intertextual. By drawing on the intertextual features of discursive practice, I am conceptualizing that agency is expressed across different forms of discourse including text expressed verbally and in writing and that these various texts represent multiple levels of discourse available to analyze. Different forms of text can "mediate the meanings and actions between people" (Bazerman, 2006, p. 77) thus highlighting the agency expressed within these discursive interactions. By attending to the intertextual features within the discourse, the agential expressions will be more deeply investigated and understood since multiple levels of discourse will be utilized. By highlighting the intertextual feature of discourse, I am underscoring that teachers do not only express agency verbally, but they can also express their agency through written expression, or through the texts they prioritize in their work.

Looking intertextually at their discourse provides an immersed look at agency from all levels of discourse available.

  The discursive process is consequential. The discursive process is a consequential process for society; and thus critical discourse analysis is a process firmly rooted in the properties of contemporary life (Fairclough & Wodack, 1997). The contemporary life of teachers engaging in discourse—within social groups, within all contexts, and within all texts—can illuminate the consequential enactments of agency seen when the discourse is examined through a framework designed to examine agency. There is an increased importance of language in social life because "people can radically alter their practices- the ways in which they live their lives- on the basis of knowledge and information about those practices" (Fairclough & Wodack, 1997, p. 260). Altering practices, expressing agency, is a consequential act stemming from these discursive practices. The interpretations of which discursive processes are consequential are highly situational and dependent on cultural meanings (Hufnagel & Kelly, 2018) which is why the discursive process is an iterational and recursive process that is interactional, contextual, intertextual, *and* consequential (Hufnagel & Kelly, 2018).

  A critical component to my personal conceptualization of agency. Critical agency, to analyze oneself and others to interrogate and understand interests, motives and relationships of power, is essential to the practice of teaching and learning (Willis et al., 2019). Being critical to just be critical is not what is meant by critical agency. To be critical about expressions of agency requires one becoming metacognitive about the people, systems, motives, and power dynamics at play and then acting in a way that tries to mitigate or manage those complex pieces to meet the need that is believed to exist (Willis et al., 2019). In part because critical reflection is a necessary

part of moving from engagement to enactment (Buxton et al., 2015), critical reflection can be an important part of conceptualizing agency (Charteris & Smith, 2017).

Critical reflection can act as a catalyst which spurns one to move to action to autonomously address those identified critiques. It is common practice as a professional science teacher to practice reflective discourse (MaKinster et al., 2006). However, to be willing to move beyond general reflection to becoming critically reflective of one self and the system one works in, *and* then moving towards action (i.e., expressing ones agency) to meet the needs called out in that critical reflection is a crucial part of agency (Leijen et al., 2019).

Critical thinking is an enactment of agency that is often required when considering a science education perspective. Teachers are interested in preparing students to think flexibly, critically and consider the evidence (National Research Council, 2012). These scientific practices are what is asked of students when they practice science through activities like scientific argumentation based on claims, evidence, and reasoning (National Research Council, 2005). However, to support students in this work, teachers must also be able to express their agency in order to practice enacting their critical thinking. When teachers are able to analyze themselves, the classroom community, the resources available to them, and the systems and structures in which they work, to ultimately negotiate and mediate these systems and structures to help make what is, to what ought to be (Rivera Maulucci, 2013), that is critical agency, an important part of agency to include in this conceptualization.

Although there is a part of agency that requires critique, that critique may not be verbalized or necessarily even considered metacognitively. In moving to action, the critique might be an unrealized, or even subversive part of why they move to action (Foucault, 2019). However, critique is a part of agency even if it is underrecognized by the agent. Emirbayer and

Mische (1998) highlighted that part of agency includes a need to be critical when they said that agency is, "the capacity of actors to critically shape their own responsiveness to problematic situations" (p. 971). Recognizing this means that actors not only shape their responses, but they also critically shape their responses when they express agency. Further along in that same work by Emirbayer and Mische (1998) they bring together the role of creativity and critique when they say that agency "can result in (which can either mean 'demand' or 'facilitate') greater capacities for creative and critical intervention" (p. 1007, emphasis in original). Across much of the literature, critique is considered as a part of how agency is conceptualized, and I too consider critique as a part of my personal conceptualization of agency.

A creative component of my personal conceptualization of agency. Adding to my conceptualization of agency, I conceptualize that agency is also in part a willingness to try creative acts. Emirbayer and Mische (1998) call out the creative element in agency when they remark that agency is, "the imaginative generation by actors of possible future trajectories of action, in which received structures of thought and action may be creatively reconfigured in relation to actors' hopes, fears, and desires for the future" (p. 971). What they are highlighting here is that through changing circumstances (which is often happening in learning environments like schools where the classroom community is creating knowledge in an on-going way) there can become a creative reconstruction of expressions of agency to meet the changing circumstances. This ability to negotiate changing circumstances creatively, in turn, can alter the individual's ability to respond to the existing situation (Emirbayer & Mische, 1998). By exerting influence, making choices, and taking stances in ways that affect their work and/or their professional identities (Eteläpelto et al., 2013) science teachers are expressing their agency in creative or novel acts to mitigate and negotiate the systems and structures in which they work.

Willis et al. (2019) call these kinds of creative acts, 'creative agency,' and describe them as acts that, "create an innovative intervention in the world that draws on one's interests, experiences and aspirations" (p. 234). This explanation of the creative role of agency highlights the entrepreneurial spirit that is part of agency. These innovative interventions are creative but also are drawn from the highly complex individual life experiences (often previously referred to such as identity, values, and emotions). Through this conceptualization I am supposing that one's perception of their right to make self-prescribed decisions (autonomy) and ability to effectively enact that decision (self-efficacy) will make one more likely to make the act take place (agency); this act is a move towards a risky and creative venture to negotiate the structures and systems in which they interact.

I also clarify that the creativity that is part of agency means that the act itself might not be creative, but perhaps how one engages with, rearranges, processes, or constructs that act is creative (Willis et al., 2019). For example, teachers often teach lessons from predesigned curricula—they are given a lesson or kit to teach a particular concept. However, if that teacher feels that the lesson is not meeting the needs of the students in some way, they might pull in additional materials, text, activities to supplement the lesson in a way that changes the intended and original structure of the lesson. Which materials, text, and activities they bring in and how they incorporate those into the lesson are creative acts. The teacher in this case is expressing their agency in a creative way by making a unique determination that there is a part of the structure of the lesson needs transforming, and they make an enactment of agency to position themselves in a way to engage with that structure. The act of changing a lesson is perhaps not creative, but in what ways they change that particular lesson is creative.

Individual's lived experiences are included in my conceptualization of agency. Part of my conceptualization of agency I am making salient is the individually related lived experiences like identity, experiences, values, beliefs, and emotions. Earlier I discussed in depth how these components afford and constrain agency—they are complex and highly contextual factors that play into expressions of agency in consequential ways (Buchanan, 2015; Richmond, 2016). One's lived experiences (both within their professional and personal life) affects their views on the world and thus affects how they express their agency.

In my conceptualization, agency is expressed professionally in discursive ways in which one positions oneself or others in order to work out the moral and social structures in which an individual works (as mentioned above), but the ways in which agency is positioned is also afforded and constrained based on the individual's full range of lived experiences, including identity, beliefs, values (Richmond, 2016), emotions (Hökkä et al., 2019), and their personal and professional experiences (Miller-Rushing & Hufnagel, in press). There is a back–and-forth relational connection between lived experiences and agency (Holland et al., 1998), often noted but not attended to in science education research (Miller-Rushing & Hufnagel, in press). Lived experiences affect how one positions oneself and others, their agential expressions (Biesta & Tedder, 2007), but depending on the self-efficacious and autonomously perceived ways those agential expressions are experienced they then recursively affect future agential expressions (Skaalvik & Skaalvik, 2014).

Attending to the research participants' lived experiences reflects my personal conceptualization of agency that professionally enacted agency is deeply contextual and thus in part based on one's professional and non-professional lived experiences. How one decides to be critical and creative within their ecological experience is in part based on their lived experiences,

expressed discursively, and thus my conceptualization of agency highlights these unique and highly individual experiences as playing a critical role in expressions of agency.

Research Questions

Based on the importance of agency as a way to understand how elementary science teachers utilize their capacity to critically shape responses to problematic situations, combined with the contribution of this work to science education research on teacher agency—to describe conceptualizations of agency based on the teachers own professional opinion of their agency; to deeply attend to the teachers' lived experiences; and to consider agency as a robust spectrum of expressions—this research will add to the current conceptualizations of science teacher agency, and to the larger body of research literature in science education in notable ways. It is for these reasons that I am asking these research questions.

My research focuses on in-service teachers (grades K–5) to address the research questions:

1. How do K–5 teachers conceptualize and enact their own science teacher agency?

    a. In what ways do the teachers' lived experiences and identities contribute to their science teaching professional agential expressions?

2. As K–5 teachers negotiate a disrupted educational system, in what ways do they discursively express their science teaching agency?

CHAPTER 3

METHODS AND METHODOLOGY

Qualitative Descriptive Case Study

To answer my research questions, I used an empirically-based qualitatively-derived descriptive case study (Patton, 2015; Yin, 2012, 2017). This kind of case study is often confused with, but is distinctive from, case studies not empirically researched but instead serve as administrative archives "case records," or "popular case studies" that describe a popular representative from something like literature or media, or "teaching-practice" case studies that are a grouping of anecdotal records that serve a professional development function (Yin, 2017).

Building a case study process. To construct this empirical case study I used a linear but iterative process of plan, design, prepare, collect, analyze, and share (Yin, 2017). Yin (2017) goes on to explain the research design process when using a case study approach as:

> A research design should include five components. The first three components—that is, defining your study's questions, propositions, and case(s)—will lead your research design into identifying the data that are to be collected. The last two components—that is, defining the logic linking the data to the propositions and the criteria for interpreting the findings—will lead the design into anticipating your case study analysis, suggesting what is to be done after the data have been collected. (p. 34)

In other words, by using Yin (2017)'s research design the design of the research project (research questions, propositions about the research, how the case(s) are defined) is linked through to the analysis, interpretation of the findings, and even recommendations. By utilizing a foundation on which to center the research design, all steps of the research process are coherently linked in a way that informs the entire process. Although the specifics of the research design is left up to the

researcher (i.e., which research questions are asked, how cases are bound, etc.), using Yin (2017)'s research design provides an effective structure that supports consistent and reasoned design, analysis, and findings. The rigor and depth of qualitative research is largely based on this flexible yet structured approach (Patton, 2015).

  Case's boundary and factor of interest. Although there can be wide disagreement over what constitutes a "case" across qualitative and quantitative studies, the common thread is the necessity of placing a boundary around a phenomenon of interest (Patton, 2015). "This boundary is inevitably arbitrary and fundamentally critical because the boundary-setting process determines what the case is and therefore the focus of inquiry" (Patton, 2015, p. 259). I bound this case to the agency expressed by a small group of six in-service public-school elementary teachers (grades K–5) who are teaching science during a time of tremendous educational disruption (COVID-19 global pandemic). By choosing the ways in which agency is discursively expressed by this small group of teachers as the case boundary I chose to deeply analyze and contextualize the expressions of agency across those teachers and highlight their collective life course (Harré & van Langenhove, 1999) that contributes to understanding how elementary science teachers express their agency. In this way I foreground the importance of elementary science teachers as a unique and crucial professional collective whose expressions of agency are valuable to consider and describe. The expressions of agency, occurring in a particular life course of a particular teacher, stimulate a rich description concerning the patterns and configurations of agency across the teachers within this case.

  The boundary for the case determines the boundary from which data can be collected (Yin, 2012, 2017), meaning, all data related to the expressions of agency within the small group of teachers could be included in the case to then be analyzed based on the factor of interest

within the case—science-related teacher agency. I sought to make sure the boundary was broad enough so that within the case various expressions and descriptions of agency would be able to be included. Within even this small group of teachers, the teachers come from various backgrounds, have various life experiences, are from various localities, and teach in various kinds of school and community settings. Therefore, the case analysis looked for the patterns, nuance, and contextualization of expressions of agency which included the data the small group of teachers generated.

  What counts as an expression of agency for the case boundaries. To help bound the case to the teachers' expressions of agency, I need to clarify what counted as an expression of agency. As I was collecting and analyzing the data I would reread and reconsider my personal conceptualization of agency (see chapter two) as well as what the participants were communicating as far as what *they* considered expressions of agency. Therefore, I considered expressions of agency to be examples of problem solving, positioning of themselves or others, ways they engaged with the structures they work within; generally, I orientated to the ways in which they were critical and creative in their professional lives. A range of types of expressions of agency counted including agency expressed through the teachers' saying, being, and doing (Gee, 2010). This range can best be explained by using specific examples from the data.

  An example of a teacher expressing agency through "saying" occurred when I interviewed Calliope during interview one and she said,

> The group [of students] I see now, I won't see for another six weeks, that it's more urgent for me to at least get the concepts and the big ideas out there. Rather than not teach it, because I don't have enough time. I'm just doing one lesson that includes a hands-on or some background knowledge, and then moving on to something else. But it's all ties

together. So, you know, I'm yeah, I'm doing the best I can. But I just don't feel like

skipping anything is going to be helpful to anybody. (Calliope, first interview)

This was an excerpt I highlighted and thus included as being within the bounds of this case (the

boundary being expressions of agency) because the teacher was expressing through their saying

what was their critical and perhaps creative way of problem solving the current reality of the

structures they were having to work within. The teacher expressed that the structure of their

educational system was providing them only limited time with the students and so to solve that

problem in the best way they could, they decided to provide a breadth of connected science

learning experiences instead of what they felt was a more desirable depth of science learning.

This teacher felt she was unable to have the time to help her students do deep dives into science

topics and concepts, so she expressed her agency by deciding to continue to try to teach science

even though she was only covering a small amount of each science topic during the truncated

time available.

Another example, and one that shows the "being" of an expression of agency that was

included within the bounds of the case, was when Maya expressed her beliefs about what role

she plays in the educational system she works within when she said during the first interview,

Part of me says I have far less control over it [science education experiences of the

students] because it is always dictated by these outside circumstances. But the other, the

truth of the matter is I'm in this corner of this beautiful building with this beautiful

science lab. And my administration really supports what I do. (Maya, first interview)

This highlighted data excerpt showcases that agency is part of a teachers' being, and that being is

expressed through agency. Maya expressed that she vacillates between feeling in and out of

control of her professional circumstances and she reflects on her understanding of her

expectations and her power within those circumstances. Maya's inner being is communicated through this expression of agency and was able to be made salient through this discursive interaction within the interview setting.

An excerpt from the data that fits within the bounds of the case that provides an example of a "doing" expression of agency is from Deborah during interview three when she said,

> I feel I feel agentic quite a bit in my in my current school, I feel that my administration is very supportive, and encouraging of me and others. I feel like I get to make a lot of decisions about my curriculum about my teaching methods about my professional development. (Deborah, third interview)

Deborah is describing what she does, actions that she takes, that are examples of times that she feels she is able to express her agency within her professional experiences. Deborah's actions, what she does to express her agency, is to communicate the importance of her ability to be able to make decisions about the curriculum she teaches, the pedagogy she uses, and the professional development she engages in. These are some of the ways Deborah communicates the "doing" of her agency.

These previous excerpts are shared to convey clarity around what counts as expressions or enactments of agency; the ways agency was made salient through the teacher's saying, being, and doing. As the case is bounded by the myriad of expressions of agency discursively communicated by the six teacher participants, it is important to therefore try to make it clear what type of data was included within those bounds.

Case study analysis. The ultimate goal of building a case to represent and describe the research participant's construction of their agency within their discourse, is to create a case synthesis (Yin, 2017). Yin (2017) reminds researchers doing case study research that case

patterns and ultimate synthesis of those patterns relies strongly on argumentative interpretation, not a reliance on a quantifiable numeric tallying of information. Therefore, although I coded, and organized data in excel spreadsheets (i.e., the attribute map) the case analysis required interpretation, not statistics, to find the overall storyline across the case. It was important as the researcher to develop strong, plausible, and fair arguments that were supported by the data (Yin, 2017).

Completing the case analysis required research to be completed at the highest level of quality. There are four principles that Lincoln and Guba (1985) and Yin (2012, 2017) prescribe as principles that should be of the highest priority for the researcher throughout the research project, but most especially observed during this stage of final analysis. Those principles are that the analysis should;

1. show that you attended to all of the evidence;

2. investigate, if possible, all plausible rival interpretations;

3. address the most significant aspect of the case study; and

4. demonstrate a familiarity with the prevailing thinking and discourse about the case study topic.

I followed those steps during the research but also carefully analyzed my data with these principles in mind when I reached the stage of being able to analyze within the case.

Orienting to Discourse as Meaning Making Within Saying, Being, and Doing

This research is informed by an approach to discourse analysis that attends to the wide variety of ways in which discourse is expressed including the saying, being, and doing (Gee, 2010) as well as the way in which meaning is interpreted within co-constructed discursive situations such as interviews (Mishler, 1986) which became the primary data that this research

relied upon. Discourse is an important medium for investigating agency since discourse is indeed a form of social action (Woldemariam & Lanza, 2014); action that emerges and is negotiated discursively within moment to moment interactions (Al Zidjaly, 2009).

Discourse, such as the discourse archived in the interview data within this research, are considered "linguistic forms through which individuals attempt to order, organize, and express meaning" (Mishler, 1986, p. 106). Therefore, the meaning of the discourse depends on how it is interpreted (Mishler, 1986). As a researcher I co-constructed the discourse with the research participants, it is therefore imperative to thoroughly describe and explain my interpretation of those discursive situations. As a result, the discourse analysis of the case is based on my interpretation of the intended meaning of those discursive situations; situations that considered all the ways in which meaning is discursively expressed by the research participants—their saying, being, and doing. My interpretation of that discourse is a valid and valuable part of the interpretation because of my role as a co-constructor of that meaning. In this way the multiple ways in which agency is expressed discursively (Martin, 2016) often neglected in science education research (Arnold & Clarke, 2014), is fully attended to. Orienting to discourse in a way in which agency is understood to be expressed variably and where the meaning making is interpreted provides the opportunity to build a case that rigorously considers the heavily nuanced and highly contextualized nature of agency.

Discourse includes the saying, being, and doing. I often use the term expressions of agency to describe agency that is communicated through discourse. Discourse is so much more than just the verbal utterings made by humans at one moment in time. Instead, discourse are the ways that participants make meaning, including both verbal and non-verbal communication events in space and time. Discourse is at its heart—saying (informing), being (identity), and

doing (action) (Gee, 2010). In framing discourse in this way, discourse is a way of meaning making that assumes that all human communication is social, influenced by and shaped by culture, contextually recursive and inevitably multimodal (Pinnow, 2011). This approach to communication seeks to understand all the discursive ways people make meaning. Through this discursive lens there is ongoing interaction and interpretation and thus language is understood as a way to inform each other but also as a way of allowing us to do things and be things (Gee, 2010).

There are important connections between the saying, being and doing in discourse. For example, even if someone says something to you, "to understand anything fully you need to know who is saying it and what the person is trying to do" (Gee, 2010, p. 2). When someone says something to you the intent is to inform. Therefore, one way I orient to teachers' discourse is through what they say, but the goal of that orientation is to understand what they are trying to inform. Teachers informed me throughout the research process of the ways in which they expressed their science teacher agency and therefore I stayed open and receptive to the ways they made meaning through that informing. The saying in discourse allows others to be informed but it also allows people to do things, by engaging in actions and activities, and be things, by taking on socially significant identities, as well. "In fact, saying things in language never goes without also doing things and being things" (Gee, 2010, p. 2). The connections between the discursive saying, being, and doing are entwined and complex but important to consider for this research to be able to describe the range of ways agency is discursively expressed.

A more narrowly defined way that discourse is communicated is through being. In Gee (2010)'s theoretical framing of discourse "being" is considered a special type of identity. In this

discursive framing of identity, identity is not the essential sense of self one believes they are. Instead, identity in this way means,

> different ways of being in the world at different times and places for different purposes;
> for example, ways of being a "good student," an "avid bird watcher," a "mainstream
> politician," a "tough cop," a video-game "gamer," a "Native American," and so on and so
> forth through a nearly endless list. (Gee, 2010, p. 3)

The way one expresses agency is part of the language-in-action, a meaning making event that communicates the way in which one sees oneself in the world. Therefore, an important consideration when thinking about how teachers express their agency is attending to how they discursively express their being, their identity, or way of being in the world at different times and places for different purposes (Gee, 2010).

Another way agency is discursively expressed is through actions, the doing. What one chooses to do expresses the meaning they are making of the situation. Who we are (being) and what we are doing while we say things matters in making meaning (Gee, 2010). Therefore, orientating to the discourse of what the teachers do helps to bring clarity to the meaning they are making. Because "we use language to say things, do things, and be things" (Gee, 2010, p. 3) discursively attending to what the teachers do, in conjunction with their being and saying, is an important part of rigorously attending to the discourse within this case. What one does, their actions, is also a way to discursively express agency, and thus an important consideration when using discourse to answer the research questions in this study.

By orienting to discourse in this way for this research, I was able to analyze, and then describe, the saying, being, *and* doing of expressed agency during data collection. Through this lens I acknowledge that discourse is inherently hybrid, emergent, and communication is a fluid

process (Woldemariam & Lanza, 2014). In other words, how language is used to make meaning is a constructed process, not defined by a particular set of spoken words. Just as no two science lessons will be the same because they are set in different times, perhaps with different parties to the lesson; orienting to discourse in this way reminds us that language is deeply contextual and not static. Being informed by a discursive practice that uses Gee (2010)'s saying, being, and doing approach clarifies and sheds light on the patterned ways in which in-service elementary science teachers are constructing their meaning of agency. Considering in what ways the research participants are expressing their science teacher agency through their saying (e.g., informing), through their being (e.g., identity), and through their doing (e.g., actions) informs the methodological frameworks in critical ways.

Discourse is co-constructed and interpreted. Mishler (1986) provides a way to orient to the discursive nature of the data collected; data from discourse that is situationally co-constructed and constantly interpreted. Within the Mishler paradigm there is an overarching impetus to consider not only what terms are expressed in the discourse but drawing attention to the very nature of how that discourse is created to understand the intended meaning of the discourse more thoroughly.

The traditional model of an interview is often seen as a stimulus-response model; a model in which the researcher provides a behavioral stimulus (i.e., a carefully worded question), and the verbal response by the interviewee is the data on which the research is based (Mishler, 1986). Often interviews are considered a standard way in which researchers attempt to garner responses from participants, and it is only those responses by the participant that are considered, analyzed, and interpreted. Instead, Mishler (1986)'s work emphasizes that an interview setting is a unique discursive situation where meaning is made by the interviewer and the interviewee interpreting

what the other is communicating in an on-going and co-constructed experience. Instead of the response to a question being considered in isolation from the rest of the interview, the primary goal of an interview framed through Mishler (1986) is to interpret the meaning intended throughout the whole experience of the discourse by way of continually reformulating questions and responses in order to understand the intended meaning. In other words, the specific wording of the question, and even the exact words used to answer to the question is deprioritized. What is prioritized is the overall meaning made during the experience which requires interpretating implicit assumptions and ad hoc hypotheses (Mishler, 1986). The exact words spoken during an interview are not unimportant, but are less important than the meaning that was understood; meaning that can only be achieved through interpretation of the co-constructed discourse (Mishler, 1986). Interpretation is occurring within every discursive interaction, and therefore the act of the interpretation is acknowledged when using this kind of interviewing framework, instead of seen as a problematic bias.

The research interview setting is a dialogical context for the production of social life and narratives (Tanggaard, 2009). Those narratives are inherently indexical meaning the meaning of the discourse is not singular and fixed. Rather, "terms take on specific and contextually grounded meanings within and through the discourse as it develops and is shaped by speakers" (Mishler, 1986, p. 64). As the researcher it is then imperative to reformulate and repeat questions and responses so that the meaning of the discourse is understood by both parties involved in the interview. By doing so and thus attending to the discursive nature of the interview process a more adequate understanding of what respondents mean helps to ultimately develop stronger theories as well as more valid generalizations in interview-based research (Mishler, 1986). The interviews were therefore not just reports through which information was elicited, but occasions

where meanings were constructed between researcher and interviewee (Seidman, 2006). I utilized the interview as one of the many ways of collecting data for analysis, but it is one of the ways in which I could directly co-construct and interpret the discourse, specifically the expressed agency of the teachers, through moment-to-moment interactions (Mishler, 1986).

By utilizing Mishler (1986), I am situating the saying, being, and doing of discursively expressed agency as part of a socially constructed interpretive experience. By acknowledging my role as part of the co-constructed dialogue, and the inherent role of careful interpretation as part of the interviewing process, I am utilizing a methodological framework that considers the nuance of how agency is expressed by in-service elementary science teachers, even when they might not themselves use the term "agency." This methodological approach prioritized the nuances of expressions of agency that occurred "in situ across forms and levels of discourse" (Hufnagel & Kelly, 2018, p. 906) through careful consideration of those ways agency might be expressed (i.e., in the saying, being, and doing), and in the acknowledging the interpretation of the co-constructed discourse as necessary in order to fully describe those expressions of agency.

Researcher Reflexivity and Positionality

Part of the affordances and constraints within these methodologies is the researcher's skill at utilizing those methodologies to effectively, rigorously, and meticulously complete the research. I enact my own agency while making research decisions and therefore knowing my reflexivity and positionality I was influenced by to make these decisions is important to understanding the process and findings of this work (Denzin & Lincoln, 2011; Lincoln & Guba, 1985).

Post-human theory posits that researcher bias and situational positioning is vital to consider when embarking on research (Kress & Frazier-Booth, 2018; Ulmer, 2017). Although I

am not using a post-human theoretical lens for this research, I ascribe to several post-human axiologies and bring these to my research in general. I position myself within the methodology of my research because as the researcher I am part of the entanglement and intra-actions (Barad, 2003) that occurred to help complete this work; I am a part of the social network that I am studying. Thus, in this section, I describe my biases and background to help the reader understand how I envisioned and completed this work.

The biases I bring to this research include a belief that teachers are professionals who are expected to do the impossible on a daily basis. I believe teachers want to help their students to succeed but are often unsure what success looks like or how to achieve it. I believe that these challenges are especially prevalent in elementary science education. Compared to many junior or senior high school science teachers, who can focus in one content area, elementary teachers work within in a system that expects them to have a broad understanding of science and all its specific, yet intricately woven, disciplines. At the same time elementary teachers are expected to be able to effectively wield considerable science content and the nature of science, elementary education deprioritizes and thus devalues science, which means that science often gets less emphasis compared to the other curricular areas (e.g., English language arts and mathematics) (Griffith & Scharmann, 2008).

Reflexively, I can see that some of my understanding as being informed by previous professional experiences. For example, within this work I refer to 'elementary science teachers' meaning all classroom teachers who teach in the K–5 grades even if they are not specifically content specialists only teaching science. I include general elementary teachers in my reference of elementary science teachers because elementary teachers are teaching science through their discursive practices within the classroom even though they do not often identify themselves nor

are they labeled by their administrators as 'science teachers.' I want to use my work to draw out the importance of elementary teacher discourse, discourse that provides the conceptual framing of science for their students, but also discourse that constitutes the ways in which elementary teachers express their agency.

My own identities as a former elementary teacher, as a science education consultant who often worked on teacher professional development, and as a teacher-researcher have encouraged me in this line of research, shaped its design, and informed its evolution. My desire to pursue this research is undergirded by a value for calling attention and giving voice to those not often heard (but frequently written and spoken about) in education research—teachers. Given the highly politicized and polarized context of the current accountability era and neoliberal policy trends sweeping across the United States (Bartell et al., 2019), the perspectives, reflections, and insights from teachers on the front lines are too often silenced (Robertson, 2008). I hope my research, in time, will help those willing to lead from within the classroom have more understanding of their agency so that they can become change agents within their school communities (Van der Heijden et al., 2015).

The critical work done by teachers "has intensified, paperwork and bureaucracy have increased, and teachers have felt increasingly disempowered and professionally marginalized" (Priestley et al., 2012). I wish to use my privilege as a middle-aged, English-speaking, upper-middle class, white woman, with multiple education degrees to try to ultimately empower and support these teachers by adding to the understanding of teacher agency, understanding that can be generated through the careful analysis and description of their discourse. I critically consider what others have said concerning teacher agency, but also move that body of knowledge

forward. Although I call out my own bias, I also use my critical friends and mentors to call out that bias and mediate it as much as possible.

Research Design

I conducted this case study from July, 2020 through February, 2021 while working remotely as a graduate student in the STEM Education Ph.D. program within the College of Education and Human Development at the University of Maine at Orono. In this descriptive case study, I analyzed six teachers all of whom currently teach in grades kindergarten through fifth grade in a public-school setting in the United States during a severe educational disruption due to the global health pandemic of the COVID-19 virus. The six teachers served as a small group making up the subject of the case study. The analytical frame of this case study was for a rigorous analysis of that small group based on deeply noticing and analyzing the discursive ways in which the teachers express their agency as they teach science during the disruption. I highlighted patterns across this group of teachers and tied the findings to the norms of that small group, ultimately constructing a descriptive case about elementary teacher's agency teaching science during a time of national and system-wide educational disruption.

This choice of researching a teacher's agency within a system-wide disruption highlights that agency influences and is influenced by the structures and systems the teacher works within—the structure-agency dialectic (Giddens, 1984). This ever-changing environment in which science teachers work creates challenges to which teachers consequentially position themselves and others, and these positions are expressed through their discourse. Teachers are system mediators, implementors, and transformers, even if they believe they are a-political (Leander & Osborne, 2008). By utilizing the methodological and design choices described above and by situating the cases in recent educational structural upheaval, I was able to observe and

describe how teachers negotiated the science teaching disruptions through their agency, in what ways their agency is influenced by their lived experiences and identities, and how teachers themselves are conceptualizing their agency.

Research Participants and Associated Educational Settings

The research participants (six teachers in total) taught science during the educational disruption caused by the global health pandemic. I felt very lucky to recruit these six teachers for this study because at the time of participant recruitment the COVID-19 virus was wreaking havoc on school systems and teachers were under phenomenal amounts of stress to pivot to the new realities they were facing (and I would argue are still facing). Even with a robust list of contacts locally, regionally, and nationally it took an extensive amount of time to recruit six teachers. I started my recruitment efforts locally and cast a wider and wider net as time went by and few teachers were responding affirmatively.

Originally, before the COVID-19 virus shut down in-person schooling, I designed research protocols in such a way as to be able to observe and video science teaching in person. Therefore, my first attempt to recruit participants was to send an IRB-approved recruitment letter via email to all the K–5 teachers in my local school district. This resulted in two teachers signing on to the research project. But, because COVID-19 protocols severely limited in-person visitation to schools and I was able to transfer the research entirely online, I was then able to recruit participants from beyond my physical location. So, I then sent a recruitment letter via email to my state science teacher list serve hosted by a science and mathematics orientated not-for-profit. This state-wide recruitment effort resulted in two more teachers signing on to the project. However, once again, not enough teachers signed up to reach my minimum goal of six teachers. I therefore sent a recruitment letter via email to the national science teacher list serve

hosted by the National Science Teaching Association (NSTA) resulting in the final two teachers signing on to the project. The recruitment process started in July of 2020, finished in October of 2020, data collection ended by February 2021.

Although I had originally planned to recruit teachers as research participants until I was able to create a small group of teachers with diverse lived experiences, in the end I took the first six that signed on due to the difficulty of recruiting during the challenging educational times. Those six teachers ended up creating a small group that include both generalists and specialist teachers; teachers that teach in rural, suburban, and urban locations; teachers who come from various socioeconomic levels, and teachers who are similar in some ways to the average elementary teacher today—a middle aged, White, English speaking woman, who has been teaching for over ten years (National Center for Education Statistics, 2021).

These teachers taught science directly but also indirectly—by providing projects and resources, science "menus," integrating science into other subjects, or encouraging students to work with community partners focused on providing science education. Whether the research participants taught science directly or provided science indirectly or informally, they taught science. And, although all the research participants did in fact provide some sort of science education to their students, had they not been able to provide any science education directly or indirectly that would have been a consequential expression of agency of note as well. Therefore, the agency that the teachers discursively constituted around science teaching at this time was valuable discursive data worth analyzing and describing.

At the time of the research, the research participants all taught in grade(s) kindergarten through fifth grade in public elementary schools in the Mid-Atlantic and the New England regions of the United States. Appendix A describes the lived experiences, attributes, and

common descriptors of the teachers and their school community. This information was largely gathered based on answers to a survey I asked the research participants to complete at the start of the research process. I also utilized publicly available demographic data about each of their schools to provide some of the basic school attribute information.

Three out of the six research participants were elementary generalist teachers meaning they taught all subject areas as an elementary teacher. These teachers were responsible for teaching science as well as math, reading, writing, and social studies. These three generalists taught one class within one grade level but taught that class all the subjects and content areas necessary across the elementary curricula. The other half of the research participants were elementary science specialists meaning they taught elementary students only science. These three teachers did not teach any other content or subject area to the elementary students and instead were focused exclusively on teaching science to multiple classrooms and grade levels within the school in which they worked. I often designate these teachers as generalists (if they were responsible for teaching all content areas) or specialists (if they were responsible for teaching only science). The expressions of agency from all six teachers were considered together as one small group of elementary science education professionals.

Each of the teachers had slightly different, yet similar, curricular structures they worked within. All of them taught science using standards that are NGSS-aligned. Although some states and districts they worked within prioritized certain sections of the NGSS and/or slightly modified the standards in ways that highlighted specific interests or focus, each of the teachers expressed that they were aware of, and following, the NGSS when they taught science.

The teachers also expressed that they had access to, and utilized, a variety of curricula to help them teach the lessons that aligned with the NGSS. The teachers expressed that they used

curricula such as Mystery Science, FOSS kits, Amplify Science, and Generation Genius by Pearson. The teachers also mentioned that they modified and supplemented their lessons heavily and routinely using National Geographic, Science! KIDS by Public Broadcasting Services, lessons provided by the National Science Teaching Association, their local educational not-for-profits, and even sites on the internet such as You Tube, and Teachers Pay Teachers. The teachers all expressed that they often started with a guiding question and the standards as foundational ways of designing their lesson, then they adapted the curriculum as necessary, often designing their own lessons. The teachers expressed that they felt they needed to address certain standards or grade level expectations outlined in their district's scope and sequence documents, but overall felt they had freedom and autonomy about how best to reach those expectations.

Although the teachers all mentioned feeling like they felt they had the freedom to design, modify, and adapt curricula as necessary they all also expressed feeling constrained to teach science in the ways they wanted because of limited resources. They felt limited in that they could design, modify, and adapt only so much as they could make those modifications and adaptations for free or with the limited resources already provided to them. The resources they mentioned feeling limited by included funding for materials and supplies, but also in limited time availability to teach science because science was an under-prioritized part of their school schedules.

Every teacher in this group was a consummate professional and was actively reflecting on how they could make sure science was still being prioritized despite the current teaching challenges and even direct messages from administration that science could be deprioritized during the COVID-related chaos affecting schools. These teachers provided me with sincerely

personal, authentic, and valuable data to consider and reminded me how deeply teachers frame their work and their profession through their goals for their students.

Next, I describe a few ways each individual teacher's lived experiences contributed to understanding and describing the deeply contextual nature of science teacher agency. I choose to describe each teacher research participant by highlighting what the teacher's themselves shared with me that they felt were important aspects to their identities or lived experiences as science teachers. Based on their survey data, four reflective responses, and data from the four hour-long interviews I center their voice in describing themselves and what feels important to them when describing who they are. All participants were given a pseudonym and their school communities were described in the most general context in order to protect their identity.

Amelia. Amelia taught for 18 years and currently is a generalist teacher teaching fourth grade in a small rural school in New England. Amelia describes the rural-ness of her community quite often and comments that although she recognizes where she is currently teaching is generally considered a very small school (169 students in a K–8 school) she is used to working in even more remote locations; one room school type of educational community. Amelia is intricately connected to the greater community outside the school and is very keen to utilize the resources beyond the classroom walls. Amelia explains that the grade she is teaching and the school that she teaches in are the greatest factors that impact the decisions she makes concerning science. She pivots to describing her students, their needs, and her excitement working with them again and again, but she also comments frequently that she wishes she had more collegiality in her day-to-day teaching life than she does while teaching fourth grade. She used to teach in the upper middle school grades and felt there was more team teaching in those grades. She also comments that her parents instilled a deep sense of wonder in her and that she continues to live a

life that is undergirded by asking questions, curiosity, and constant learning. She loves to explore her world and ask questions about it and wants to make sure her students build this value in themselves as well.

Jane. Jane is a generalist teacher who taught for 12 years. Jane currently teaching first grade in the same school as Amelia. Although the school is a very small school, Jane is in the lower elementary section of the school and Amelia is in the upper elementary section of the school—their schedules and physical space do not overlap as much as one might assume. Neither of them commented on the other during the research process so do not seem to be close work or personal friends. However, Jane, like Amelia, prioritized the grade in which she teaches as the most impactful factor to her decisions regarding science. Jane also frequently brings up how she is comfortable with science, likes science, and is often friends with people who are scientists. She orients to science through a nature-based experiential kind of educational mindset and makes the connection that she also believes in a nature-based religion. Connections to nature and asking questions about the natural world is an important part of her identity and how she values the use of science. Jane uses the outside space surrounding the school as much as possible and utilizes nature-based educational resources available throughout the community. Jane shares that it is hard to get science into the weekly schedule, and that she is willing to work hard so that she can make sure science is kept in her schedule. She also comments that she believes she teaches science more than other colleagues in her lower elementary grade band, and she also realizes she values different pedagogical and curricular choices than they do. She is comfortable and confidant doing science "differently."

Delilah. Delilah taught for 12 years and although she teaches in a different school than Amelia and Jane, Delilah is also a generalist teacher in a rural community in New England.

Delilah comments frequently that much of her orientation to her expectations in her classroom are different than her colleagues' because she has a very different background than most of the colleagues that she teaches with. She was born and raised in Canada, had a previous career as a lawyer, and taught internationally. Delilah was also willing to share personal lived experiences that put her in the minority of the general population like her sexuality—pansexual; gender orientation—androgenous; religious beliefs—Christian and Buddhist; languages spoken—English and French; and that she has both learning and mental health differences. Across the interviews, Delilah also iteratively reflects on the gender of her colleagues (i.e., overwhelmingly women) and the potential consequences to science education because of elementary education professionals so frequently being women. Another subject that she returns to with frequency is her agrarian upbringing. She talks about the importance of being raised in a way that connected her to the land and to nature. She also had a lot of freedom and responsibility in such an upbringing, and she appreciated what that gave her in terms of a lifelong value in asking questions, exploring, and appreciating nature.

Maya. Maya taught the longest out of the six in the group, 37 years, and she talks frequently about how she has transformed as a teacher over that time. At this point in time, she is teaching in a small rural school with a student body that comes from a lower socioeconomic background than the other schools discussed thus far. Maya talks about how much she has enjoyed enculturating into this community over the last decade after she moved to her current location from a nearby state. She also talks a lot about how she continues to be a teacher because she enjoys the profession so much, it gives her an opportunity to keep learning every day. She has always been a learner and has found great satisfaction, joy, and comfort in school and schooling. Maya talks about finding fulfillment in the education profession because not only was

she good at academics growing up, but that the school space was a safe space for her during a tumultuous and difficult upbringing. She was raised in a very low socioeconomic household and found the school a rewarding environment. So, to this day going back to school in the fall is immensely pleasurable to her. Maya is also different than the previous three teachers mentioned in that she is a science specialist and not a general education teacher. Maya only teaches science to upper elementary students—primarily fifth graders. Maya also identifies as Hispanic or Latino which is different than the other five teachers in the group that identify as White or Caucasian. Maya talks a lot about how much she likes science, how she is very comfortable with the subject, and how central science is to her life. Like all the science education specialists, Maya refers to herself as a *science* teacher, versus the generalists that all refer to themselves as a (insert grade level) elementary teacher and do not use the "science" descriptor in their job title when they describe what they do for a profession. Maya is linked to a plethora of state-wide and regional science resources and organizations. Maya is constantly either attending or leading professional development experiences in science education around her state. Maya writes and receives numerous grants to support her science education goals, and Maya is seen and utilized as a science education leader within her district and the state.

Deborah. Deborah, along with Maya, is another science specialist and teaches K–6 within an urban district in the Mid-Atlantic region of the U.S. She teaches only science to a wide range of grades and was a former scientist in industry. Deborah says that her previous professional background certainly informs her science teaching over the past 11 years. However, she is similar to the generalists in that she says the grade and school she teaches in impacts her science teaching decisions more than her previous professional background. Deborah is credentialed to teach in grades K–12, and multiple science content areas in grades 9-12.

Although she did teach science in high school for several years, she comments that she enjoys teaching in elementary more. Deborah is highly connected to science education resources both locally and nationally and comments frequently that she can tap into some of these resources because of her school's strong funding for teachers' needs. She recognizes the privilege afforded to her and her students because they reside in a more affluent community. Although she is already making her science teaching videos available to the public on YouTube, she wishes she could do more to support the students coming from lower socioeconomic backgrounds and from more marginalized and underfunded schools. Deborah, like Amelia, also comments a lot on how isolated she feels in her teaching community. She, as a specialist in the school, is often not considered along with the rest of the faculty and staff and is expected to work without much interaction or collaboration from other teachers. She feels the sting of this isolation even more intensely while teaching during COVID-19 because the general classroom teachers have gone back into the school to teach the students in person, but in her school the specialists have all been asked to continue to work remotely.

Calliope. Calliope is also a science specialist, teaching only science to second and third graders in a suburban town in New England. She has taught science for 22 years and comments on her wide range of experience frequently. She talks about how she feels confident that she can pivot and make things work as necessary because she has her deep experience to draw on, including her previous professional experience as a scientist in the field of medical technology. Despite her frequent sharing that her administration is often a challenge to doing her job efficiently and effectively, she participates and leads professional development opportunities including advanced graduate courses, and even taking self-funded international science education professional development trips. She likes to think about science and wants to

communicate the importance of science at every opportunity—even using her Zoom software backgrounds to communicate about the structure of the COVID-19 virus. Calliope enjoys talking about the research design of this dissertation research and is confident that she knows what she is doing as a science education professional both in the content and the pedagogy. Calliope also frequently returns to the subject of the system of education and the current inequities and inequalities facing so many students and communities. She points out ways she is trying to address these issues as a community member and as a classroom teacher. Calliope collaborates with other science specialists across her state and sees her role in the profession as a teacher willing to stand up for other teachers, thereby supporting more students' science education than just the students who are sitting in front of her in her school community.

Data Sources

I collected multiple data sources related to how teachers express and conceptualize their agency: (a) researcher field notes and reflective memos, (b) teacher attributes (based on responses to a survey questionnaire) (c) video recordings of semi-structured individual interviews, (d) teaching artifacts (i.e., lesson plans, weekly schedules, science menus, etc.), and e) recordings of science teaching (for those that were available). Data collection occurred through online or virtual methods only due to the in-person educational disruption happening at this time due to the global pandemic of the COVID-19 virus. The data I collected provides the foundation of my analysis and findings.

I collected various types of data so that I could investigate and identify the patterns across and within levels and contexts of the case. Each type of data source was planned to answer various aspects of the research questions (see Appendix B). The ways in which the tools for data

collection were informed by my conceptualization of agency are described within the following sections on each tool specifically.

However, the interview data became the foundational data on which the research findings were based. Each of the six research participants worked with me to co-construct over four hours of interview-generated discourse. Being able to spend this much discursive-generating time with each research participant enabled me to repeat and reformulate questions and responses again and again in ways that ultimately provided analyzable discourse; discourse I felt I was more likely to have understood the intended meaning of. All data described below was collected, reviewed, and considered as part of the research process but when it came time to do in-depth analysis and generate findings it was the interviews which became the primary data source utilized.

Researcher field notes and reflective memos. Notes and memos act as a rapid way to capture thoughts and ideas that occur throughout data collection and can include, but are not limited to (a) how the researcher is personally relating to the research participants and/or the experience; (b) code choices and their operational definitions; (c) emergent patterns, categories, themes, concepts, and assertions; (d) any problems with the study; personal or ethical problems with the study; and (e) future directions for the study (Miles et al., 2014). An analytic memo— documenting the researcher's reflections and thinking processes about the data—are not just descriptive summaries of data but attempts to synthesize them into higher level analytic meanings (Miles et al., 2014), an additional way to capture the contextual nature of the discourse being expressed (Hufnagel & Kelly, 2018). Notes and memos constructed by myself as the researcher were considered as part of the data created during this research project as a way to

encourage constant comparative analysis which aids "in generating a theory which is integrated, consistent, plausible, and close to the data" (Glaser, 1965, p. 437).

Because discourse is consequential (Hufnagel & Kelly, 2018), I wanted to make sure I was documenting all possible instances, thoughts, wonderings about the ways in which the research participants constitute their agency discursively throughout the research. I recorded field notes at least two to three times per week to make sure I captured the moment-to-moment interactions, thoughts, and reflections that occur during data collection and analysis. I recorded the notes and memos in Microsoft word documents uploaded into NVivo software (released March 2020, version 20.6.1) so that I could search across notes and memos for ideas, words, and patterns that might emerge and could assist me in engaging in rigorous interpretation and analysis.

My conceptualization of agency informed my notes and memos in that I focused these reflections on what I was noticing the teachers were communicating about their critical and creative ways of problem solving. Although I intentionally listened deeply and considered what the teachers communicated about their conceptualization of agency, my own conceptualization naturally informed the focus of my personal reflections throughout the research project.

Survey. Although I asked the research participants questions related to their personal and school-related lived experiences throughout the interviews, I also generated an attribute map of the research participants largely based on a survey questionnaire (see Appendix C). The survey questions were delivered to the research participants near the beginning of the research project via Qualtrics software (version January, 2020), and the responses were then transferred into an excel spreadsheet to allow for analysis.

Discourse is a contextual process (Hufnagel & Kelly, 2018), meaning the myriad of contexts in which one is engaged will influence the discourse. To describe the research participants accurately and richly, and answer research question 1a, "In what ways do the teachers' lived experiences and identities contribute to their science teaching professional agential positioning?" I generated data about the contextualization that make up the lived experiences and identities of the research participants. The questions asked in this survey were aimed at generating data that provided additional contextual understanding about the highly personal lived experiences and identities of the research participants. The survey questions were asked in such a way as to provide singular responses from the research participants (Patton, 2015). This survey provided time to ask basic background and life history information without taking up valuable face-to-face interview time to collect this beneficial, yet easily gathered, data that supports the contextual nature of the discourse (Hufnagel & Kelly, 2018).

I included survey questions about the teachers' background, life history information, and lived experiences because my conceptualization of agency asserts that agency is influenced by one's lived experiences. I included professional and personal lived experience questions within the survey questions because I also assert that teacher agency is expressed based on one's full humanity, and such a consideration is rarely included in the current literature's conceptualization of agency (Miller-Rushing & Hufnagel, in press). Including the teachers' personal and professional lived experiences was an important way to communicate to the teachers from the very start of the research project that I valued their humanness and considered their entire range of lived experiences as part of my analysis of their teacher agency.

The answers provided to the survey were also used to inform the interview questions. It was helpful to have the survey which provided initial participant responses so that as time went

on I was able to refer to, restate, and reformulate these questions in ways that encouraged interpretation of the response in a way where the intended meaning of those responses was more fully understood.

Semi-structured individual interviews. Video recordings of approximately hour-long semi-structured interviews with each research participant were conducted four times over the course of the research project. The interviews were conducted and recorded via a virtual face-to-face online software service like Zoom or Google Meet so that the interviewer and the interviewee were able to hear and see each other during the interview. The design of the interview setting was such that the interactional components of discourse (Hufnagel & Kelly, 2018) could be attended to. The research participant and the interviewer participated in an interactive and co-constructive discursive practice, so making the participants feel comfortable to interact and engage was an emphasis of designing the interview setting. Verbatim transcripts were constructed from the video recordings. The interview questions addressed each section of the research questions as the interviews progress across all four interviews (see Appendix C).

In this research, the interview highlights the teacher's experience by attending to how they are discursively expressing the ways in which they constitute agency in relation to science teaching. Additionally, when considering the specific methodological choices made for this research project, Yin (2017) reminds us that interviews are not only important in qualitative research in general, they are also important in case studies when he goes on to say that "interviews are an essential source of case study evidence because most case studies are about human affairs or actions" (p. 121). This research project aimed to understand the agency that teachers are expressing as they negotiate and navigate a tumultuous time in educational history using their critical and creative problem solving. The many ways in which the teachers expressed

agency through their saying, being, and doing were critical to consider throughout their communication within extensive discursive episodes such as the interviews. Thus, the interview was a critical data collection tool to deeply describe and contextualize the teacher's/research participant's experience within an educational disruption, descriptions that were expressed discursively and thus represent the meaning they make.

Artifacts. "Records, documents, artifacts, and archives, what has traditionally been called, 'material culture' in anthropology, constitute a particularly rich source of information about many organizations and programs" (Patton, 2015, p. 376). The daily act of teaching produces a trail of paper, digital records, and artifacts of the educational process in general. I collected artifacts related to science teaching such as (a) four reflective teacher journals, (b) teaching calendars, (c) lesson plans, and (d) student work samples. These artifacts were all collected digitally to ease data collection during this time of disrupted school communities.

The ability to collect artifacts such as these listed above "prove valuable not only because of what can be learned directly from them but also as a stimulus for paths of inquiry that can only be pursued through direct observation and interviewing" (Patton, 2015, p. 377). As I collected artifacts, I also then analyzed these artifacts, making researcher memos, and determining follow up questions to be asked during the subsequent interviews.

The artifacts I collected are artifacts created by everyday teaching scenarios and were therefore, collected across various classroom and educational community settings. I collected these kinds of artifacts from all the research participants throughout the research project. These artifacts added to the ability to deeply describe each teacher's expressions of agency by being able to collect data that documents many of the decisions, actions, and priorities made by each teacher throughout the case. The artifacts produced from their daily life of teaching provide a

physical manifestation of the ways in which teachers solved problems and creatively and critically addressed the needs of their classrooms.

Video recordings of science teaching. I collected video recordings of the teacher teaching science from five out of six of the teachers. The video recordings were made in such a way as to aim the camera only at the teacher, students were not in the video, thus allowing for ease of collection to meet IRB protocols. Therefore, on some videos I was able to hear the students' questions and comments, but the primary focus of the video was of the teacher directly teaching students (i.e., Calliope, Amelia, Maya), or were videos of the teacher teaching a prerecorded science lesson via video and then they shared this teaching video with me as well as with their students (i.e., Maya, Deborah, and Delilah). Jane was unable to provide a recording and mentioned that the technology, the planning needed, and the concern about focusing the camera on her and not the students was too much to consider and therefore she could not provide a video. Although I would have been happy to go to the school and make the recording myself, I was not allowed in the school building because of COVID protocols in place to severely limit all visitors into the building. I used the data collected to analyze in what ways the teacher positioned their science-related teaching agency when they were teaching their students and used the data from the videos to inform the interview process. In this way I underscored that agency is expressed in moment-to-moment interactions and all the ways in which meaning is expressed can be included when considering expressions of agency.

Consideration of COVID-19 pandemic to data collection. Data collection for this project was challenged in that the educational system is under a severe disruption due to the global health pandemic of the COVID-19 virus. At the time of the data collection, school systems across the United States had moved to entirely remote and online instruction. School

buildings were shuttered to try to combat spreading the virus by encouraging social distancing of people. Although each school's response to this pandemic can, and does, look quite unique, there has been an overall disruption to the educational system that has been unknown before this occurred. This is a remarkable moment in history and one which provides a distinctive context to this research study. This disruption provides a backdrop to look at how teachers express their agency within the pandemic. However, it also proved quite difficult to perform traditional research practices during this time due to the pandemic—namely challenging participant recruitment and data collection efforts.

Physically, I was limited in that I could not go to the teachers, meet them where they were, see where they work in person, observe them in their professional habitat. I was only able to collect data that was available through online generation and dissemination. However, I was prepared to meet this challenge and collected data in various ways even while not being physically present with the teachers while they engage in their teaching practice.

As discussed previously, the research participants that I was able to choose from was also limited. I would have preferred to have been able to have had more of a possible pool of participants from which to select a small group of teachers for the case, but the reality at that time is that I needed to find teachers teaching science in K–5 elementary classrooms during the educational disruption, and that proved harder than expected. When faced with overwhelming and severe disruption to the educational system, elementary teachers by and large focused on Common Core Standards (Common Core State Standards Initiative, 2010) that prioritize reading, writing, and mathematics. Based on informal conversations with many teachers I know personally, some elementary teachers were not teaching science during this time, and thus

finding research participants teaching science *and* willing to take the extra time to participate in a research study such as this was difficult.

Data Collection Protocols

Ethics, safety, and security. Each type of data collected is selected to assist in answering a specific research question (see Appendix B) and was compiled and organized using NVivo and Microsoft Office software. All IRB protocols for securing data and securing voluntary consent from research participants was strictly adhered to. These protocols include but are not limited to keeping data (original and working) on password protected hard drives, providing a chain of evidence, providing anonymity for the research participants, and reminding the research participants of their rights throughout the research process.

Data Analysis

Overall, the data was analyzed through a process of highlighting, text searching, coding, and attribute map creation in an iterative and abductive process (Agar, 2006; Yin, 2017) to create a thick description (Geertz, 2008) of the case—science-related teacher agency within a small group (n=6) of elementary (K–5) teachers. This analytical process is informed by discourse analysis-based (Gee, 2010; Mishler, 1986) methodological frameworks to discover how elementary science teachers conceptualize agency.

It is important to note that as the researcher embedded in the research process, I recognized agency in ways not explicitly accounted for in the tools described below but is based on my closeness to the data and the context the data was produced within. For example, much of the interview data gathered was from semi-structured co-constructed interviews. Therefore, much interpretation occurs along the way of data gathering and analysis because the person being interviewed describes and discovers new relationships and patterns in their "life world"

during the interview and as the researcher I was summarizing, reframing, or reflecting on what I heard and thus condensing and interpreting the flow of meaning (Kvale & Brinkman, 2009). Miles et al. (2014) describe this process as the data not actually being collected but instead coauthored.

Software utilized for data organization and analysis. Although the data was analyzed in part using software such as NVivo to support the analysis (Bazeley & Jackson, 2013), the data was entirely processed and coded by myself. Software features available in NVivo like auto-coding were not useful in this research project because I was not setting up *a priori* codes that the software can search the text data for. Unlike statistical analyses, I did not use the software's potential outputs themselves as if they are the end of the analysis. The software was only used to help organize, categorize, and visualize large amounts of data.

I also used Microsoft Office Excel to create an attribute map to scaffold the data analysis (Kelly et al., 2001), but the categories in this this map emerged and changed based on the analysis of the data. The categories in this attribute map, like the questions in the interviews, were not static a priori codes, they were a framework on which I used flexibly and reflexively based on initial findings. I noted, coded, and analyzed the data in an on-going, iterative, and hands-on way to stay close to the data and throughout the process of its analysis.

Highlighting. During and after collecting the data I noticed sections, instances, moments, or spaces where agency was made salient through the ways in which the research participants discursively expressed their agency within moment-to-moment interactions as well as patterned ways in which they engaged with their agency. One of the first analytical tools to help bring to light these sections was to use Goodwin (1994)'s analytical tool of "highlighting." Goodwin described highlighting as one of the first steps a researcher takes by using colored markers,

sticky notes, or making notes in the margins to highlight certain sections of the data so that those parts that contain information relevant to the specific work is made salient (Goodwin, 1994). I used highlighting across all data sources—as I watched the videos, reviewed artifacts, and re-read my memos I highlighted instances of potential expressions of agency to return to for closer examination. These highlighted sections were video clips, sections of transcripts, sections of lesson plans, or answers in surveys that seemed to be particularly apparent at capturing how agency is made salient through the discursive process. For examples on what "counted" as agency and what was included in the case boundary for expressions of agency refer to the earlier section in this chapter on case boundary. It was those highlighted sections of the data, data that represented expressions of agency based on my conceptualization of agency and how the teachers were communicating their conceptualization of agency, that were brought to the forefront of the analytical process and then underwent further analysis. Highlighting data does not mean the un-highlighted sections were discarded. All data was still considered in an iterative process. Instead, those sections that were highlighted were found to be an effective way to foreground or structure the prominence and relevance of sections of data best suited toward answering the research questions in order to create a case analysis (Goodwin, 1994).

Because it was rare for a teacher to come out and talk about agency directly in ways such as, "This is how I conceptualize agency" or, "I use my agency in this way" or, "This is the part of my identity that gave me the confidence to believe I had the right to make that expression of agency." Instead, teachers more often discussed their profession and their identity and role within that profession within more general science education topics such as, curriculum, pedagogy, school community, personal decisions, role in the school, interactions with students, and interactions with other faculty and staff. Therefore, some specific examples of data I

highlighted included sections where the teacher discussed ways in which she positioned herself or others when sharing that she (a) utilized research to improve student learning; (b) participated in professional learning; (c) facilitated improvements in instruction and student learning; (d) promoted the use of assessments and data to improve schools; (e) improved outreach to families and communities; and (f) advocated for student learning (Berg et al., 2014). Overall, I oriented to and highlighted sections of data where teachers expressed the ways in which they are working out the moral and social structures in which they work (Harré & van Langenhove, 1999; Martin, 2019) through a critical and creative problem solving process, drawn from lived experiences, and expressed discursively (Biesta & Tedder, 2006; Emirbayer & Mische, 1998).

Constructing an attribute map. The highlighted data was then used to construct an attribute map. The attribute map was informed by Kelly and Chen (1999)'s event map whereby they identified key events that took place across their research project. In this study the focus was on the attribute, ways in which agency was attributed through discursive expressions, and not the events, hence an attribute map.

Creating an attribute map is a way to utilize a Microsoft Excel spreadsheet as an analytical tool to track expressions of agency across the research project so that I could zoom in and out to understand how the expressions of agency are situated within the case (Hufnagel, 2019). Hufnagel (2019)'s work provides an example on which both the micro and the macro frames are explored in such a map, frames that help to organize all the ways agency was expressed. An attribute map demarcates moments of expressed agency in the discourse in a way that provides analytical decisions to be considered in interconnected ways (Hufnagel, 2019) including, what counts as agency, when was agency expressed, how was it expressed, in what ways did the attribute connect to the expression of agency.

Using this tool, I oriented to the data in a way that allowed me to understand and then describe how agency is being discursively expressed by the teachers. An attribute map is a more comprehensive tool than just a place to organize at which scales agency is constituted. In addition, the attribute map is an analytical tool that captures documenting possible aspects of how agency is constituted discursively by the research participants including, (a) how agency is expressed discursively, (b) how agency is afforded and constrained by one's lived experiences and identity (Miller-Rushing & Hufnagel, in preparation; Richmond (2016), (c) where agency falls along a continuum from reproductive to transformative (Rivera Maulucci et al., 2015), (d) epistemic agency (Stroupe, 2014), emotional expressions connected to the expressions of agency (Hufnagel & Kelly, 2018), and (e) how agency emerges at what timescale and spaciotemporal envelope (Wortham, 2012). As the case was building, the attribute map was an important way to analyze across the case in subsequent steps during the analysis (Hufnagel, 2019). This document was an ever growing and responsive document that assisted in producing the desired rigor and responsiveness.

To keep track of these expressions of agency within the attribute map I built out the Excel sheet in the following way (see Table 1 for a section of the constructed attribute map). As new highlighted sections were entered into the attribute map, more and more rows of highlighted data were added. Then, I would create additional columns which described the expression of agency I was noticing in the highlighted excerpt. I created these additional column headers, which I thought of as first cycle codes (Miles et al., 2014) in an attempt to pull out the nuanced point being expressed that I thought was especially relevant to answering research question(s). I labeled these new column headers with words and descriptions matching the original discourse expressed as closely as possible. In other words, I attempted to create in vivo coding as column

headers as first cycle codes when possible. Then, I would find where this new column and the row of highlighted data I was analyzing intersected and mark that cell with a number "1" so that I could ultimately keep track of and count the number of times that particular expression of agency was utilized (Table 1). As I analyzed the entire data set, the Excel sheet grew to be very robust and wide as rows and columns were continually added as I went through and added and analyzed the highlighted sections of data.

Data that populated the attribute map came from highlighted discourse from all aspects of the data collection tools. Although much of the attribute map was made with data from the interviews, because that data became the primary source of data utilized, highlighted data from all data sources were iteratively considered and included in the attribute map. So along with discourse from the interview, sections of notes from my memos, reflections on or quotes from the teaching videos, survey, and artifacts were also included in the attribute map. All data was considered for highlighting, and those highlights were then included in the attribute map so that the full range of the ways that agency was expressed within the case was considered for analysis. This inclusion of data sources within the analysis underscores the theoretical underpinning that agency is expressed in a myriad of ways that are interactional, contextual, intertextual, and consequential (Hufnagel & Kelly, 2018) and is discursively communicated through one's saying, being, and doing (Gee, 2010).

Table 1

Attribute Map Showing Highlighted Excerpts and First Cycle Coding Quantification.

Participant	Data Location	Excerpt	Teach same curriculum	Inequity within education system	systemic racism	not enough funding	Should expect more from children	Hope science continues to be hands-on, not sure it will be in 5 years	a lot of kids that have slipped through the cracks	Would like national standards	Science needs to be threaded throughout K-8	Her own students high SES yet, expectations of others weighs on her	its going to take a woman to fix all this	my focus has been in my curriculum to find things that reflect different people	Wants any student to be able to access her science
Totals															
Deborah	Int1@32:13	We have the same curriculum. We teach the same topics. It's still a science lab for me, I still try to make it fun, interesting, hands on. And I still I had, I still have the same ultimate goal that I want them to be excited about science	1												
Deborah	Int1@32:51	Something that I have been thinking about more lately. Um, is the amount of inequity we have in our education system, both within my state, and within our country			1								1		
Deborah	Int1@34:08	I've been putting many of my videos on YouTube. And when I have time, and I'm unable to focus on it, I would like to organize my lessons in a format that will make them accessible to everybody everywhere.													1

Once I had all the highlighted data in the attribute map (the original data in the "C" column and my first cycle codes framing the importance of that data noted as a column header), it was at this point I was able to code the data by looking across the column headers for patterns, rich points, and anomalies within the data. I will describe the exact coding steps I took in the following section. However, I should note that as I coded the data within the attribute map, I saved a separate file of each map version I created and saved the new file with that day's date. I wanted to make sure I kept track of each iteration of my coding process and be able to track how the analysis evolved.

Coding included four cycles—first, second, third, and synthesis. Although I am describing these as analytical steps in a sequence, I restate that this was an iterative and abductive process to build a case. Coding however was, in general, a phase that followed the

attribute map creation and therefore I will describe that part of the process here. I prescribe that coding *is* analysis since coding is a researcher-generated construct that symbolizes and thus attributes interpreted meaning to each individual datum for later purposes of pattern detection, categorization, theory building, and other analytical processes (Charmaz, 2001). Creating codes, at any part of the coding cycle, is deeply reflective and interpretative work that "attempts to assign a summative, salient, essence-capturing, and/or evocative attribute for a portion of language-based or visual data" (Miles et al., 2014, p. 72). Thus, I did not use an *a priori* codebook to identify categories or themes, instead I used an inductive coding process. I based my coding decisions on a heuristic theoretical framework, coding as a method of discovery (Miles et al., 2014), based on what I found within the data produced through all the data sources mentioned above.

The coding process I utilized was informed by two coding manuals. I was informed by Saldaña (2015) because this coding manual specifically included chapters that addressed qualitative and discourse-based coding schemes for interview-based data; data similar to the type of data that undergirded this research. The other coding framework I was informed by was Miles et al. (2014) because once again this methods sourcebook provided coding considerations for qualitatively generated data and highlighted the ways in which different coding schemes could work together in effective ways. Combined, both manuals provided excellent examples of what different coding schemes look like in practice in qualitative research which helped me to then be able to make an informed decision about the coding scheme for this work in particular. Because the primary data from this research was discourse from interviews, discourse that was a co-generated dialogue interpreted for overall meaning making (Mishler, 1986), the coding I utilized stayed connected to the original data while iteratively and cyclically analyzing all the discursive

ways in which agency was being expressed. Therefore, informed by Saldaña (2015) and Miles et al. (2014), I coded the highlighted data in four major stages—first, second, third, and synthesis cycle coding.

First cycle coding. In the first cycle of coding, I assigned codes (codes created in vivo as much as possible) to the excerpts of highlighted data that brought to light the expression of agency within that highlighted data. This first cycle of coding utilized multiple abductive coding approaches including coding for descriptions, processes, emotions, values, evaluations, hypotheses, causations, and attributes (Saldaña, 2015). Depending on how the agency was being expressed determined what type of first cycle code was applied to the data. See across the top row in Table 1 for examples of those first cycle codes based on the excerpts of highlighted data.

Part of the first cycle of coding also included considering how to put Gee (2010)'s theory that discourse conveys one's saying, being, and doing to work. I considered each highlighted excerpt and added a second layer of codes to the highlighted data with a "saying," "being," or "doing" code. In that way I was able to then look across the excerpts and analytically consider the ways in which agency was being expressed. Being able to filter the excerpts by the saying, being, and/or doing codes allowed me to analyze the discourse in ways that took into consideration the ways in which agency was being expressed, and the ways in which those expressions of agency represented the teacher's intent to communicate meaning about their agency because "who we are and what we are doing when we say things matters" (Gee, 2010, p. 3). Not only was it important to analyze the types of expressions of agency communicated by the teachers, but it was important to also consider the ways in which those expressions of agency resonated across their life world in their saying, being, and doing, which was a useful way that I was able to put Gee (2010)'s theory to work during the first cycle of coding (Table 2).

Table 2

Examples of Data Excerpts Coded with Gee (2010)'s Theory

	Example 1	**Example 2**	**Example 3**
Saying (Informing)	"I start with the standard, then I look at so I do UBD [universal backwards design]. So, I start with the standard. What's the standard? Ask what do I want the kids to know? And then what activity will support that?" (Calliope, first interview)	"The way in which Maya laughs often seems to indicate an example of a time in which she pushes back against the system and is signaling her discontent with the reality of the situation. Look at these instances and review these sections in the transcripts again." (Researcher memo)	"Ask Jane about her selected religion [Nature/Wiccan] on her survey (question 21). Does she feel her religion influences what and how she teaches science, even though she listed it as the last on the priority list of what she feels impacts the decisions she makes concerning science teaching (question 36)? Her science teaching seems to be foundationally nature/outside focused, in what ways does she feel like what and how she teaches science maps onto her lived experience of religion? (Researcher memo)
Being (Identity)	"Well, this year it's very different. So, up to this point, and in the past two years, I've worked kind of solo. And been quite lonely, I have to say that even though it's being recorded. So, I've kind of begged and pleaded with my principal I said I needed a team, I need a team to work with I really work best when I have a team player, you know, teams on board where we're planning together working together, you know, working toward that end goal I think it's better for students to have a team of teachers." (Amelia, first interview)	"I consider myself a science teacher. Maybe because I taught high school science, first." (Deborah, first interview)	"My colleagues have a hard time giving us [science specialists] giving science the value that we bring, even though they love the kids love doing it. And they love having us in the classroom and they love seeing the kids, you know, we don't our needs are last. Our needs are last. That's the frustrating part." (Calliope, first interview)
Doing (Action)	"I go to conferences." (Deborah, first interview)	"Without being asked to by her admin, Maya is creating and sharing videos with her students that provide an example of a science concept and encourages her students to practice science at home." (Researcher memo)	"I work with some elementary engineering department at [a local university]. Where and I got a certification from there." (Calliope, first interview)

Second cycle coding. Once the first cycle codes were created in the attribute map, I then worked with the first cycle codes themselves to do second cycle coding to create pattern codes. "Pattern codes are explanatory or inferential codes, ones that identify an emergent theme, configuration, or explanation" (Miles et al., 2014, p. 86). To do second cycle coding on so many first cycle codes, I found that I had to work outside of the Excel software and manually take each first cycle code and move it around in a large workspace so that I could see the pattern groupings emerging across the data. To do this I printed out two copies of the attribute map. I took one copy and cut out the first cycle codes so that they were each on small strips of paper. The second copy I kept intact so I could quickly go back to see which first cycle code I had originally linked to which highlighted raw data excerpt. Then, with those first cycle codes cut up I arranged and rearranged them on a large workspace into patterns I saw emerging (Figure 2). Specifically, I took the first cycle code and started placing them into piles I thought fit a pattern I was seeing in the codes. As these patterns abductively emerged and solidified I labeled that pile of first cycle codes with the pattern code I was seeing which included categories or themes, causes and explanations, relationships among people, and theoretical constructs (Miles et al., 2014).

Figure 2

Picture of Creating Process Codes During Second Cycle of Coding Analysis

This coding cycle was especially helpful at analyzing which expressions of agency were more prominent within the data. As you can see in figure 2 some codes were more prolific and important than others, and through this process I was able to look across the codes and analyze the patterns emerging. Patterns emerged that included the ways in which agency was expressed, but also the frequency and significance of those codes.

For example, a pattern emerged when considering the influences on expressions of agency. Those influences are discussed in detail in the findings but the analytical process for how patterns like this emerged should be described here. The teachers described what they felt influenced their agency. As those codes were laid out and considered, a pattern emerged where certain codes of what influenced agency were more prevalent than others. The teachers shared again and again across the data some influences more than others. They described these influences in the number of times they mentioned it, and their overall meaning was communicated in how fervently they described these influences. Therefore, I was able to quantify the number of codes by looking at the number of certain codes as they were spread out, and I was able to look across the attribute map for the count of each code to support and consider the patterns emerging; patterns like what influential factors were more or less mentioned than others.

Along with considering the number of times a code was mentioned to determine prevalence, I also wanted to consider the overall meaning being communicated. Thus, during this, and subsequent coding cycles, I went back again and again to the video data where these influences were discussed and considered the ways in which the influence was mentioned, the larger meaning trying to be conveyed. As the iterative coding cycle continued, I was considering how the meaning was being conveyed discursively by analyzing the video data from whence that

data came originally and saw which influences were being discussed in what kind of affective or emotive ways. I noted the expressed meaning making through memoing and notes as pattern codes emerged. For example, one teacher laughed or chuckled in a way that communicated to me that they were trying to explain their discomfort of that expression of agency. Whereas other teachers expressed frustration through their tone of voice, and others expressed a connection and affection of their students through tears. Teachers expressed their affect and emotions through their non-verbal and verbal communications and I noted instances that seemed to be tied to their expressions of agency within my researcher notes. Although it is perhaps a limitation of this study, I did not use methodology that would have allowed me to do a frame-by-frame video analysis, or an utterance-by-utterance discursive analysis that looked for emotive or affective stances and positioning. Instead I focused on the integration of the teachers' saying, being, and doing—who is saying it and what the person is trying to do (Gee, 2010). In this way I was putting Mishler (1986)'s theory to work by orientating to the teachers' discourse in ways that allowed me to reformulate, reconsider, and reframe the discourse in evolving ways to achieve making meaning of what the teachers were saying, being, and doing to express their agency.

Creating process codes as a second round of coding was a way to include a higher-order pattern I was seeing in the data while continuing to utilize the type of discourse analysis informed by Mishler (1986) that had underscored how the interview data itself was generated. In other words, while looking for patterns within the first cycle codes I was interpreting the data to clarify the overall desired meaning of that discourse. By staying close to the original highlighted text while analyzing the first cycle codes for process codes, I was able to attend to both the nuance of the excerpt as well as the larger patterns emerging across the data. Thus, the intended meaning making of the discourse was considered while simultaneously identifying broad

emergent themes, configurations, or explanations. Some examples of the second cycle process codes that were created included how agency is conceptualized, agency in service of the student, power, role of COVID, and epistemic agency.

>   ***Third cycle coding***. As process codes solidified and patterns emerged, I worked with each broad process code to find deeper level patterns, or themes and subthemes, within that code. In this third cycle of coding, I was looking to more deeply describe the data in a way that further illuminated teachers' expressions of agency while continuing to attend to the overall intended meaning from the research participants. To do this third cycle of coding I took all the first cycle codes I assigned to the second cycle process code and created patterns, themes, descriptions, and theoretical constructs within that specific process code (Figure 3).

Figure 3

Picture of Themes and Subthemes Created During Section of Third Cycle of Coding
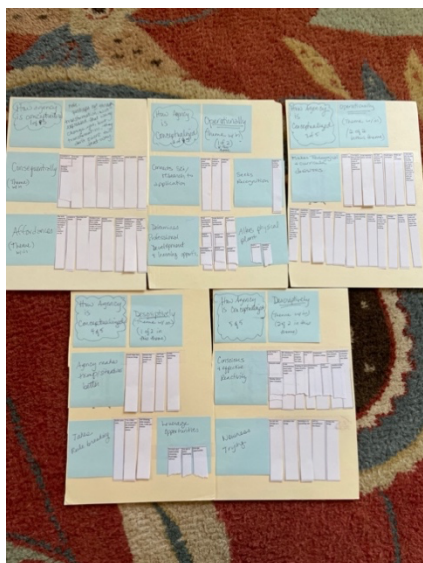
>   For example, as seen in Figure 2, one process code that emerged with a lot of data attached was the code I labeled "How agency is conceptualized." I took just those pieces of first cycle codes that I had assigned to the "How agency is conceptualized" process code created

during the second cycle of coding and created themes within just this process code. Those themes included consequentially, operationally, affordances, and descriptions. Then in the third cycle of coding I continued to look for subthemes—patterns, nuance, and context to further analyze and describe the data within those themes. Therefore, what emerged under the theme "Operationally" within the overall process code "How agency is conceptualized" were subthemes such as—(a) connects science research to application, (b) seeks recognition, (c) determines professional development, (d) alters physical plant, (e) alters assessment, (f) works collaboratively or independently as needed, (g) uses, creates, shares resources, (h) makes pedagogical and curricular decisions, (i) advocates, and (j) joins groups and memberships.

Figure 4 shows how these themes emerged during part of the coding cycle—specifically how themes emerged from the second and third cycle of coding. The process of coding synthesis, which I explain below is also shown in this figure. However, what is important to note in this figure is that this is only a part of the coding cycle. Every first cycle code that helped to inform the second cycle process code is not shown, nor are all the process codes shown that helped to inform the synthesis which then became a major finding. There was simply too much data to show all at once.

Figure 4

Diagram Showing an Example of 2ⁿᵈ Cycle Process Code Through to Coding Synthesis
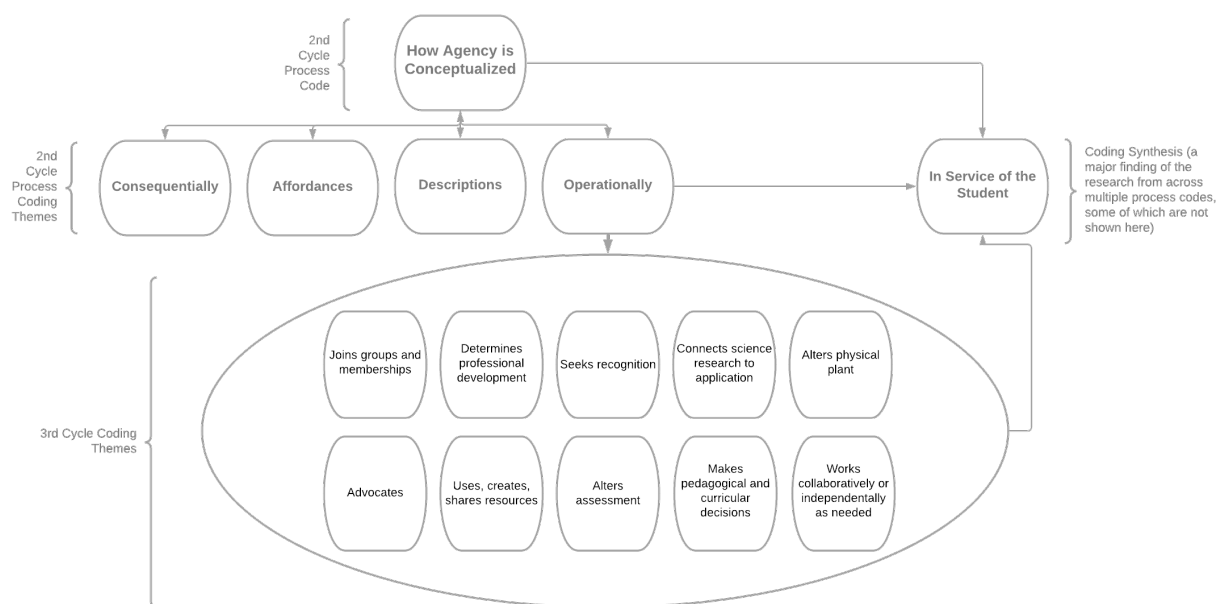
Synthesis coding. After the third cycle of coding, I needed to synthesize across the codes in a way that clarified the storyline, the main findings, of the case. To do this synthesis I made an outline of the process codes as well as the themes and subthemes within each of those process codes. This outline became a way to synthesize a draft of the storyline of the findings. After the third coding cycle I looked across all the cycle codes and saw that the process code of "agency in service of the student" created during the Second Cycle of coding needed to ultimately be moved into an overarching finding. This particular process code became central to the dissertation findings because I noticed each time I was ascribing evidence to support other process codes there was often part of the evidence that could also be taken to support the "agency in service of the student" finding. For example, as seen in Figure 4, in the third cycle coding themes one of the themes the teachers were expressing was that they were advocating for science. But, I noticed when iteratively going back to the original data again and again and attending to the intended

meaning of that discourse, what became clear was that the teachers were not just advocating for science for the sake of advocacy. They were often advocating for science for the benefit of their students. Therefore, "In service of the student" was synthesis coding at the broadest perspective. In this way I utilized the coding process as well as the iterative nature of returning to the data again and again to not only look for specific instances that supported the findings, but to reconsider the context and what I know about the case.

Denzin (2001) describes this process as interpretive synthesis because after isolating the relevant data passages, inspecting them carefully for essential elements and components, then the elements are rebuilt into an ordered whole and put back into the natural social context of the case. This process of breaking apart the data and rebuilding the data into a synthesized ordered whole is an important part of the research process and what Bazerman (2006) was referring to when he said, "it is usually not enough to just cut up all the parts and show them lying on the table. One must select and put them back together in new and enlightening ways" (p. 80). In this way the data was iteratively and abductively considered from the moment of creation to the synthesis of how to tell the important story of the findings to answer the research questions.

By using the coding process that included first, second, third, and synthesis cycle coding, a process informed by Miles et al. (2014) and Saldaña (2015), I was able to keep a link between the original data, the more refined and nuanced subthemes, and the broadest perspective findings that emerged in a rigorous process that allowed the data to be broken apart, rearranged, and communicated in ways that helped to answer the research questions (Bazerman, 2006)—notably the ways in which agency was expressed within the case.

CHAPTER 4

FINDINGS: HOW THE TEACHERS DEFINED AGENCY

To answer the first research question, "How do K–5 teachers conceptualize and enact their own science teacher agency?," I first needed to understand how teachers defined and thus used the term agency. Because the word "agency" is not utilized very often in teachers' everyday discourse and when it is, is applied loosely and uncritically (Priestley et al., 2015), I wanted to know how teachers did use and define the term, if at all. I sought to reach understanding of terminology, definitions, word choice, and meaning in a way that centered the teachers' voice, so that I would be able to rigorously build out a case that described and analyzed elementary science teacher's agency based on their voice and choice of that discursive expression of agency. In order to achieve the goal of centering the voice of the teacher in the research, the majority of data in this research is from interviews where I and the research participants participated in co-constructed dialogue that aimed at overall meaning making (Mishler, 1986) and was analyzed in a way that considered the saying, the being, and the doing of that agency-derived discourse (Gee, 2010).

It is more challenging to reach meaning making when the primary language of the interviewer and the interviewee are dissimilar in fundamental ways (Mishler, 1986), which was the case with me as the interviewer steeped in academic use of the term "agency," and research participants that did not start off the research process using or being comfortable with the word "agency." However, I found that my orienting to the teachers' discourse in the ways I did, allowed me to reformulate, reconsider, and reframe the co-construction of the discourse in evolving ways to achieve making meaning of what the teachers were saying, being, and doing to express their agency. In that way I was able to describe how the teachers defined agency.

Therefore, this chapter describes how the teachers defined agency—(a) "agency" is a term the teachers were unfamiliar with, (b) they did describe agency by using other terms, descriptions, and examples, and (c) they used and reflected on the term "agency" more readily over the time of the research process.

"Agency" is a Term the Teachers were Unfamiliar With

The research participants were upfront, honest, and authentic when they shared that they were not aware of the term agency, that term was not in their working vocabulary. Although the teachers knew from the beginning of the research process that my topic was focused on science teacher agency even by interview three the teachers expressed a limited understanding about the accurate meaning of the term, they admitted they did not use that term, and they felt "odd" using that term.

Because I asked about agency more directly during the third interview, and I suspected that the interviewees might be less comfortable using that terminology, I tried to normalize any and all responses upfront, and thus increase the comfort of sharing authentically. I tried to achieve this by introducing the interview by saying to the interviewee, "Today's interview is going to have less questions, it's going to be asking for more of a stream of consciousness. I'm going to be encouraging you to just keep talking and talking. It might feel a bit uncomfortable to have thinking time or silences but that's okay. I'm just wanting your thoughts, there's going to be no right answer" (Researcher, third interview).

Therefore, I was pleased that Delilah felt comfortable enough in co-generative dialogue interviews with me to have said, "I don't even know that word. Would you spell it for me?" (Delilah, third interview). After spelling "agentive" for her, she tried to describe her meaning of agentive from her understanding of being an agent, a term she was familiar with from her past as

a lawyer, but ultimately gave up when she said, "So, um, right. So having agency, agentive. So, someone who, oh, it's, I've never." (Delilah, third interview). Even after about fifteen minutes of reframing and providing possible cases of agency in use when asked about the ways in which she considers and defines agency she openly said, "This feels odd for me" (Delilah, third interview). Delilah was referring to feeling odd talking about agency in such a pointed way, yet she was willing to continue in the interview and her discourse helped me to understand and describe that in this case elementary science teachers did not initially use or feel comfortable using the term agency.

Other teachers, such as Jane, expressed less about their feelings concerning using the term but also directly stated that they did not use the term agency. Jane exemplified her limited use of the term agency when she said,

I don't think a lot about agency, honestly, or at least not with that word…I feel like what the what keeps coming out of my mouth is like the ability to do what I want, but that's not quite it. It's like more purposeful than that. It's not like just I can do whatever I want. But it's. Augh this is hard. I'm not ever good at defining words, you know it's like having agency…Why don't I think more about that one then come back to it. (Jane, third interview)

Jane seemed to be trying to express that she understood how agency is expressed (i.e., doing with purpose) but that she felt unable to capture her definition of agency because she doesn't use that word.

Instead of talking around her definition of agency as some of the others did, when asked "What do you think of agency" (Researcher, third interview), Maya succinctly answered "I don't know what that means." (Maya, third interview). Even after prompting in a different way, "Can

you think about, tell me about feeling agentive, or being an agentive teacher?" (Researcher, third interview) Maya once again clearly and concisely answered, "I don't know what that means." (Maya, third interview). Maya shared that she does not use the term "agency" nor is she able to express meaning of that terminology, instead she openly said she doesn't know that term. This response once again further supports the case's finding that elementary science teachers were initially unfamiliar with the term "agency."

Lastly, I also appreciated Amelia's honesty when she said, "Being an agentive teacher? I can't think of what that term means, so you'd have to remind me what that means again." (Amelia, third interview). Although she sought to understand how agency is defined, and asked me to define it for her, she was upfront in her lack of knowledge of the term.

The teachers were willing to discuss the term agency and were seeking to understand the use of the term but were clear in the fact that they were not initially familiar with the term "agency," do not use the term currently, and do not know what it means.

The Teachers Invoked Other Terms and Examples to Describe Agency

Although the teachers clearly expressed that "agency" is not a term they were initially familiar with, they did use and describe other related terms to illuminate what they meant by agency. The terms that teachers did express included change agent, autonomy, and voice. The more deeply descriptive ways in which teachers conceptualized agency and these related terms is discussed in the following chapter. However, outlining what the teachers did use for terms when discussing how they defined agency should be mentioned here before going into the nuances of those teacher-centered conceptualizations of agency.

Change agent. "Change agent" was a term more readily utilized instead of "agency." This term was used in various, yet related, ways including, "change agent," "agent of change,"

"change maker," and "making change happen." It should be noted that perhaps this was the most readily utilized term because in interview three, I often prompted the interviewees to consider this term. If the teachers seemed stymied talking about "agency" as a stand-alone term, a follow up question I asked the interviewees included, "Tell me about being an agent of change." (Researcher, third interview). To continue the co-generative dialogue in the interviews, it became necessary to ask teachers directly about other terms they potentially oriented to instead of "agency." Asking the teachers about being a "change agent" was one way to reformulate and reframe the original question in a way that acknowledged striving for meaning making within the dialogue (Mishler, 1986) but in a way that still centered the teacher voice in that dialogue.

This technique seemed to work because although Maya earlier said she did not know what agency meant, this time she responded with, "I know what that means." (Maya, third interview) when I asked her, "What about being an agent of change?" (Researcher, third interview). Maya quickly went on to describe what she meant when she used the term "agent of change," when she said, "To me it means being bold enough to try new things, and not being embarrassed by mistakes just thinking of a mistake is data and moving on from there and correcting it." (Maya, third interview).

Delilah, similarly to Maya, seemed more comfortable with the term "agent of change" when she expressed, "I really like that term agent of change or a change maker." (Delilah, third interview). Delilah also went on to describe what she meant by that term, and in doing so compared being an agent of change to being an activist. Delilah believes that the term activist "comes with a lot of baggage…but by choosing different words it's not going to have such a strong reaction." (Delilah, third interview). Delilah implied that by choosing words that are less

potentially irksome to others, the desired change has more potential for taking effect. Delilah went on to say what an agent of change does including,

> I'm a vector for the change. I'm opening opportunities for change. I'm bringing information to my students that can change them. So, I'm raising their awareness. And I, I do that, I know I do that in different ways in the classroom all the time, right? (Delilah, third interview)

Not only did Delilah orient to the term "change agent" more readily she went on to say what it means, and what it means for her and her students. Interestingly, Delilah underscored her belief that being an agent of change is in many ways a service to her students.

Amelia, like Delilah, orientated to being an "agent of change" more readily and easily than to the term "agency," and she also oriented to being an agent of change in a way that was in service to her students. Amelia expressed this belief when she said,

> An agent of change. Well, I like that. I like being an agent of change. I often don't like things as status quo, that's for sure. I often like to take the pulse of my kids and figure out where they're at and lead them from there. (Amelia, third interview)

Although Jane was less confident in the term "change agent" compared to Maya, Delilah, and Amelia, she still was more willing to use and define "change agent" versus "agency." When prompted to consider "agent of change" Jane said, "Oh, an agent of change, that's even different. All these new terms…you're taking action that has affect that makes change for other people as well as yourself, I guess." (Jane, third interview). Jane did use and define this term although she hedged her response.

Autonomy. The teachers also felt that the word "autonomy" resonated for them when they were describing their agency. The teachers, similar to Luck and d'Inverno (1995) and

Skaalvik and Skaalvik (2014) describe that their perceived autonomy promoted their move to action, their agency.

Jane described her resonance with the term autonomy when she describes that she oriented to "autonomy" more assuredly than "change agent." When I followed up on an earlier comment from Jane and asked her if she, "thinks of it with a different term?" (Researcher, third interview) Jane replied, "Autonomy maybe is the word I would use, I mean I just think agency isn't a word I use very much." (Jane, third interview). Jane also went on to say that,

> So, for me about having agency and my science teaching would be having that autonomy, but also like having it because I have a direction I want to go in. So, kind of purpose, full autonomy I don't I don't know it's gonna make me think about that word, more. (Jane, third interview)

Although Jane was still hedging a bit by saying "maybe" and that she is going to "need to think about that word more," autonomy is the word she used and described instead of agency.

It is also important to point out that these terms were not used exclusively of one another. At times the teachers used the terms as ways of further explaining what they meant by another term. For example, Delilah said,

> For me, as an agent of change as an agent of science information. Really, I really, really value the autonomy that I have within the curriculum as it is like I know that my administrators trust me so they're not up in my room all the time. Which would really hamper what the way I at least, like my sense of being able to have the freedom to pivot and respond. (Delilah, third interview)

Delilah called on autonomy, and a sense of freedom as a way of describing what she meant by being an agent of change. The terms utilized by teachers instead of agency are therefore not

utilized independently of one another, but instead in a way that attempted to further explain the meaning making they tried to express. Yet, what is important to note is that the word "autonomy" was still utilized by Delilah and others within the case more readily and comfortably than "agency" thus expressing how teachers are defining agency since they are not defining agency through the term "agency."

      Voice. Along with "change agent" and "autonomy," Calliope choose to define agency through an additional term— "voice." When asked, "What do you think of agency?" (Researcher, third interview) Calliope responded by prioritizing voice. She expressed this when she said,

> So, to me, it means a voice, it's important. It's on the top of my list, I'm going to give it I personally will give it more attention. Or if it's someone else's, it makes it more important for me to hear it or others to hear it or others to participate in it. That's where I see that what agency means. (Calliope, third interview)

Calliope spoke the word "agency," but did so in a way that described what she meant by agency by invoking the idea of giving voice to what is prioritized for herself or others. She even went on to explain that her idea of giving voice is,

> not a complaint, it's not a problem. It's a solution. And making that solution address, the issue of the day or the problem of the day, um, like solving a problem, you know, we identify the problem, we figure out some strategies, how to use it, and we take agency, we give it voice, and we implement. Um, I think that has a lot to do with what agency.
> (Calliope, third interview)

Calliope's quote is rich with ideas about what she meant by agency. She called upon the idea of giving voice as a way of expressing agency, but she did so in a way that also illuminated the role

of collective agency, problem solving, prioritization, and even implementation and action. I spend more time unpacking the nuanced conceptualizations of agency in later chapters, but for now the important finding to consider is that teachers do define and explain agency, but they do so by utilizing other words and terminology other than the word "agency."

The Teachers Shifted to Using and Reflecting on the Term "Agency"

The ways in which the teachers discussed agency evolved over time. As the project progressed, the teachers used the term agency more readily, more accurately, and more reflectively from when the project started. By the end of interview three and into interview four, the teachers expressed that they were reconsidering and reframing what agency meant to them.

For example, near the end of interview three Delilah reflected on her changing understanding around the term "agency" when she said,

> Well, thank you for the opportunity to think through this. And and teach me some new vocabulary. Now I'm going to go off on I think, probably a little hunt and think about being agentive. And thinking about teaching agency. Yeah, I feel very honored for the opportunity to think think about that, and possibly include it in my identification of myself as what kind of teacher I am. (Delilah, third interview)

Not only does this excerpt highlight Delilah's high level of reflective capabilities, but it is important to remember that at the beginning of this interview Delilah asked about how to even spell the term agentic. By the end of interview three she was naturally using the terms "agentive" and "agency" and considering how these terms might recalibrate her teaching identity. Delilah's use of "agency" evolved over one interview from one of not knowing about a term to using, considering, and reflecting on that same term less than an hour later.

Jane's use of the term "agency" also evolved over the time of interview three. By the end of interview three, Jane was able to identify that by me offering up related terms like "agent of change" it helped her to gain a deeper understanding of "agency." Jane talked about the process of coming to understand "agency" over the interview time when she said,

It gets interesting when you [Researcher], when you said 'agent of change' it kind of opened up that word [agency] a little bit for me. Because if you go and if you go in that direction then there's also kind of the feeling like this is important enough to want to do what you're doing, I guess. (Jane, third interview)

For Jane, the definition of agency took on a level of importance by being part of interview three and the co-generative dialogues that were meant to center the teacher voice in what they meant by "agency."

Some teachers returned to the idea of their evolution of the term "agency" during interview four. Maya was one of those teachers when she said,

I learned that new word agentive. And I actually have been, …So I have some papers on my desk, here at home. And I write things I write what I've done, I write phrases, agentive is on there. And yeah, so that's, that's all been helpful. Because, um, you know, I, I, I'm, I appreciate change. And I respect the search for being a better teacher or a better science teacher. And there's things like being a responsive teacher. (Maya, fourth interview)

This excerpt from Maya highlights that Maya appreciates being a responsive teacher, and to her being responsive means appreciating change and always striving to be a better science teacher. Part of her responsiveness was to orient to new vocabulary she believed was helpful for her. She expressed that not only had she thought about the term "agency" since interview three, but that

she had also written it down in a space that was important to her, so she didn't lose the idea. Maya during interview three said, "I don't know what that [agency] means" (Maya, third interview), and yet in interview four Maya expressed that she had considered agency and considers it an important part of her being able to be a responsive teacher.

In another example of a teacher's evolution of how they define and use the term "agency," Calliope is asked, "if the research questions have changed your thinking about agency as part of your teaching practice?" (Researcher, fourth interview). Calliope responded by saying, "A little bit. Yeah, a little bit" (Calliope, fourth interview). To try to reach for the intended meaning of the dialogue, the researcher/interviewer reframed the question and asked again, "Okay, how would you describe agency at this point?" (Researcher, fourth interview). Calliope responded by saying,

> So, I would describe it now in two ways. Agency for the subject of science being taught in the elementary school and the way I do it now. And the agency of helping to dispel science falsehoods with my students or help our scaffolding them so they make those realizations for themselves. They come in with one idea, and hopefully by the end of class or end of two classes they have a better understanding. (Calliope, fourth interview)

Through this excerpt Calliope expressed that she recognizes that her understanding of agency has changed over time, her definition of agency has evolved. Calliope also expressed that as part of the evolution within her definition she has gone from framing agency through collective agency generally, as she expressed during interview three, but now frames agency more specifically and narrowly through her desire to assist her students in their understanding of science. Once again, the definition of agency has evolved, and is framed through the teachers desire to be in service to their students.

The evolution of the utilization and consideration of the term "agency" was apparent. Teachers went from not being familiar with the term, from not being able to describe it without using complementary terminology, to being able to use the term agency in various ways and describing its importance to their teaching identity. The teachers took up the term agency, they evolved in their use of the term agency rapidly and deeply.

CHAPTER 5

FINDINGS

THE TEACHERS' EXPRESSED INFLUENCES ON TEACHER AGENCY

In the last chapter I described the ways in which teachers within the case used the

terminology of "agency." In this chapter, I highlight the teachers' expressions that described the

factors that influence their agency. By centering the teacher voice as the case was being built in a

way that attended to their expressions of agency within their saying, being, and doing (Gee,

2010), I was able to attend to the research questions of how K–5 teachers expressed and

conceptualized their own science teacher agency. This chapter aims to provide a thick

description (Geertz, 2008) of what the teachers themselves express influences their agency.

The teachers expressed that the following personal factors were influential in their agency

including, (a) engaged and responsive students, (b) a love of learning and reflection, and (c)

confidence, and passion about science (see figure 5). The teachers also expressed that a series of

broader system-level factors play an influential role in how they express their science teaching

agency. The system-level factors included, (a) the administration's influence, (b) time for science

in the teaching schedule, (c) policies such as standards and mandated assessments, (d) money

and funding, (e) inequities across the educational system, (f) utilization of elementary science

teaching positions, and (g) the influence from the COVID-19 virus (see figure 5). Below I

describe each of these factors independently, which ones were expressed to be more influential

than the others.

Personal Dispositions and Motivations That Promoted Agency

The teachers expressed what they felt constrained as well as promoted their agency, and

these factors were often the inverse of one another. By highlighting and focusing on describing

what promoted their expressions of agency, it was unnecessary to describe what constrained their agency because it was the inverse of whatever they were expressing promoted it. For example, when Maya expressed that she felt confidence is an influential factor necessary to expressing teacher agency, she also described that what can constrain teacher agency is being scared. Maya said, "You have to have confidence that your ideas are good...[agency] takes energy and I think it takes confidence. Period. It's much easier to not change. And it's scary to change. But for some people it's scarier not to change" (Maya, third interview). Maya expressed that she believed it is scary to change, easier to not change, but that to express agency it takes confidence to overcome the ease of the status quo. Therefore, by focusing on confidence as an expressed factor that promotes teacher agency, the inverse of that factor based on how she described it, fear, can also be implicitly understood as a constraint when it is highlighted that confidence is an affordance to agency.

Engaged and responsive students. Having students that engage and respond to the teacher's science teaching enactments provide a feedback loop that then further promotes science teacher agency. Specifically, the teachers talked about the kinds of student engagement and responsiveness that most influenced their agency included students that showed enthusiasm and eagerness. The teachers were more willing to keep enacting their agency to provide their students with the science their students are expressing enthusiasm and eagerness for.

For example, Deborah described the importance of student engagement and responsiveness when she said, "It's the feedback from the students, if I try something. And they say, that was amazing or can we do this again, or. This is my favorite thing ever. That's, that's oxygen to me. That's what keeps me going" (Deborah, second interview). Deborah's metaphorical "oxygen" to her teaching is getting feedback from her students. But her expression

communicated that she really appreciated when that feedback is showing that her students engaged with the activity and were enthusiastic (i.e., when students say things like, "this is my favorite thing ever) and eagerly wanting to do more (i.e., when students say things like, "can we do this again"). Deborah explained the nuance to student interaction and the influence of that on her teaching agency. Deborah described that it is the way in which her students respond to the activity that keeps her making the choices to provide science experiences in the ways that she does.

Deborah even went on to say that she liked to start her day by checking in with how her students engaged with the science lessons she had sent out via video the day before (Deborah, second interview). Even though she was not able to engage with her students in face-to-face science activities as frequently as she was able to before the COVID-19 pandemic, Deborah still chose to start her day in a way that shows her that her students are engaging and responding to her science lessons, even when those lessons are remote based science videos she provides. Deborah made the choice to provide video-based lessons remotely, it was not a mandated activity she had to provide to her students (Deborah, first interview), and she chose to start her day engaging with her students in whatever way she could during the remote teaching time. The engagement and response of her students fed her desire to continue to provide these videos, an expression of agency on her part.

Jane, like Deborah, referenced how influential student engagement, specifically student enthusiasm, is to her expressing her science teaching agency. Jane shared that she often uses Delta[1] lessons as they are originally designed as a base on which to build and modify as needed

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[1] Delta is a for-profit company that provides science kits, curriculum, and resources for K–8 classrooms. The resources are also often referred to by their individual product names, FOSS, SCIS 3+, or other custom-made resources provided to school districts.

(Jane, first interview). She returned to this idea and expounded on what makes it easier for her to make these changes to the lesson design when she wrote in a reflection that, "Student engagement made it easier to continue with the exploration" (Jane, first reflection). In a second reflection I asked what made it harder to get her science goals met that week and Jane expressed that getting students to deeply think about science, versus just watching science reactions is made more challenging without student engagement (Jane, second reflection). And, in a third reflection Jane once again returned to the importance of student engagement as being a component of her willingness to modify lessons based on students' enthusiasm, ideas, and questions when she said, "Student enthusiasm also made it easier to complete the [additional lessons] series in, students made lots of connections to mixtures and solutions they are familiar with, were excited to try to separate, had lots of ideas and questions" (Jane, third reflection). Jane expressed over multiple times that she is willing to make expressions of agency—specifically by modifying lessons—because she witnessed her students' responsiveness and engagement in the science lessons she provided. Her students communicated their desire to continue exploring the science topics in ways which were not originally provided for in the Delta lessons, and yet, Jane expressed her agency in ways to modify those lessons so that she could meet her students' expressed desires.

Amelia also expounded on the influence of students' responsiveness and engagement, specifically their eagerness, over multiple interviews. In interview one I asked Amelia, "What makes it easier to teach science?" (Researcher, first interview) and Amelia's response highlighted that she is excited to teach science when the students ask questions. Amelia specifically said, "It is kids' questions. Just one going with where the child is at, and being interested in what they're really interested in. There's nothing more exciting, nothing more

exciting" (Amelia, first interview). Amelia expressed that it is not just random and unengaged questions that excite her to use her agency in ways to teach science. Instead, Amelia expressed that she likes questions that help her to engage with her students in authentic ways. Then, later in the research process, during interview two, Amelia talked about her enjoyment when the kids are engaged in the kinds of science activities she provides when she said,

> I love that the kids were willing to join me. In my project, it was really fun. It's really fun to feel like, they were just as interested as I was and am in our trees, I feel like it set the foundation for us for the year. (Amelia, second interview)

When Amelia expressed that when her students are, "just as interested as I was" she described how influential it was to her when her students express their eagerness to the lessons she is providing. Amelia expressed across multiple interviews that the way in which her students engage and respond to her through their questions and eagerness set the stage for her to be able to provide the kinds of science experiences that she does. Her students influence her agency to provide science experiences in the ways she finds makes her excited to teach science.

Maya connected the engagement and responsiveness of her students to her desire to keep teaching science every day when she said,

> I have a lot of fun. I have a lot of fun doing what I do. I really enjoy watching the children experience success. Um, I love their excitement. I love their discoveries, even if it's something that I know exactly what's going to happen, they're surprised and therefore I'm surprised, and so that so I get in my car the next day and I do it all over again. (Maya, second interview)

Instead of succumbing to teacher attrition as so many others do, Maya not only chose to be a science teacher each day (as she has for the past 37 years) but she also said that it is fun for her to

be a science teacher. And what did she express as the source of that fun? The engagement and responsiveness from her students, and specifically engagement and responsiveness that evokes "excitement" which is a combination of eagerness and enthusiasm.

Love of learning and reflection. Within the case, it became apparent that the teachers felt that another factor that promoted their science teacher agency was their love of learning and part of that love of learning is a willingness to engage in a reflective practice. The teachers expressed that part of what makes them more willing to engage in a practice that changes and transforms the ways in which they teach science stems from a deep belief that part of who they are is a learner. However, the teachers specified that they are the type of learner willing to continually consider ways in which they can improve and grow through reflexivity. For example, Maya during interview three said,

> I think, I think, I believe wholeheartedly that change and grow are good. Can't do the same thing. Even if it's successful you can't keep doing it you have to find ways to make it better. So therefore, you meet you know change, you always need to change you always need to think how can I make it better. (Maya, third interview)

Maya communicated so much in this excerpt. She expressed that part of who she is, "wholeheartedly," is someone that has a deep belief that changing is growing, and that that growth is a net positive on her teaching. She said that this is a constant practice, even if you consider yourself successful already, that you need to continue to grow and change in ways to make it better. She used the word "need" here which is interesting. Maya expressed that part of meeting our personal needs as science educators is to change, and to continue to change in a positive direction. And, for Maya, who is already considered by many to be a science teacher leader in her state (Researcher, reflective memo), even she considers that change is a necessary

component of being a better teacher each year, but she takes this on as part of who she is when she said, "you always need to think how can I make it better" (Maya, third interview). She emphasized her role in the change by constantly being a reflective practitioner and continuing to learn and reflect on that learning so that ultimately, she is a better teacher each year. She expressed that her desire to be the best science teacher she can be relies on a personal belief that she needs to engage as a reflective learner so that she can make the changes she wants to make, so that she can express her agency in the direction she desires.

Delilah also brings up this idea that being a reflective learner depends on being able to have the kind of personality that welcomes change and growth. Delilah expresses this when she said,

> I'm so happy that it's life as a teacher that I'm constantly able to grow and stretch and change, and respond and give back. And rather than I just knew when I just knew that I could never, ever, ever have the kind of a job where I would have to sit at a desk all day. Um, so I'm really grateful for the opportunities to even despite, despite attempts to just still have a really full, meaningful and happy professional life. (Delilah, third interview)

Delilah expressed that being able to grow and stretch and change is a way to not only be happy in her professional life, but also, she sees it as a way to respond and give back to the system in the ways she wants. Delilah expressed appreciation that her professional life is one that pushes her to make this growth and change. Being in a profession that encourages one to grow and change is not a burden, but a blessing in Delilah's perception.

Even after the official research project was done, Delilah continued to express the importance of reflection being an important part of her teaching practice, that she had considered

ways of expressing agency as a science teacher due to her reflective practice when she communicated via electronic mail that,

> I wanted to let you know that your research results…changed my practice. I realized I needed to advocate more strongly for science education in my school and district if I wanted to see the changes I was moaning about. That said, this year I am not much involved in science curriculum (I'm point person for writing), so I'm not saying much but now I know how I need to proceed. (Delilah, Electronic mail September 22, 2021).

Delilah took it upon herself to communicate these thoughts with me after I had sent out some early findings to be member checked. That communication expressed her continued belief that part of the factor that promoted her agency is to engage in a reflective practice as an educator that is also a lifelong learner. Delilah said that she understood that her being, and thus her teaching, was modified and changed because of a willingness to be a reflective learner open to new ideas and considerations.

Deborah also specifically highlighted the idea of reflection as being an important part of learning and is a factor that helped her to make the kinds of choices she wants to make as a science teaching professional when she said,

> I think self-reflection is an important part of every process, every profession, and it's often ignored. In the teaching profession, there's a shortage of time. When I have been reflective, I have found that to be productive. At the end of the year, sometimes I will write up a summary of new things I tried that year. And I think that that process has a lot of benefits, it helps. It helps me to review what I tried, how I tried it, how I felt about trying it, how I felt after I tried it, I think it inspires me for the future. So yeah, I think we should make time for that. (Deborah, third interview)

Deborah called out the importance of self-reflection as part of being a life-long learner. Although she pointed out that there is never enough time to do this practice as deeply and as often as she thinks would be beneficial, despite the lack of prescribed reflective time, she makes time in her professional life to engage in this reflective learning even on her own. By considering oneself to be a life-long learner that learns in part by making time for reflection, Deborah underscored that her science teaching agency is benefited by her belief in a love of learning and reflection. Deborah expressed that she considers her agency in the future because of her reflective practice now.

Confidence. Another factor that teachers within the case felt important to express as a factor that promoted their science teacher agency was being a confident person. The teachers expressed that confidence can come from experience,

> I think if I was less experienced, I would feel less confident expressing it [agency]. So luckily, I've been teaching for a while. And luckily, I was a scientist before becoming a teacher. So, I feel very secure with the content and with lab procedures in general. So that that the that makes me feel more confident. (Deborah, third interview)

The teachers also expressed that confidence can not only come from teaching experience in general, but what kinds of experiences one undergoes can also influence one's confidence and thus one's agency. The teachers described that when they have experiences that end in success, when the attempt at agency is fruitful, they gain more confidence from having experienced earlier success. Maya expresses this when she said,

> I think that when one is when one is an agent of change, the more overall success, one has, the more you're apt to continue to try and be an agent of change. You have

confidence to make the changes. Similarly, I think if you meet with defeat um it takes

energy to be an agentive person.

Other teachers went on to explain that confidence is a necessary component to "feeling like you know what you're doing and your decisions are valid enough to go ahead and make them without having to check in or get the okay from somebody" (Jane, third interview). Confidence can also make you feel empowered in ways that allow you to feel like you can do what you need to do. As Maya put it, "I'm here and I'm a little crazy and I just do whatever I damn well please" (Maya, third interview). Or as Deborah put it, "The confidence to try things, even if even if they don't completely work out, they usually do work out" (Deborah, third interview). Within the case the teachers express that confidence helps them to feel like their agency is valid and useful which encourages them to express that agency in various ways as science teachers.

For these teachers, confidence was a necessary personal disposition that influenced their agency in ways to promote their feeling like they could express their science teaching agency autonomously. Deborah called on her teaching and professional science experience as having helped her to feel confident so that she can feel more secure in her teaching. Jane expressed that confidence helped her to feel like her decisions are valid and she can move into action in ways she feels are most effective. And, although Maya downplayed her extensive professional knowledge by saying she is a little "crazy," she also pointed out that her confidence helped her to do what she felt she needed to do. Having confidence is a factor that the teachers expressed can promote their science teacher agency.

Deborah summed up the connection between agency and confidence when she said,

Sometimes we have more agency over situations, and sometimes we have less, and

sometimes we feel that we have more confidence, and sometimes we feel that we have

less, I think it depends a lot on our own view of the situation. (Deborah, third interview)

In this quote Deborah expressed that although confidence is not static, it waxes and wanes just as

agency does, the feeling of being confident as a teacher in the science teaching profession is

inexorably linked to expressing one's science teaching agency and that that expression is based

on one's own view of the situation. In other words, how confidently one feels about the situation

can affect how one engages with it.

Deborah also expressed how these personal factors that promote teacher agency

intertwine and comingle in influential ways. Deborah mentioned the connection between

confidence and student responsiveness and engagement when she said that,

When I try something new, and I get good feedback from students, that definitely is

rewarding, because I feel like like the feedback that they're giving me is based on

decisions that I made. And so if I created a lesson from scratch, I came up with the idea I,

I created the whole thing. And they tell me they liked it that makes me feel really good

about what I did. And it gives me the more more confidence to try that again in the

future. (Deborah, third interview)

Deborah expressed that not only does confidence and agency shift over time and context, but that

it also influences and is influenced by other personal factors. In this example she expressed the

connection between confidence and her students' responsiveness and engagement. When her

students are more engaged and responsive, she is a more confident teacher, and that increased

confidence in turn encourages her to express her agency in her teaching decisions. These

personal factors that the teachers expressed promote science teacher agency are influential factors and are factors that intertwine with and influence each other.

Passion about science. Whether or not the teacher was a generalist (and taught all the subjects including science) or was a specialist (only taught science), the teachers expressed that having a passion for science influenced their choices to express their agency. The teachers not only wanted to model the passion they personally feel for science, but they had a goal for their passion—to pass along this passion so that the students also feel passionately about science; and they have an outcome of their passion—they prioritize teaching science. Having a passion for science was expressed as a factor that therefore influenced in them promoting their science teaching agency. For example, Jane talked about the science choices she makes to prioritize science in her first-grade classroom because she feels science is important, she is passionate about it and therefore wants to make sure it is prioritized within her classroom. She expressed this when she said,

> In my classroom I definitely you know prioritize my time so that we can have science education. Science is important and I am passionate about it and. Um, and, um yeah I mean I because I was thinking about this this morning that like the planning is time consuming and the prep is usually depending on the science unit we're doing but often in first grade on some of the units I do in second grade there's materials and there's a lot of prep that goes with it so then a lot of cleanup that goes with it. So, you know, for me, deciding that I'm taking that time, because it's important. (Jane, fourth interview)

Jane expressed that it takes extra work on her part to make sure science happens in her classroom. Jane expressed her agency spending extra preparation and clean up time so that science could be taught in the ways she felt are important. She made this time in her classroom,

she prioritizes science, because of her passion for the subject and thus her feeling that it is an important subject for her students to engage with.

Delilah also expressed that she wanted to pass along her passion for science to her students when she said, "because I am passionate about science, and we have such little time teaching science. I hope to be a passionate science teacher who is inspirational" (Delilah, fourth interview). Delilah shared that she considers her passion for science to be an important part of how she wanted to teach science. She hoped that her science passion inspires her students. Therefore, Delilah made the choice to express her agency such that she taught science with passion, with a goal of being inspirational to her students, because she would like to pass her passion of science along to her students and she felt this is best accomplished by modeling a passion for science.

Similarly to Delilah, Amelia expressed that her goal for science teaching, what would make her science teaching successful, is to help her students find their passion for science. Amelia felt she can best ignite her students' passion by sharing her passion and resources for the subject. Amelia expressed this when she commented that,

> If I can awaken that science passion in them. Then I've done my job, really, if I
> can heighten their awareness…and put them in touch with resources that I have stumbled
> on to that really ignite a passion for science. That's, that would be a successful mark for
> me to do that. (Amelia, first interview)

Deborah too shared her passion for science with her students and expressed that one of her teaching goals is to pass that passion along to her students. Deborah said,

> If I wanted to explain what my main goals were for my students. By the time they
> graduated from my school, I would want them to be excited about science and curious

about it. I, I feel like getting them to learn the content is less important. I want them to be

the kind of students who think that science is doable. It's accessible. It's worth studying

it's interesting, and they're interested in doing it more in the future. So I try to make it fun.

I try to give them a variety of different kinds of experiences. I, I try to show them how

passionate I am about it.

The teachers expressed that how they define successful science teaching is through the eventual

passion their students feel for science. The teachers within the case are using their own passion

for science in ways that express their agency so that their passion for science is transferred to

their students.

System-level Dynamics That Influenced the Teachers' Agency

The teachers communicated that along with their own personal dispositions influencing

and motivating their agency, their agency was also influenced and motivated by broader system-

level dynamics including (a) the administration, (b) time for science in the teaching schedule, (c)

policies such as standards and mandated assessments, (d) money and funding, (e) inequities

across the educational system, (f) utilization of elementary science teaching positions, and (g) the

COVID-19 virus. The broader system-level factors that were expressed most often and ardently

by the teachers are described first, and how the factors were expressed as influencing each other

is also considered throughout the case.

Administration's influence on the teachers' agency. Within the case, one of the

primary factors that teachers expressed as influencing their science teacher agency was the

administration they worked with. With and without prompting the teachers frequently and

unequivocally expressed how the administration could either afford or constrain their teacher

agency. For clarity, when the teachers expressed thoughts concerning administration, they were

referring to the staff positions within the school and/or school district that set policy, supervise, and manage the teaching staff. The positions mentioned included curriculum coordinators, principals, vice principals, and superintendents.

Often, they were in their classrooms before or after school time, but sometimes teachers also choose to be in other locations around their school, or at home while being interviewed. During the first interview Amelia was speaking to me from a public space in the school, a large gathering space that was open to hallways and could not be sequestered visually or auditorily from random passersby. Therefore, when I asked Amelia to "Describe your administration" (Researcher, first interview) Amelia first proceeded to look uncomfortable, shifted, looked around, and then said, "Our administration... I'm standing here in the forum..." (Amelia, first interview). I offered to "talk about that another time" (Researcher, first interview) and Amelia responded, "I would…ask that next time, and when I'm in a smaller room" (Amelia, first interview). Her concern that her response would be overheard made me wonder what she was going to say about the administration that was potentially so negative. Instead, when I asked her the same question at the start of the second interview, she spoke about the heavy handedness of the COVID health team in place to monitor that the school is following CDC COVID-related guidelines for school safety. However, she ultimately said that the principal is fair and supportive but also that she recognizes that her principal has her hands tied in dealing with all the COVID-related protocols and guidelines. Amelia explained that there are tiers of restraints within the school system and although the principal, along with the COVID health team are layers that can feel restraining to her, she can see that the principal's agency also is constrained when Amelia said,

she [the principal] also has got her hands tied a little bit, or a lot of bit, I guess you would

say by the higher up administration, meaning, you know, other people who are in charge

of her. And so I feel restraints kind of coming down from above that there are restraints

out there. But I do know that in her heart of hearts, she as an administrator is very

supportive, and usually very open to any and all programs as long as we have tried and

tested them, or we have the gut that says that they're okay. And that they're a possibility.

(Amelia, second interview)

That Amelia found it necessary to make sure she was not overheard, and then proceeded to talk

about the administration in an overall positive way, highlights the consequential nature of

administration in a teacher's professional life. Amelia's discourse emphasized that the

administration is a significant part of the broader system in which teachers need to negotiate. The

context of the administration is an omnipresent part of the professional life of the elementary

science teacher within this case, and the influence of that context is expressed in the agency

teachers express.

   The administration affords the teachers' agency. The teachers within this case described

in detail how they felt administration can afford, support, and promote teacher agency. Again,

rather than focus on the constraints, I focus on the ways in which the teachers expressed that the

administration affords teacher agency. Not only are the constraints an inverse of the affordances,

but by focusing on the affordances it highlights the potential of the administration to influence

elementary science teacher agency in ways that feel positive in ways expressed by the teachers.

   The tension expressed by teachers that they desired their administration to both leave

them to work autonomously as well as to engage and support them when asked, was expressed

by Amelia when she first started discussing her principal and she expressed that she wished the

principal were more attentive to her and her students when she said,

> I don't feel like it should be my role, you know, to place things in front of the principal
>
> and say look at these please please pay some attention to. It's like she doesn't have time, I
>
> don't, I don't know, I think she has a heart toward that. And she's probably feeling glad
>
> that that I am as involved as I am, with, with the whole process, you know, with my
>
> students but that's just, that's a that's a personal woe that I have experienced with being
>
> here. (Amelia, third interview)

But then Amelia went on to also express that she appreciated the freedom her principal gives her

to teach in the way she wants when she said,

> She [the principal] gives me a lot of freedom to teach the way I want to teach, and I think
>
> she trusts. She trusts the direction that I'm going with these kids. So, and the kids are
>
> often, you know, leading me like I said earlier, we can't lead in 20 different directions but
>
> it feels like the path that I have started them out on is is a good one. And it feels feels
>
> good. (Amelia, third interview)

Amelia expressed in this excerpt what was a theme by the teachers when discussing their

administration—a desire to be actively supported and simultaneously to be given the autonomous

freedom to make decisions based on their professional expertise.

Deborah also addressed the tension between wanting administrative support but also

wanting freedom and teacher autonomy when she said,

> Teacher agency depends on the environment that the administrators create. Some
>
> administrators treat their staff members the way traditional teachers teach their students
>
> they say this is the right way this is what you must do. Other administrators give their

teachers more room and freedom and they let them figure out what the right way is for them...I have worked in a couple of different schools and um the school that I work in now, I feel that my administration has been very supportive of me as a professional, and very encouraging while still giving me a lot of freedom. I don't feel like they ignore me, that's not agency, I feel like they're there for me when I need them. And they, and they, they model appropriate professional behavior. But they don't micromanage me.

Deborah was able to express what works for her—which is an administration that is there for her when she needs but is not overly involved in the minutiae of teaching details. She appreciates the support, but when she expresses a need for that support.

Deborah continued to spend substantial sections of each interview discussing the ways in which the administration is a factor in her science teacher agency. She provided an overview of what she thought the administration should consider for them to create a positive and agency influencing teaching environment when she said,

There are many ways that administration can affect the environment and the and the viewpoints of the people who work for them. I think they they need to create an environment where teachers' voices feel heard. When, when there are meetings, and teachers express their opinions, the administration needs to show that they're listening and are taking actions based on what they heard. I think that they need to be encouraging and provide positive feedback. When when teachers initiate things, I think they need to give praise and public recognition to teachers who have initiated new things. And I think they need to refrain from all the negative reinforcement of risk taking. I think they need to give individual feedback to teachers, make them feel valued, and comfortable and safe. (Deborah, third interview)

Deborah was specific in what she envisioned as the ideal way for the administration to set up the environment to positively influence teacher agency. She believed that it is important for the administration to not just hear what teachers had to say but also act on what those teachers said. She went on to explain that the kinds of actions that are helpful are when the administration is encouraging, provides feedback, and encourages teacher risk taking. Deborah expressed that it is not enough for administration to just to listen to teachers, but that the administration must express their own agency in ways that in turn supports their teacher's agency. Deborah was expressing what it takes for her to work in an environment where she feels valued, comfortable, and safe.

Calliope underscored this same point as Deborah, that it is important that the administration listens to your teaching voice as an important voice within the school when she said, "administration not listening can affect a teacher's agency" (Calliope, third interview). Although Calliope expressed more frustration toward her administration than the other teachers when she went on to say things like,

> then admins failure to understand the working conditions of the educator, and not not
> being collaborative. Um on several occasions. I mean, now there's agency and urgency on
> the admin part to get some things done. And it's like, we asked you in the summer, why is
> it an emergency now?

With comments like this, Calliope underscored the importance of administration listening to teacher needs, especially when they ask to be heard, as an influential factor to teachers expressing their science teacher agency.

Deborah felt that she was heard by her administration and so could express her ideas and try new things in her school. She said, "they [administration] give me good feedback when I try

new things. And so I feel that that encourages me to be creative, and explore um explore ways in which I can grow professionally" (Deborah, third interview). Jane expressed that she likes how her administration creates this environment when she said,

> I would say, for the most part they give us a lot of autonomy, which I really like about this school, actually…We are trusted that we know what we're doing…I think generally speaking, we're trusted to know what we're doing and do it…which is good. (Jane, first interview)

Maya expressed the same feeling of appreciation about how her administration supports her agency when she said,

> I could be haunted and harassed by an administrator. And I am not. And I definitely appreciate that. And appreciate the support I have from the superintendent and the recognition. And that makes my life pretty comfortable because I can just pursue what I want to pursue. (Maya, second interview)

Delilah described more of what she means when she says she appreciates teaching in an environment that supports teacher agency when she said,

> Having the having the autonomy, to respond to my students in a way that I think is most appropriate is extremely important. For me, as an agent of change as an agent of science information. Really, I really, really value the autonomy that I have within the curriculum as it is like I know that my administrators trust me so they're not up in my room all the time. Which would really hamper what the way I at least, like my sense of being able to have the freedom to pivot and respond.

Delilah provided a specific example of the freedom she enjoys so she can educate in an agency expressive way; meaning, she can pivot and respond to the needs of her students in an action

orientated and autonomously driven way when she does not have to worry about the administration being in her room all the time. Delilah expressed feeling hampered if the administration were in her classroom all the time, and since they are not, she felt she has the freedom to make decisions as needed for her students, which she appreciated.

Jane also brought up her appreciation of the administration allowing her to express more freedom and flexibility to teach in the way she feels is best when she responded to my survey question asking about "What makes it easier to try new curriculum?" (Researcher, initial survey) when she said, "Having school administration that does not expect rigid adherence to the district chart of grade level science topics" (Jane, initial survey). Jane expressed that she understood that by getting more flexibility from the administration concerning what topics and curricula she could teach allowed her to feel like it is possible to try out new ideas in her classroom. Jane described that a factor in her trying out new teaching ideas, i.e., expressing her teaching agency, as being linked to some of the freedoms and flexibilities allowed by the administration.

Deborah once again expressed that part of her reason for feeling that she could express her agency in her school is that she felt supported and encouraged by her administration. Deborah expressed this when she said,

> I feel I feel agentic quite a bit in my in my current school, I feel that my administration is very supportive, and encouraging of me and others. I feel like I get to make a lot of decisions about my curriculum about my teaching methods about my professional development, I think they they give us a lot of choices. And they and they, they when they say any of these are fine, they really mean it. And they've given me positive feedback on new things that I've tried. Sometimes we have informal discussions, and I feel that my feedback is really valued. (Deborah, third interview)

Through this discursive expression, Deborah highlighted that to feel it is okay to express agency as a teacher the administration must mean what they say, they need to make the teachers feel like it really is okay to try out their new ideas. In other words, if the administration says teachers can try new ideas, or that their voices will be valued, or that they have choices as a professional educator, then the administration must live up to those ideals through their own enactments of agency.

The teachers expressed that the administration is a major system-level factor that influences their science teacher agency. The teachers deeply described the influence of the administration on their agency and were also able to express what they feel the administration can do to afford and promote elementary science teacher agency. The teachers expressed that in order to feel safe and supported to express their agency, the administration needs to walk a fine line between actively engaging with teachers and providing the teachers with freedom and autonomy. The teachers expressed that the administration does this effectively when they listen when the teachers use their voice, support teachers when asked in the ways teachers are asking to be supported, but also the administration needs to back up what they say they believe in with their actions. In other words, the administration needs to make sure their teachers feel they will be supported and appreciated when they try to express agency, even if that attempt is not deemed successful.

Overall, the teachers felt that their administration was achieving this desired balance between engaged support and total freedom with their teachers. Throughout the research process the teachers had a lot to say about the administration and the effect of the administrative agency on teacher agency, but they also expressed that by and large they were pleased with the administrative systems they were working within and felt they were able to express their

elementary science teacher agency without being drastically constrained by their administration. Their teaching agency is significantly influenced by their administration but in ways that they felt promoted and afforded their agency.

Scheduled time for science influences teacher agency. Another part of the broader educational system which the teachers within the case expressed as greatly influencing their science teacher agency is the way in which science is scheduled into the school and classroom schedule. But what the teachers' discourse crucially highlighted was the deprioritization of science in the day-to-day and weekly schedule of the classroom. The teachers expressed that the broader educational system's deprioritization of science emerges in the classroom as a decreasing amount of science time that is scheduled into the classroom week. Therefore, the decreased amount of scheduled science time requires greater amounts of science teacher agency to continue to get science taught in the classroom. Maya put it concisely when she expressed that, "time, time is a huge constraint and a challenge to teaching science" (Maya, second interview).

The teachers expressed that science has less time in the schedule as compared to the other subjects, but especially compared to the subjects often considered core to elementary school education including reading, writing, and mathematics. The teachers expressed that science along with social studies are often subjects relegated to the fringes of the elementary classroom schedule. Deborah described it in this way,

> In elementary school it's [science] generally not a priority. It's not considered one of the most important subjects, so it doesn't get as much time and resources as reading and writing and math do. Every time we reorganize our schedule, reading, writing and math,

get the most priority, and sciences social studies are kind of like whatever time we have

left. They get the, they get the dregs. So, so that's tough. (Deborah, first interview)

Deborah pointed out in this excerpt that the school staff work collaboratively to create the

schedule of when the subjects will be taught across the teaching week when she said, "we

reorganize our schedule." When creating these school teaching schedules, the school staff is

influenced by the larger sociocultural influences and thus certain subjects "get the most priority"

of which science is not included as a priority. Instead, science is considered a left over, a content

area that gets taught when there is time. But the teachers in this case pointed out that without

prioritizing science time to be considered in the teaching schedule on equal footing with reading,

writing, and mathematics it is challenging to squeeze science into an already full teaching

schedule. When science is considered to be the "dregs" of the content areas, it is "tough" to make

sure science is taught. Thus, requiring inordinate amounts of science teacher agency to solve this

problem.

Jane gave a specific example where this situation happened to her schedule. The

administration redid her schedule and "Science time is now shortened to 30 min, so less time for

the kind of exploration that leads to new ideas & questions" (Jane, second reflection). Jane told

about this change to her schedule and explained how it made it harder to meet her science

teaching goals for that week. Jane expressed that she would like the students to have time to

explore new ideas and questions but with a predetermined schedule that only allows for 30

minutes of science per week, it makes it hard to teach the kind of science education she wants to.

Although it would be easy to imagine a teacher dropping science altogether when this kind of

schedule is imposed, and science is therefore relegated to such a small amount of time in the

week, Jane instead showed her resiliency to this new schedule when she said, "and that [science]

was a little shortened this time [of a new schedule] but it's what I got so I'm gonna have to go with it" (Jane, second interview).

Despite this constriction on time for science in the official schedule, Jane is a teacher that strived to continue teaching science. Jane explained that she expressed her agency by trying to get science in where she can, even when teaching remotely by offering options and choices to her students. She described her mitigation of the science schedule when she said,

this year it's more like we have these remote schedules we're working on and now they're pretty set and science isn't in there anywhere. At all. So, I still want to figure out a way to offer some things for kids who do and I did offer a lot of science stuff for kids to do in the spring in the afternoon that were stuff that they can do on their own, they didn't need an adult, it was more like, because it was spring, it was outside stuff, but that would still have them thinking and engaging with science. And I feel like I want to figure out how to get that in there too so we have this like menu place. At the end of the day, so maybe that's I'll just manage to put some things in there. But I think it's important and I think, I don't know. It's easy to drop it because you're doing 500 other things but I feel like a lot a lot a lot of learning happens there. And it's a missed opportunity if you just drop it. (Jane, second interview)

Jane provided science menus and options to her students even when her teaching is fully remote because she deeply felt the importance of teaching science. Jane did not want her students to miss out on the opportunity of learning science and so whether her in-person schedule is shortened to only thirty minutes of science per week, or whether she is teaching remotely and has no official science in her schedule, Jane was constantly squeezing and sliding in science when and where she can. Jane altered how much science is actually taught in her classroom versus the

schedule-based expectations of how much science is scheduled to be taught. Whether science disappears entirely from the schedule (as it did when remote) or when science time is truncated (as it was when the in-person schedule was reconfigured), Jane had expressed ways in which she still gets science into the classroom schedule, and therefore into the learning experience of her students.

Deborah described a linkage between the administration and the schedule when she comments that she wishes the administration understood just how much time it takes to teach science. When I asked her, "So what do you wish your administration could know about your science teaching that you think they don't know?" (Researcher, fourth interview) Deborah responded, "I guess, I wish I, I wish they knew how much time it takes for me to create a lesson" (Deborah, fourth interview). Jane earlier described that the administration imposed on her a classroom teaching schedule that deprioritized science compared to the other subjects. Now Deborah described that when the administration is making these schedules, they might not even be aware of just how much time science teaching takes. Deborah expressed hope that if the administration only knew how much time went into creating and teaching these lessons, that the administration would alter the schedules in ways that prioritized more science time within the schedules they create.

The teachers expressed their longing for more time to teach science, especially more time to be able to teach science in the ways they believe it is important to teach science. As Amelia said it, "I have never had enough time for the science I've longed to teach" (Amelia, fourth reflection). But these teachers also mitigate, mediate, and manipulate the schedule in ways that still get science into the schedule and thus into the learning experiences of their students. The enactments of agency by these teachers to teach science when and how they can, despite science

being deprioritized within their administratively imposed teaching schedules, highlights that the time allotted to science in classroom schedules greatly influences the science teaching agency of these teachers.

    State and national standards influence teacher agency. After the agency influencing factors of a school's administration and imposed classroom schedules that prioritize subjects other than science, the next system level factor influencing teacher agency are system-wide policies. Some of the policies the teachers expressed as influencing their science teacher agency are standards like the Common Core (Common Core State Standards Initiative, 2010), Next Generation Science Standards (NGSS Lead States, 2013), or individual state designed standards. Calliope succinctly professed her commitment to standards in a way that was heard in similar ways throughout the case when she said, "Right, right. So I use my state standards. So yeah, it's standards based" (Calliope, first interview). The teachers go on to express nuance on how those standards influence their agency. The teachers express that with the standards in place they feel more self-assured to teach science because they have a directive of what and how to teach. However, these same standards also create an additional context with which the teachers need to mediate and negotiate which can at times be frustrating. The teachers expressed that although they are generally supportive of standards and find them helpful in supporting their ability to teach science, how they as science teachers negotiate the influence of those standards can get complicated. For example, Jane expressed that while she likes that the standards provide a consistency between the grades, she also expressed that she appreciated that in her school there is some flexibility in how aligned her teaching must be to those standards. Jane explained her appreciation of the consistency that standards provide while also appreciating that in practice there is some flexibility, at least for her, when she said,

We did it in our school to kind of go through the next gen standards and looking at them

and, you know, kind of, and I think I can see the idea behind saying like first grade we'll

do this second grade we'll do this so kids, there's just a consistency and if kids, switch

from one school to another there's consistency, but I'm glad that it's not in stone. (Jane,

third interview)

In another example of complexity around the standards when asked if the NGSS

standards were part of her curriculum Amelia said,

They're [the standards are] in there. They're in there. Yep, yep, yep, they're all listed out

…I'm not a master stick master the standards kind of teacher. Sorry to say that but I don't

think I don't believe in that so anyway. (Amelia, first interview)

While professing that the science curriculum she teaches is standards-based, Amelia then

elaborated and admitted she is not even sure that she believes in standards. In one way she has

expressed that her science teaching is influenced by the standards and is proud that she is

meeting that standard. Yet, Amelia is unsure that she even agrees with the idea of standards, or at

least of these specific standards. Despite her underlying personal doubts about the NGSS, she

continued to use her agency to teach science in a way that maintains that she is teaching to those

standards. The policy of teaching curriculum that addresses certain standards has shaped

Amelia's agency in how she goes about teaching that science.

Maya, on the other hand, believed deeply in standards and wished there were national

science standards in addition to the NGSS standards that states have a choice in adopting or not.

However, Maya believed there is still room for improvement in how science is being taught, and

what standards are being used currently. Although she is teaching using the current NGSS

standards as a foundational part of how she designs her science teaching which she explains

when she said, "Well, I start with the [NGSS] standards. Actually, look at the storyline, and I figure out what my questions are gonna be for the year…. most big questions come from NGSS" (Maya, first interview). Maya even expressed her agency by advocating for the NGSS standards, "NGSS I love it if I've marched in the parade, and I wave the NGSS flag, happily" (Maya, first interview). Yet, she still would like to see more work done to align around a set of national standards when she said,

> I'm happy that the NGSS standards exist. I really want national standards. I don't think
> that they are the be all or end all. I think there's a lot of room for development for
> national standards. I just we're not there, where we're not at the right place, or a good
> place for teaching science, we're at a better place than we were 15 years ago. But it's not
> right. (Maya, fourth interview)

Whether or not they believe that standards are the right way to proceed in science education, the standards that are part of policies that undergird the educational system writ large, influence the agency of these elementary science teachers. The teachers professed that they are aligning their curricula with the standards, they are creating their guiding questions for the year based on the standards, and that the standards have shaped their teaching. Deborah enjoyed taking a leadership role in aligning the district's curriculum to the new NGSS standards and also expressed that the NGSS standards changed what was taught in science and how it was taught when she said,

> It was a learning process at first when the standards [NGSS] were introduced in our state
> it meant that our entire curriculum was very, very different than what it had been before.
> In both content and everything else. And so it was a it was a learning process for all of us.
> Luckily, I was involved in rewriting our curriculum documents because being the science

specialist in the, in the school I became the expert on the new standards and so I helped put them into writing and I helped implement them and that was that was an interesting process.

The teachers within the case expressed their agency by advocating for the standards, aligning their curriculum to the standards, using the standards to guide their teaching, and leading the implementation of the standards.

Money and funding influence teacher agency. Within the case the teachers expressed how influential money and funding were to their agency concerning their teaching of science. With funding comes an increase in choices and options of resources which provides the teachers with an increased ability to teach science using the materials and means they see as most effective for teaching science in the ways that they want. Thus, science teacher agency is not constrained by the logistics of materials or resources when adequate science funding is provided.

When I asked Maya what is difficult about teaching science, or what holds her up from teaching science (Researcher, second interview) Maya replied, "Money! Money! Money!" (Maya, second interview). Maya called out the material needs she has to teach science in the way she desires when she said, "Occasionally, like I would much rather have 30 sets of binoculars then 10 sets of binoculars. I would like my microscopes, which I had fixed three years ago because you put them in focus, and then the stage would drift" (Maya, second interview). Maya's desire to purchase more binoculars and have microscopes with functioning parts requires funding and resources she just does not have at her school (Maya's school has the highest percentage of students eligible for free and reduced-price lunch within the case, 46%).

Although Maya received numerous grants and material resources from the projects she is part of, and from proposals she had applied for, and she even shared these resources with her

colleagues, she expressed that she would like the flexibility and ability to purchase the supplies she needs when she wants them. Maya said,

> I buy stuff when my local resources [and project funders] says you've got this much money. I tell the principal and I say I've got this much, much money and I've got this much stuff already. What is it that the lower grade teachers need? And I tell the low-grade teachers that you know, first of all, never buy anything until you ask me because chances are I have it in my storeroom but also if you happen to need a thing for a project, you know let me know. So, I feel like I facilitate that.

Maya accrued so many science teaching resources over the years that she was able to support her colleagues in their ability to have the materials necessary to teach science. Maya realized it is her choices, her expressions of agency, her facilitation as she termed it, to be part of projects that give out materials, or apply for funding so that ultimately, she has what she considers enough to not only teach science herself, but also support her colleagues in what they need to teach of science. However, she still is quick to point out that money is an influential factor for her teaching agency. Despite the resources she has thus far, she could still use more supplies and resources to have even greater choices in what she could teach and how she could teach it.

On the opposite end of the economic spectrum, Deborah taught at a school with the lowest percentage of students eligible for free and reduced-price lunches (FRPL) within the case (0.8%). This percentage of students on FRPL is significantly lower than the state average of 40.5%. This indicates that the specific geographic area Deborah taught in has a lower level of poverty than the state average and Deborah expressed that she realized the increased funding for her school is a privilege that afforded her many opportunities. Deborah expressed some of the science teaching opportunities an increased budget allows for when she said,

I would say compared to other public schools, our school has a lot of resources. If, if

teachers want to get something for their students and there's no money in the school

budget. Sometimes the PTA can help out with things like that. We have a science lab in

an elementary school, a dedicated science lab, and my position is full time is, it's only

working in this science lab I don't do other classroom teaching I'm only a science lab

teacher. And that I think that's kind of a luxury most districts can't afford something like

that…Luckily, our district has, has money available for conferences, I, I know that there

are schools that just can't send teachers to meetings ever. So typically if I find a meeting

that I'm interested in going to even if it's in another part of the country, they will usually

pay for that so that's great.

Deborah highlighted that an increased school budget allowed for an increase in her ability to

have the option to make expressions of agency in her science teaching like being able to attend

conferences or professional development, purchase resources for her teaching, but also just the

fact that her position exists in the first place. She understood that most schools do not have it

within their budgets to even consider a position such as hers—a science specialist for lower

elementary students with a dedicated science laboratory space within the school. Deborah

articulated that she understood that her school is located within a community that has a higher-

than-average socioeconomic level and with that increase in funding comes increased privilege in

her ability to choose how she expressed her agency.

 Calliope also commented on the resulting consequential inequities to science learning

due to underfunding school districts when she said,

In a suburban district, that's a regional school district, we get less money because we

don't get enough money for transportation, it has to come out of our operating budget.

And then we we're struggling to get computers for kids, we, you know, you would think, oh, that's easy. You know, kids have computers, but now we're using a parent's computer. That's not right, we should have every kid should have a computer that the district gives them. (Calliope, third interview)

While Calliope's school struggled to provide computers to every student, they also struggled to keep teaching positions because of tight budgets that must flex based on how many people are paying into the property tax of their community. So, if fewer community members paid into the property tax of the community, they needed to decrease school budgets and the way they do that is by not hiring as many staff, including teachers. Calliope expressed this when she said,

We have a good retention of teachers. Unfortunately, because we're suburban, and middle upper middle class, we don't get a lot of funding from the state. So, it's property tax funded. So, our budgets are really tight. So, it reflects on how many teachers we can keep each year. (Calliope, first interview)

Calliope and Deborah pointed out that not only do teaching resources like science supplies need funding, but that their very jobs depend on the funding and budgets provided for by their school systems. And, even when they do have a job, they are often spending a lot of time to precure resources, as is the case with Maya, or often decided to pay out of pocket for supplies and experiences they felt they needed to teach science in the way they feel is best. For example, Delilah expressed that she has made the decision to pay for supplies and resources in the past but said that she is now, "tired of spending another 50 bucks of my own money for materials. So, I'm not going to do that" (Delilah, second interview).

Teachers are having to make a host of agency expressive moves due to the monetary and budgetary context they are facing within their educational system. Teachers within this case

experienced a wide variety of socioeconomic situations and therefore their choices and options

for their science teaching agency vary as well. However, the teachers all expressed some of their

expressions of agency are influenced by science education funding when they described, (a) that

the very nature of their job depends on funding, (b) that they spend their own money to buy

supplies and items as needed, (c) that they participate in projects and experiences so they can

receive resources, (d) that they then share these resources with colleagues so others can also

teach science, and (e) they use their school and community allocated funds to buy supplies and

participate in professional development. These enactments of agency are influenced by the

broader system-wide influence of money and funding on the science teaching within the case.

Inequalities across the education system influence teacher agency. The teachers

expressed that their teacher agency is influenced by system-level educational inequities in

various ways—through concerns about inequities affecting student perceptions about science,

how elementary teachers teach science and how their time is utilized, and staffing within schools.

The way Deborah expressed her initial overall concern about the inequities within education she

said,

> Something that I have been thinking about more lately. Um, is the amount of inequity we
>
> have in our education system, both within my state, and within our country. I, I see my
>
> students struggling. And yet these are students who have so many resources. They all
>
> have internet access, they all have computers. Most of them have parents who are
>
> working at home because they're white-collar jobs. And so, it just boggles my mind how
>
> kids without all those things are managing. That's that weighs on me. (Deborah, first
>
> interview)

Deborah is a teacher that teaches in an affluent community and so she understood that if she saw the students in her community struggling, she understood that other students from less affluent communities must have experienced far worse conditions. The inequities caused Deborah to spend a lot of her time thinking about education as more of a system and she tries to do her part to change that system in her own small way. One way that she expressed her agency was through her hope that she can make even a small difference to these inequities by making her science teaching videos freely available online on YouTube (Deborah, first interview). Although she realized students without computers or internet access will still be unable to access her videos, it bothered her to be making these videos and then only have them available to her students that have more privileged access to her science teaching.

Student perceptions about science. The teachers discussed not only students' access to science learning, but they regularly expressed that they felt concerned that the students would leave their science educational experience with an inequitable perception of science. For example, the teachers expressed worry that since women are less visible in the professional science field that their female students would think science was not for them. Jane expressed it this way when she said,

> I would want to make sure that they're learning about both genders of scientists. And I do remember teaching third grade and it was, I was reading a lot of biographies of women and someone said, well why isn't there a men's history month? And so I asked them to name some inventors and sure enough, like, you know, Benjamin Franklin and Edison and they have all these male names and they couldn't name, a single woman I'm like, well, great, here's one. Let me tell you about her. (Jane, fourth interview)

Topics around gender inequity in science are topics Jane spent time helping her students consider during her science time. Other teachers might not recognize the inequity in science or might even ignore the inequity as they teach about science. However, Jane as well as other teachers chose to call out and addressed these inequities in various ways.

While Jane expressed how in one instance she addressed the gender inequity in science, Calliope also took an opportunity to address the inequities of underrepresented racial and ethnic backgrounds of scientists. Calliope needed to show a video to her students and so she made sure to select one that had a more diverse representation of young people in the video from various racial and ethnic backgrounds. She described this video selection in the following way,

> There were all different cultures all sitting around a table. And the two main characters, one was Hispanic, and one was African American. And they were solving a problem. And what I thought was great is that even my white kids are going to see different kids being able to do it. So in the back of their mind, they're not going to look at a brown or black kid and say, oh, they can't do it, because they're brown or black, or they're poor, or whatever. They're like, oh, I want to listen to them. Because, you know, this is good and it showed us so many different ways kids are thoughtful about solving problems. You're not negating someone's reasoning because of the color of their skin, which is exactly what systemic racism it. (Calliope, third interview)

Calliope took the opportunity to leverage her science teaching requirements to address systemic racism in this one small act of video selection. While Calliope and Jane chose to focus on different aspects of science and science education inequities, they tried to combat those inequities and the resulting student perceptions about science which required decisions based on what to discuss in class and what videos to present in class.

How elementary teachers teach science. The teachers also discussed the teachers' role as potentially adding to these systemic science education inequities. Delilah discussed the ways in which female elementary teachers (who are more prevalent in elementary teaching positions) might teach differently than male elementary science teachers and the resulting consequences from those teaching differences when she said,

> I think gender, though, also can inform our instructional styles. And we bring our own biases, to our instructional styles, just who we are, right, like we can't, that's just who we are. Um I'm. I didn't, I think I mentioned but it comes to my mind, again, that I'm concerned that especially an early elementary female science teachers might not give as much time to students for their own investigations, because they might want to help too much. And I also wonder if gender sort of informs the topics that we end up teaching.
>
> (Delilah, fourth interview)

In this excerpt, Delilah wondered if female elementary science teachers might be feeling the need to assist their students to such a degree that instead of supporting a rigorous inquiry process where the student struggles and constructs their own knowledge, instead they jump in too early, or jump in unnecessarily, to provide support for the student. Although she equivocated her wondering when she said, "I wonder," she was clear and expressed that this type of teaching style is perhaps a bias of female elementary science teachers and could potentially be a disservice to the students and their ultimate learning of science.

Although Amelia certainly spoke within the case about her concerns about inequities across the educational system, she also expressed that she did not have as much mental space or availability to spend professional resource time on science specifically because the extra time she spends on professional development she is using to learn about and consider anti-racism topics in

education more generally, not within science specifically. She said, "I'm not going to any seminars or workshops on it [science] right now. The seminars and workshops, I'm going to right now are all about anti-racism so that's that's kind of consuming right now but um" (Amelia, fourth interview). Amelia very honestly described that she has expressed her agency to use her professional development time to focus instead on anti-racism in education rather than on science as its own content area. Therefore, the current and pressing issues around inequity in education are being prioritized through the choice of professional development time over more narrowly defined science, or even science education-based inequities.

Staffing within schools. Delilah pointed out that she noticed that the female to male ratio of science teachers changes as the grades of those teachers increases. There are more female elementary teachers than male (Banilower et al., 2018), and

> As we move up through the grade spans that there are more and more males teaching maths and sciences, relative to how many women teach that. So? I'm concerned, like, for so many reasons, one concern is that students, my greatest concern is that the takeaway for students would be that males are better at math and sciences. (Delilah, fourth interview)

Delilah pointed out that for students just by seeing more math and science teachers who are male instead of female might cause them to perpetuate the bias that males are better or more suited to doing math or science or being mathematicians or scientists.

In the same interview Delilah expounded on her wonderings about the gender discrepancy within elementary science education when she said that from her own experience male elementary science teachers seem to be more respected. In her personal experience concerning one of the few male elementary science teacher colleagues she has she said,

There is a bias towards a male science teacher somehow to be more qualified, or somehow a better teacher, even at this young age. And that was coming from my colleagues, some of whom have been in the district a very long time. (Delilah, fourth interview)

Not only did Delilah wonder if female elementary science teachers are teaching their students in a less inquiry-rigorous way than the male teachers, that there are less female elementary science teachers than male ones, and she also noticed male science elementary teachers were treated as more of a science professional than a female science teacher like herself. Delilah was open to thinking about one's own gender and biases informing the ways in which we teach, and she was reflective about what those differences might mean for how science is taught. Yet, she also noticed the ways in which she, as a science education professional, was treated differently as compared to a male colleague.

The COVID-19 pandemic context influences teacher agency. The teachers within the case study expressed how the COVID-19 global health pandemic influenced their science teacher agency. The teachers generally describe these influences in three ways—as freedoms, as fears, and as frustrations. The context of COVID-19 greatly influenced this research as well as the broader system of science education. The teachers were able to deeply express the various ways in which the pandemic influenced their science teacher agency. It would be easy to assume that the pandemic only inspired fears and frustrations, but instead the pandemic also opened up new possibilities and new freedoms for the teachers concerning how they taught science.

Freedoms. The types of freedoms the teachers noted included releasing them of some standard expectations that had historically been in place, allowed them to prioritize student-based projects, and allowed them to give their students more autonomy.

The teachers described that in some ways the reactions by the schools to the COVID-19 pandemic released them of some expectations that has been in place just "because it has always been done this way" kind of argument. Maya described this freedom as the ability to now deprioritize some of the lesser effective system-level policies that had taken up significant time in the educational schedule. For example, Maya said, "COVID is taking the focus off of everything like the standards, testing, and assessments and we just want to teach and keep everybody alive" (Maya, fourth interview). Maya expressed that especially during the beginning of the COVID-19 pandemic, those expectations and mandated accountabilities could not be maintained thus giving the teachers more freedoms to do as they sought best during this time of educational upheaval. Maya expressed that her priorities changed dramatically to more basic concerns like health and wellness and less focus on mandates and policy requirements; a change which in some ways she valued.

Like Maya, Amelia also expressed that she enjoyed the increased freedom to prioritize student projects instead of taking class time to perform mandated testing and assessments. Amelia described her thinking this way when she said,

> There's a lot of testing that is required of the kids, and also the prompts need to be written and scored and all that but this fall. We don't have those restrictions, we cannot test the kids while they're at home. So, we are kind of freed up. And that feels kind of nice to be freed up to do whatever project deems important to our kids and right now. (Amelia, first interview)

Because of the logistical impossibility to assess kids while they are learning remotely from home, she took that opportunity to spend more time on student projects, which is time she enjoys, and believes is time well spent.

Delilah described liking the increased freedom afforded by COVID-19 in a bit of a different way when she expressed being able to give her students more autonomy over their learning. Delilah described this increased freedom to provide students with more learning autonomy when she said,

> So it's fun to be able to do that and not do it as like, actually, as part of the lesson [watching videos and content shows], but if they if they're [the students] curious, they can look at that. So that's, that's a freedom I think that COVID bought. That I could just put videos and content up there and they can access it if they like. (Delilah, second interview)

Delilah described that her increased freedom to provide resources to her students online so that they can access learning when and how they choose is a change from her teaching norm before COVID-19. She expressed that she enjoyed this change because she can encourage student curiosity based on their own learning desires. She expressed her agency by providing supplementary videos and content resources in addition to the curriculum she was expected to teach, and she expressed that she enjoyed the freedom to be able to do so, a freedom that was sparked by the COVID-19 pandemic.

Fears. Along with freedoms, the teachers also expressed fears related to teaching during the COVID-19 pandemic. Much of the fears they expressed related to the physical safety for themselves and their students including that others' lack of science knowledge increased the risk of contracting the virus, and that some of the fears stemmed around changing teaching duties and expectations.

Calliope described that she is concerned about the COVID-19 virus and felt justified in her concern because of her science background. She felt she has more knowledge about viruses

and therefore, can make a more informed risk assessment. She then went on to describe in depth
what she does to mitigate her, and her students', health risk when she described that,

My background is microbiology and virology. And I wear a mask, a shield, an apron.
And going back on Monday. I'm wearing gloves in every class. Have to, because I know
it's contagious. I know what contagious looks like and sounds like and how it manifests
itself. And it's invisible….The other piece was I eat lunch in my car. So, I put my coat on
and I go out, I sit in my car and eat lunch. Again, anytime you take off your mask and
you're in a group of people and you're eating it is high risk. Teachers don't understand
that. And there they were eating together in classrooms and I'm like oh my god oh my
God. Oh my God. It only takes one person. So anyway, but I'm not going to tell them that
that's their own health issue that's their lunchtime if they want to get and chitchat and talk
and do whatever, that's fine with me. So, I go to my car…. it was just like okay another
thing I got to do to keep myself safe because this building is not safe. (Calliope, third
interview)

Calliope expressed her concern with the possible health consequences of the COVID-19 virus as
well as her experience with the science of how the virus is transmitted. She suggested that the
non-science teachers are less familiar with the science of the COVID-19 virus and that explains
their behavior that Calliope felt is less safe. During another time in the same interview, she
continued to express her concerns about the health effects of the COVID-19 virus and this time
did so in a way that conveyed her concern that the governor of her state just doesn't seem to
understand how viruses are transmitted when she said,

Because you don't get we don't we don't have COVID in schools. The virus stops at the
door. As the Governor says there's no transmission in schools. The virus doesn't come

into the school. So yeah, apparently the virus knows it's a school and it turns around and

leaves. (Calliope, third interview)

Calliope expressed that she felt the teachers in her school as well as the Governor of her state did

not adequately understand the science behind the transmission of the COVID-19 virus. Calliope

relied on her science knowledge to help her make decisions to manage her risk, but she also

expressed fear that because of others' lack of science knowledge she was put at a higher risk for

contracting the virus herself.

Jane also expressed concern about the choices being made by others that affect the health

and safety of those in the school community. Jane expressed these concerns for the health of the

school when she said,

The people who are paying attention to the science and how things work are the ones that

are I don't know making better decisions about staying healthy, I would like to say where

everybody staying healthy is making those choices but that doesn't always happen but

um, yeah, I just feel like it can really. (Jane, Interview 4)

Jane chose to hope that other people make decisions that are healthy and will keep her school

community safe, but she expressed distrust that this will actually happen in practice. The teachers

expressed concern over their, and their students', health and yet still enacted her agency through

her decision to stay in the classroom and continue to teach science throughout the pandemic.

Deborah expressed fear around a different concern other than health. Because of the

COVID-19 virus, meeting staffing needs was a challenge in Deborah's school. Deborah was

asked to do a job which she is not experienced with—be a substitute teacher. When Deborah

wrote her reflection that week, she expressed trepidation about performing this staffing position.

She expressed it this way, "I will be doing some substitute teaching tomorrow on zoom. I'm

nervous about doing things wrong but looking forward to interacting with students again"

(Deborah, second reflection). Deborah, along with other teachers within the case were asked to

perform teaching duties that are not part of their normal, pre-COVID teaching expectations. This

demand for the teachers to be flexible and adaptable was an undercurrent of the expectations that

were highlighted during the COVID-19 pandemic. But the increase in expectations of flexibility

and adaptability often put the teachers in situations that they felt nervous or fearful about.

Deborah expressed her agency by agreeing to meet the expectations and teach as substitute

teacher, and she showed her resiliency by focusing on the part of the situation she felt positive

about—seeing the students again.

Frustrations. The teachers experienced increased freedoms and fears, and they also

experienced daily frustrations with having to mitigate and maneuver teaching around the new

logistics and protocols required to try to stop the spread of the virus, as well as frustrations with

the decreased time with the students directly. The challenges of teaching increased with the

arrival of COVID-19 and those challenges then increased the frustrations of the teachers in trying

to teach while they also tried to meet the new guidelines and requirements put in place to attempt

to keep everyone in the school community from acquiring COVID-19.

Delilah expressed that it was difficult to teach the kind of hands-on science that she

wanted to teach because the protocols in place to try to keep everyone safe were difficult to work

around. She wanted to be able to find a work around and keep teaching science the way she

thought it should be taught, but it was a frustration and tremendously difficult with the protocols

keeping everyone social distanced and hands off materials. Delilah expressed this frustration

when she said,

The safety things right. But does that affect my agency? Yeah, it really does. Because if I'm saying like I want to be the kind of science teacher who gets kids excited about science and I want them to have meaningful and hands on activities, and we literally cannot do that because the way our district has interpreted guidelines, federal and state guidelines. Another way of saying that would be our requirements for safety right now are impacting negatively impacting. But I don't I don't want to accept that either, because I want to overcome that. And it just means I have to do it differently. (Delilah, third interview)

Jane echoed Delilah's frustrations in trying to deal with the day-to-day realities of meeting the new protocols when she reflected on what makes it harder to teach science right now when she said,

Finding the time to gather/prep materials before each lesson. And even more: time to sanitize materials after use, then put them away the next morning before students arrive! Also, like everything else these days, maintaining COVID safety protocols [3ft or more distance when students want to go over to see what their classmate has done, etc.] is frustrating. The schedule changed last week, so my science time has shrunk to 30 minutes a few days per week, I had an hour window before, at 2:00 after specials, which we did not have before. This started on Friday and the transition & time of day were indeed difficult, and I had to set up elsewhere since students were in the classroom for art. (Jane, first reflection)

The frustrations of having to mitigate increased prep time to sanitize materials, enforce social distancing, and deal with changes in schedules and prep spaces were frustrations expressed time and again within the case. Jane was able to navigate the new protocols and realities by

expressing her agency so she was able to continue teaching and teaching science specifically. She found alternative spaces to set up, she took more of her personal time to prep lessons, and she tried to keep everyone safe. However, the COVID-19 protocols created increased workload, increased resiliency demands, and thus an increased level of frustration as expressed by the teachers.

Calliope expounded on one aspect of her frustration, the lack of time to transition between remote and in-person instruction. Calliope, in the third interview, said that she did not have enough time to transition her curriculum plans from in-person to fully remote when she said,

> We went fully remote last week, right? I had two working days to pivot to fully remote. I had to do the curriculum I had for face to face and do the best I could because it wasn't enough time. to to to switch that to a way. You know, I did it on the fly when I realized something wasn't working, I had to pivot. (Calliope, third interview)

Then, again in the fourth interview Calliope came back to this point of not having enough time to transition between in-person, hybrid, and remote teaching requirements but she also added that her administration does not fully appreciate how much time this took, and she was frustrated that she was continually asked to switch teaching modalities without enough time to properly plan for that transition. Calliope expressed this when she said,

> Well, they [the administration] didn't know that I we needed I needed time, not appreciating that I have a synchronous I have lessons that I've planned and as for a certain amount of time. And to pivot in less than 24 hours to do fully remote meant I had to, I had to supplement stuff, which I had in my back pocket because of my years of experience. But they are not appreciating that there was a pivot that I had to do and there

was time that I needed to plan for that. They just assume I could just do it at the snap of

my fingers. (Calliope, fourth interview)

The lack of sufficient time to prepare for the different necessary teaching requirements is a

specific example of a frustration Calliope as well as others expressed.

Deborah also expressed frustration with the COVID-19 situation, but she expressed

another aspect to her frustration, that she was not able to engage with as many students as she did

prior to COVID-19. Earlier in these findings the teachers expressed that student engagement and

interaction was a key part of promoting teacher agency. Due to remote learning during the first

year of the pandemic Deborah felt the frustration of not being able to engage and interact with as

many of her students. She explained it this way when she said,

The whole structure of remote learning is challenging for me. Students are asked to go to

a particular site at a particular time for science lab, but they don't all go for many many

many reasons. And if we were in school, I would have all the students. And if I say okay

now do this quick exit slip or a quick assessment at the end, I would get 100%

participation. And now I say, you know, I say okay go to my site, do my lesson, fill out

this Google Form and I only get about 50% of the students, sending in a Google form. So

that's frustrating that I'm reaching fewer students. Yeah, and I talked about how I don't

get to have conversations with them. That's hard. And I don't have my supplies, that's

hard we won't have a Robotics Day this year. So, I just, I just have to work with what I

think they'll have at home. A lot of challenges. (Deborah, second interview)

Deborah expressed frustrations at the challenges she had to mitigate because of COVID-19. She

navigated those challenges, but while she did so her frustration level increased.

The frustrations, along with the freedoms and fears, teachers expressed are part of their reaction, their enactments of agency, to the ever-changing logistics, protocols, and requirements that are part of the new system in which they work due to the COVID-19 pandemic.

CHAPTER 6

FINDINGS

TEACHERS' ENACTMENTS OF AGENCY WERE CENTERED IN SERVICE TO

THEIR STUDENTS

Another finding of this research was that the teachers enacted their agency in ways that prioritize serving their students. The teachers expressed that they were interested and willing to express their agency when they knew those actions would be serving their students in some way. In other words, the teachers expressed agency across the research but how they enacted their agency largely depended on how they felt their students would benefit from those choices.

The teachers expressed that they serve their students through (a) making changes to the classroom, (b) making professional decisions that ultimately serve their students, (c) use their teacher voice and choice to advocate for their students' science education, and (d) by promoting student agency. These findings helped to answer the research question, "How do K–5 teachers conceptualize and enact their own science teacher agency?" The teachers enacted their own science teacher agency largely in ways that serve their students.

Calliope stated this finding most directly and succinctly when she said,

So being an agentive teacher would mean that in the classroom, I need to pivot based on my students' needs…If we're not if we're not meeting our overarching goal for our students, then we need to take agency to that to correct it. (Calliope, third interview)

The teachers pivoted in a myriad of agency expressive ways, but they saw those pivots as ways of serving their student's need, and perhaps most importantly were willing to make those pivots not because they feel it is best for their own professional existence but because it is what they felt is best for their students.

To Serve the Students Teachers Make Changes to the Classroom

The teachers predominantly expressed that they make changes to the classroom through the sharing of new ideas they put into practice and engendering resources for their classroom's need. In this section of findings I focus on the expressions by teachers that communicated the ways in which they felt they were making these classroom changes for their students' benefit. The teachers expressed that from their perspective they were making classroom changes in service to their students primarily through the ways in which they share new ideas and engender classroom resources for their students. Other enactments of teacher agency that are in service to their students were numerous and will be discussed in detail later on in this chapter—that teachers frame their professional decisions for their students, that teachers use their voice and choice to advocate for students' science education, and the teachers promoted their students' agency. Yet, these enactments while ultimately expressed as in service to their students, were more implicit in how they served their students. The ways in which the teachers explicitly shared how they felt they made changes to the classroom were primarily through trying new ideas and resource acquisition.

Teachers share new ideas in the classroom to serve their students. The teachers shared that they had a mindset to try new ideas in the classroom that they felt benefited their students. The teachers talked about trying new curriculum ideas and lessons, or even trying new pedagogical ideas in their teaching.

Jane talked about trying a new lesson idea in her classroom when she shared how the current fourth grade students talked to their current teacher about the time they got to do experiments with ice cubes for a states of matter lesson with her two years ago (Jane, second interview). Jane remembered that that lesson "became a very big focus of the class so that was

kind of a successful new idea that really took off that I had never done before" (Jane, second interview). But what she also expressed was her enthusiasm that this was a lesson the students remembered, it seemed to serve her students, and thus that lesson has now become a standard part of her second-grade curriculum when she said, "I now do it in some way or another every year with second grade when I teach second" (Jane, second interview).

Calliope also shared that she tried new lesson ideas, and that she felt her students were able to actually learn the lesson because of her agency to make up a new lesson when she said, "I made up a whole new friction experiment, because the standard is for second grade rubbing creates heat…I was like, thank God I was able to do it because I didn't know any other way of doing it" (Calliope, first interview). Calliope enacted her agency to try out a new science lesson in order to serve her students with what she felt they needed in order to meet a standard for that grade.

Maya, instead of talking about a specific lesson, talked about creating a type of teaching pedagogy that she felt is a valuable way for students to learn. Maya expressed her willingness to try out new pedagogical ideas in her classroom when she said, "I think I invented project-based learning for myself before it was a term out there in the world" (Maya, third interview). Maya talked about the importance of project-based learning to teaching her students effectively and how engaging in project-based learning has now become part of the school community's expectations (researcher reflective memo dated September 24, 2020). But what is important to point out here is that Maya had enacted her teacher agency to try out a new idea in her classroom because she felt it was the best way for students to learn, in this case what she tried was a new pedagogical teaching technique.

Besides curricula and pedagogy, there were also many examples across the data of a general willingness to try out new ideas in the classroom because they have a mindset that serves their students. For example, Deborah responded to my question, "What do you hope your science teaching will look like in five years?" (Researcher, fourth interview) by saying, "I hope that I will continue to learn new things, try new things with my students. I always try to make my lessons, better" (Deborah, fourth interview). And, in an earlier interview Deborah said she had found success when trying out new ideas when she said, "I've been pretty successful with trying new things. Um, maybe I've gotten good at rejecting ideas that are not promising for my students" (Deborah, second interview). And, perhaps Deborah answered this idea most directly when she stated, "There are many ways to be an agent of change. A teacher can be innovative in their classroom, they can be an activist in their community, in their professional groups. What is it about the students being served?" (Deborah, third interview). Deborah expressed that she enacted her agency through innovative classroom ideas and that she felt that these acts serve her students.

Teachers engender resources for their classroom's need to serve their students. The teachers expressed how often they created, provided, gathered, or procured resources for their classrooms, resources that would benefit their students. The resources most often mentioned were supplies, materials, special learning opportunities, or connections with community learning resources. The teachers expressed that they used their agency to engender these supplies for their students' use within their classroom. They felt that providing these resources to their students was an important part of how they could utilize and enact their agency.

The teachers wanted to provide what they could for the benefit of their students. Even if they were not sure how many of their students were using the resource, they still were willing to

provide it just in case some students found the resources educationally stimulating. For example, Deborah talked about providing science lesson videos to her students via online modalities when she said,

> I'm glad that my students still have science lab, as part of their school experience. I know that they're fortunate to have that most elementary school students don't have a lot of hands-on science. So, even if only a small percentage of my students are doing them [i.e., the videos modeling science experiments she is making and providing to students] enjoying them learning. That's, that's still a bonus. So, I'm glad that, that, that, my experiments are available to them. (Deborah, second interview)

Deborah made the science videos without being told or requested to do so. She made them freely available to her students and made the links open resources for anyone on the internet to use as well. Deborah felt the video resource might support student learning and so she made the decision to make and provide these online resources for her students even though she was not sure how engaged the students were in the resource. Despite not knowing the depth of effectiveness of the resource she still expressed her agency to provide resources for the students in her classroom.

Another teacher saw it as an important part of her enactment of her agency to be a resource conduit. Amelia felt it was important to make sure her students were provided with resources from a local conservation/outdoor education center. Amelia expressed her agency to make sure her students were connected with these community learning resources and took the time and energy to reach out to the community learning provider to arrange for the resources to be provided to her classroom. She explained this when she said,

I have endless resources with [a conservation area] in our back pocket, providing,

especially this fall with remote learning going on. They have provided us with a ton of

resources per grade K to eight, and they've, they've just supplied us with a ton of science

resources, including virtual field trips including science kits that are coming to us really

soon I think ours are due to come next week to foster outdoor learning. Amazing. I mean

I've always had everything I could ever dream of here.

Although Amelia expressed that the resources came to her, she did need to make the effort to

make sure the resources were provided for her students in her classroom, they were not just

provided automatically. It took her expressing agency to make sure these resources were

provided, and she did so because she felt the resources this learning center could provide would

be to the benefit of her students.

Maya expressed that she provided physical materials so that her students could create

inexpensive birdfeeders to supplement the lessons she had been teaching on birds. Maya brought

over to the interview screen a birdfeeder she had made out of household materials and proudly

explained how she would be providing the materials to her students so they could create their

own birdfeeders. She explained it this way,

And because my science lessons are all touching upon birds in some manner I did this

whole thing on. I said we're not going to do a bird I want to do bird feeders and feeding,

what types of bird feeders there are and why feeding birds in the winter is important, and

I will thrill you with this. It took me a couple of times to find the right screen in my home

in order to have the right patience to create this thing [recycled materials bird feeder].

(Maya, third interview)

Maya's agency to decide the lesson needed to be supplemented with an activity such as birdfeeders, and then provided the materials for that supplemental lesson from her own home is conveying layers of expressions of agency. These expressions of agency were meant to provide the very best lessons she could for her students. The resources she provided for her students were for the learning benefit of her students. In other words, Maya's agency was expressed to engender materials for her classroom in ways that benefited her students.

Teachers Frame Their Professional Decisions for Their Students

Just as the teachers expressed enacting their agency in ways that served their students by trying out new ideas and providing resources for the classroom; direct ways of serving their students, they also expressed serving their students through their professional learning decisions and their mindset about their science teaching professionality; more indirect ways of serving their students. How a teacher enacts their professional learning decisions clearly affects the classroom and thus their students. The teachers were serving their students through their own learning and professional identity as a science teacher.

Science teacher agency is enacted through professional learning experiences. One principal way the teachers expressed their agency was through their choices and actions concerning professional learning experiences. What professional learning experiences they attended and what they did with that experience are expressions of agency they shared. For example, Maya talked about her experiences around professional learning when she said,

> Well, some things [in professional development] are fun and worthless. And some things
>
> are make me think, and I can I can implement them in my classroom, like talk
>
> science…It's just like anything I go to. I go to things and I'm always watching for what's

new and what's valuable, and they're willing to bring it back and share it. (Maya, first

interview)

Maya was highlighting that she felt that professional learning has various levels of resonance to

her professional development but that when she does find something valuable, she brings it back

to share her learning with others. Maya also expressed that she believes she can implement the

learning she deems valuable. When the learning is effective for her, she can implement that

learning in her classroom. She served her students through her expressions of agency by

attending learning experiences and then bringing back that learning to her school community.

Calliope also brought up the importance of professional learning in her role as a science

teacher when she responded to my question, "What has helped you become a science teacher?"

(Researcher, first interview) with, "I would say the professional development that I've done on

my own… I think itself, myself, my professional development that's got me where, you know,

ideas and stuff. Yeah (Calliope, first interview). Calliope went on to say that she often has had to

find her own learning experiences, and "have had to make it up as we go along" (Calliope, first

interview). Calliope interestingly doesn't just mention that the professional learning experiences

have really shaped her role as a science teacher, but she also included the nuance that she has

done this learning on her own. Calliope highlighted that as the school's only science specialist

she is isolated from other faculty members even when participating in professional learning,

learning which she has had to find on her own. Finding one's own professional learning

experiences is an example of an expression of agency—it shows the level of commitment she has

towards her own growth as a science teaching professional and how these experiences build

many of her ideas she then shares with her students.

Deborah also mentioned not only the importance of professional learning to her but also that she too has had to find these learning experiences on her own, and how the ability to make the decision of what learning experiences she does engage with is her decision. She valued the autonomy of having a say in what her professional learning looks like when she said,

> I feel I feel agentic quite a bit in my in my current school, I feel that my administration is very supportive, and encouraging of me and others. I feel like I get to make a lot of decisions about my curriculum about my teaching methods about my professional development…I enjoy going to conferences...I really enjoy going to meetings, and both taking the workshops and networking with people and learning about different resources that are available I really, that sort of energizes me I like to do that…I connect with people on Twitter...I occasionally do webinars on my own. (Deborah, third interview)

Deborah made decisions around her professional learning and expressed that this agency is something she takes pride in as part of who she is as a science teacher and thus how she serves her students.

Science teacher agency is enacted from a mindset and attitude. Another way that the teachers expressed that their professional agency decisions serve their students is around their mindset and attitude about science teaching. The teachers expressed that they saw their role as an agent in the classroom and that their mindset and beliefs affected their students and the classroom environment. The teachers described that part of the way they enacted their agency is from their mindset about their role as a science teacher and that role as a teacher is a consequential act that serves their students. For example, Delilah across interview three outlines how she considered her agency and her mindset about her role as a science teacher to be

connected and consequential to how she can serve her students. Delilah first described how she conceptualized her agency when she said,

> So, to me being an agentive instructor having agency lies in between those two extremes, like coming up, like being completely creative, like creating your own materials curriculum, agendas. And simply delivering what [the school district] says to? Yeah, it's probably a good spot to be. I think it allows allows the agent to a little bit of room for pivoting if your students need more time with the vocabulary today, we can do that. I don't have to, or, oh, they've got this so I'm going to fast forward through this section. But, still it's the mandate of delivery, I think that's that's inclusive in being agentive or being an agent. That's how I interpreted it. (Delilah, third interview)

Delilah saw her role as a science teacher as negotiating the extremes between complete autonomy and complete scripted regurgitation of mandated curriculum. But what is also important to point out that this excerpt makes clear is that this negotiation is in service to her students' needs. She was willing to pivot and negotiate the way the learning is delivered based on what her students need in that time and space. Delilah's mindset about being able to negotiate the learning delivery results in expressions of agency that pivot to the needs of the students.

Delilah is a good example of how deeply the mindset of the teachers plays a role in their professional decisions because she went on to say that she likes having a role as a professional science teacher. She described how she sees this role and then went on to say that she also liked having this role as a science teacher that uses their agency to serve their students. Delilah described it this way when she said, "I like being an agent for change for my students, I think that's, it's something that's a phrase that I do hold in my head a lot, because I want to provide them opportunities for growth" (Delilah, third interview). Delilah saw her role as a professional,

not just to be a professional in her own right, but because the way she enacted that agency allowed her students to grow and change. Her mindset about her agency serves her students, not her, but her students, with an opportunity for growth.

Delilah summarized the lens through which she saw the connection between her professional mindset and her agency when she said, "So my mind what I'm trying to say is my mindset has a lot to do with agency…I think I think my own attitude. Because really, really, really long way towards shaping what I think about my agency" (Delilah, third interview). Delilah's professional attitude and mindset affected how she enacted her agency, which in turn affected how she served her students. Delilah was acutely reflective about a connection between her professional mindset and her agency. She could not only describe how she conceptualized her role as a science teaching professional, but she was also able to describe how that agency was enacted is in part how it was coupled to her mindset. That mindset in turn shaped her ability to serve her students through her expressions of agency. Delilah represented the teachers within the case and how they described that part of their professional decisions, their expressions of agency, are the decisions concerning their mindset and attitude as a science teaching professional.

Teachers Use Their Voice and Choice to Advocate for Science Education

Another aspect of the teachers centering their agency in service to their students is the way in which they enact that agency through their voice and choice to advocate for their students' science education. The teachers expressed their desire to serve their students by advocating for their students' right to a science education. The teachers expressed their expressions of agency through their advocacy for their students' science education in many ways—for certain curriculum and learning experiences for their students, for implementation of standards, for resources and support, and for the time to teach science. Science education

advocacy is an additional way that the teachers described enacting their professional science teaching agency in ways that serve their students.

Deborah described the importance of her science teacher advocacy when she said,

I feel glad for our students that we have a dedicated science lab and that we have a person who doesn't just teach science but also advocates for science [her position] so I always try to advocate for more time and more resources. And, Yeah, I make sure that science doesn't get forgotten. (Deborah, first interview)

Delilah described her science education advocacy as having importance even beyond the walls of her classroom when she said, "I do advocate for science education. And that might not necessarily be education in the classroom, but education that's accessible to all students in different ways" (Delilah, fourth interview).

Calliope advocated to her administration for more time to teach science education, to serve her students at the expense of her own personal comfort when she said,

I pushed our principal to make science, and all the other related arts 40 minutes versus 30 minutes because they [the teachers] wanted to change it. And we were the only elementary school doing that all the other elementary schools were 30 minutes and I told the other teachers in the other buildings, and they really didn't advocate for that. I advocated for that and had less time in between classes to disinfect and get myself and mask break and all that for myself, because I thought it was that important. So, um, I think the teachers appreciated that I advocated and pushed for that. (Calliope, fourth interview)

Calliope attempted to advocate for science teachers within multiple buildings so that their students could have more time for science education despite the COVID-19 schedule truncating science time.

Amelia advocated for a specific science curriculum, Mystery Science, be continued at her school after she trialed the water cycle lesson provided by this science curricula program. She said, "I will definitely do the water cycle process again, that same Mystery Science if we have it available. I'm hoping it will still be available. I will definitely become a loud advocate to get that into our schools" (Amelia, fourth interview). Amelia made a professional decision to advocate that this program be available to her students and that professional decision is an enactment of her science teaching agency in service to her students.

Unlike Amelia, Deborah is not advocating for one particular curriculum, instead she points out her advocacy is more widespread and included advocacy for science education standards and science learning experiences for her students when she said,

> When the NGSS standards were first announced I was the person who brought it to the attention of the administration. I was the person who guided our school on its transition and implementation. I am constantly advocating for events, science fairs competitions. Yeah, things like that. Yeah, I definitely advocate.

Deborah listed the ways in which she advocated for science education for her students and described that this advocacy is multifaceted and part of her professional science teacher identity, advocacy that serves her students.

Maya described her commitment to advocating for her students' science education most succinctly when after I asked, "Do you feel like you advocate for science education in your

school?" (Researcher, fourth interview) she replied, "Oh, God. Yes. Yes" (Maya, fourth

interview).

Whether or not the advocacy is for a particular curriculum, or a standard, or time for

science in the schedule, or other learning experiences, the teachers described that they enacted

their agency in ways that made their professional decisions serve their students.

Teachers Serve Students by Promoting Students' Agency

Another professional decision teachers made to serve their students is to use their agency

to promote their students' agency. The teachers felt that it was important for them to make

professional decisions that then promoted their students' voice and choice thus guiding their

students into enacting their own student-based agency. The teachers described the importance of

using their teacher agency to promote student agency in the following ways.

Delilah called out what she saw from other elementary science teachers, teachers she

describes are often female, as interrupting a student's learning opportunity by trying to help too

much when she said, "I'm concerned that especially an early elementary female science teachers

might not give as much time to students for their own investigations, because they might want to

help too much" (Delilah, fourth interview). Delilah felt that it was important for teachers to allow

the students space and autonomy to be in the most effective learning environment. Delilah was

willing to make professional decisions so that her students are given the opportunity to build

their own agency in ways that will support their science learning.

Deborah seconded Delilah's belief that students should be supported in ways that support

a student's own autonomous learning process. Deborah described how teachers can and should

use their agency to promote their students' agency when she described agentive teachers as a

"teacher who gives their students options, and gives them the ability to feel that they have some

control over their learning process" (Deborah, third interview). Having control and options over the educational process was something the teachers expressed at length as something they valued for themselves (and has been discussed in the previous chapter), a way that they felt teacher agency could be afforded. However, the teachers also expressed that using their agency, their own control and options, is valuable in order to help their students feel these same motivations.

Amelia described how important it is to use her agency to promote her students' agency because as a teacher she can learn a lot from her students, and they can, in turn, learn a lot from each other if they have the agency to make actions within the classroom learning environment. Amelia described it this way,

> I believe that a teacher has to be open to her students too, and that you can learn a ton because that has just, it's totally changed the way I teach about birds. And that came from the student. And how beautiful is that…I have to trust those students who have a grasp of this, and I'm going to trust them to become the teachers to each other. And hopefully they're going to come up with some ideas that are going to help Susie or Bobby Joe or whatever, you know, come up with a question that can help them and already I feel like there's a sense of trust, after five days of being with them. (Amelia, first interview)

Amelia communicated that giving her students trust is an important part of being an effective science teacher, that trust allows her students to engage in the science learning process in ways that would be impossible if she was the only one with the agency to direct the learning that happens in the classroom.

Amelia also mentioned that along with the importance of promoting students' agency for the learning potential of herself and the other students, she also made the comment that the process of promoting student agency is "beautiful." By saying that it is beautiful when students

have agency over their science learning she expressed that she valued students enacting their own agency. Amelia made professional decisions in such a way as to use her own agency so that her students felt empowered to enact theirs.

Again and again throughout the case the teachers centered their agency in service to their students. Delilah clearly summarized the findings that teachers center their agency in ways that serve their students when she said,

> I'm an agent of change. I'm a vector for the change, I'm opening opportunities for change. I'm bringing information to my students that can change them. So, I'm raising their awareness [of science]. And I I do that I know I do that in different ways in the classroom all the time, right. (Delilah, third interview)

Delilah and the other teachers within the case are reflective that they make a difference in the classroom, that they are the ones creating opportunities for change and transformation. Yet, it is important to note that desire for change is centered on impacting the student's experience in positive ways; the teachers deeply described that they enact their teacher agency so that students' lives can change, and their awareness of science can be increased.

CHAPTER 7

DISCUSSION

TEACHER AGENCY SERVES STUDENTS BUT DEPRIORITIZES THE TEACHERS

Teachers' agency is expressed in service of their students—even if that deprioritizes or depowers the teacher's goals for their professional self. The teachers expressed how they enact their agency largely to meet their students' needs and goals (see chapter six of this dissertation). The teachers described through their own examples what Gurba (2021) referred to as the American preference for teachers that offer themselves up as tribute for their students. There is a standard for teachers to act saintly and to always be giving which, results in a viscous cycle of disempowerment (Dunn, 2020). Interestingly Gurba (2021), along with the teachers in this research, identified that perhaps the belief that acting as tribute for their students is rooted in stereotypical gender roles and norms.

When Delilah mentioned in the fourth interview that, "I'm concerned that especially an early elementary female science teacher might not give as much time to students for their own investigations, because they might want to help too much" she pointed out her concerns that perhaps because so many elementary teachers are female, with their associated gender norm standards to be helpful and self-sacrificing, they jump in too quickly to assist their students which can take away from the learning opportunities for those students. Although Delilah is pointing out that helping too much on the part of the teacher disempowers the student, Gurba (2021) focuses on how the gendered standards of the teaching profession disempowers the role of the teacher as well. A self-sacrificing standard as the norm for teachers, "exists because, like nursing, teaching is a feminized profession with moral expectations dictated by fucked up gender

norms" (p.1). Gurba and Delilah are considering the genderedness of the teaching profession and the ways in which gendered standards affect the educational system.

Delilah brought up her wondering about the influence of gender on science instruction when she said, "I think gender, though, also can inform our instructional styles. And we bring our own biases, to our instructional styles, just who we are, right, like we can't, that's just who we are" (Delilah, fourth interview). However, Gurba (2021)'s article goes on to call on the educational system to step up and stop encouraging or even allowing teachers to play a self-sacrificing role no matter their gender. Instead of teachers being praised and honored for self-sacrificing their own needs and goals the system needs to praise and honor teachers, administrators, communities, and a system that works against these perniciously flawed loyalties.

The teachers engendered resources for their classroom that they felt would be in service to their students. These resources were sometimes materials they found around their own homes, or resources provided by community learning partners, or resources they made and provided online. But what is important is that the teachers expressed that they felt these resources were important for their students and thus they were willing to make enactments of agency, even at their own time and expense, in order for their students to get access to these resources. Teacher agency is often expressed in such a way that provides resources to the classroom for the benefit of their students, even if that expression is at a "cost" to the teacher.

Teacher voice and choice important. Calliope pushed back against these self-sacrificing standards and also called out that "the good-educator-as-unflinching-martyr trope is being used to shame those of us who express concerns about IRL [in real life] instruction" (Gurba, 2021, p. 1) when she sarcastically mentioned during interview three that the Governor of

her state seems to think the COVID-19 virus stops at the school house doors. Calliope felt she had a strong understanding of how viruses work because of her background in microbiology and virology (Calliope, third interview) but that those in positions of power and authority are using teachers' desire to serve their students, often in martyred type ways, in tactics that continue to put them at an increased physical health risk. Calliope sees that as part of her role as Vice President of her teacher's union is to enact her agency by,

> speaking up and making things a priority, and being attentive to the issues of that moment, and making it important. On the other hand, I think others might think of it as someone who's stirring the pot or, not complaining perhaps, but making more work for me....as a VP of my union, I sometimes have to go in there to say, hey, you know, this is a problem for my teachers. (Calliope, third interview)

But, then again, just as Calliope is speaking up for teachers as a leader within her teacher's union she is also continuing to enact her agency in ways that serve her students to the detriment of her own personal well-being when she mentioned in interview four that "I advocated for that [more science instructional time] and had less time in between classes to disinfect and get myself and mask break and all that for myself, because I thought it was that important" (Calliope, fourth interview).

Perhaps what Calliope is pointing out is that voice and choice are an important part of a teacher's professional life. Just as giving voice and choice to students is seen as an advantageous and effective way to teach science (Laux, 2018), Calliope is pointing out is that she would like her voice, as the teacher, to be considered and the choices that she makes through that voice to be supported as well. When she speaks up and says that it is a priority to have more science teaching time, or makes the choice to spend less time on a mask break so that her students can

get more science teaching time, she is expressing her agency in consequential ways. However, for that agency to be most influential her voice and choice must be supported by the system in which she works.

Purdy (2013) underscores what the teachers within this case expressed, that teachers are agents of change, but they need to consider themselves agents of change and be given the autonomy to make enactments to be that change. Listening to the voice of the teachers is then a critical part of conceptualizing teacher agency theoretically and understanding how teachers choose to autonomously make those changes in practice. Science teacher agency seeks to critically shape responses to problematic situations (Biesta & Tedder, 2006, 2007; Emirbayer & Mische, 1998), so science education researchers need to center the teacher voice, in all of its complexity and contextuality, to understand why teachers make the choices they do.

The teachers in this research expressed the ways in which they felt their agency was afforded, the ways in which it made it easier for them to enact their agency, and what the meaning from their discourse communicated was that having the autonomy to make decisions and the support from administration once those decisions are made were crucial for teacher agency to be enacted habitually.

Stigma for teachers to express agency for self. Perhaps one of the ways in which the science education system can help to support teacher agency is by calling out the stigma for teachers to express their agency in self-serving instead of self-sacrificing ways. When teachers use their "teacher voice" for their students that voice is praised and honored. But, when teachers use their voice for teacher-based interests, needs, and goals those voices are often considered to be "stirring the pot and creating more work" for others (Calliope, third interview). Instead, of being seen as annoying pot-stirrers, these voices could be considered voices that are crucial to be

heard so that the foundation of our educational system, the teacher, is well supported and appreciated so they can do what they need to do, for themselves as professionals, but also in turn for their students.

The teachers within this case spoke up time and time again about how they enacted their agency in ways that they felt was in service of their students. However, if the teacher is not supported in *their* needs and goals, and the educational system continues to prefer teachers that act as tribute to their students, ultimately, we are left with the current neoliberal system that doesn't serve those that serve the students (Bartell et al., 2019; Gurba, 2021). Thus, teachers continue to give themselves away until nothing remains and they are forced to leave the profession, as they are doing in droves (Carver-Thomas et al., 2021) especially in hard to staff teaching positions like science (Floden et al., 2020).

How Agency is Conceptualized by Elementary Science Teachers

The teachers within this case primarily conceptualized agency through their descriptions and expressions of how they operationalized agency. The teachers described their agency cogently and thoroughly and they did so by describing what actions they took and why they took those actions in order to critically shape their responses to problematic situations (Biesta & Tedder, 2006, 2007; Emirbayer & Mische, 1998). In the process of discursively expressing their agency, the teachers made it clear that although they did not initially use the term "agency" they did describe agency by using other terms, descriptions, and examples. In other words, the teachers did not coherently use the term "agency" especially in the beginning of the research process, but they did communicate their meaning of agency by engaging in long-term co-generative dialogues with myself as the researcher.

By centering the research around the teachers' discursively expressed agential saying, being, and doing (Gee, 2010) across four co-generative interviews per teacher, the ways in which they conceptualized agency became clear, they communicated their meaning of agency without initially being aware of the term itself. The teachers expressed that, to them, agency is threaded through their beliefs, their identity, and their actions. They feel that agency is influential and consequential, but they often do not label, name, or speak of their agency. They were rarely given the space to reflect and consider their agency and thus enact their agency without knowing the ways in which agency is generally considered and conceptualized within a theoretical framing. Elementary science teachers deeply utilize and operationalize their agency, but they rarely theorize about it.

As the teachers described, expressed, and enacted their agency in discursive ways, their focus was on the classroom and their students. While science education researchers use a scale to consider agency that is more systemic, the teachers consider their agency on a more narrowly defined scale, the classroom.

Agency Influencers. Although the teachers within the case did not readily use the word "agency" itself, they were able to clearly communicate what they felt both affords and constrains their expressions of agency (Figure 5). The influential factors of expressions of agency were numerous, nuanced, contextual, and consequential. Although I have listed the influential factors as independent factors that influence teacher agency, it is important to note up front that the influences on teacher agency are clearly intertwined with one another. The threads of influential factors on teacher agency cannot be thought of as wholly separate, but what is important is what the teachers expressed as influencing their agency, and the ways in which they prioritized and highlighted those influences.

Figure 5

Agency Influencers
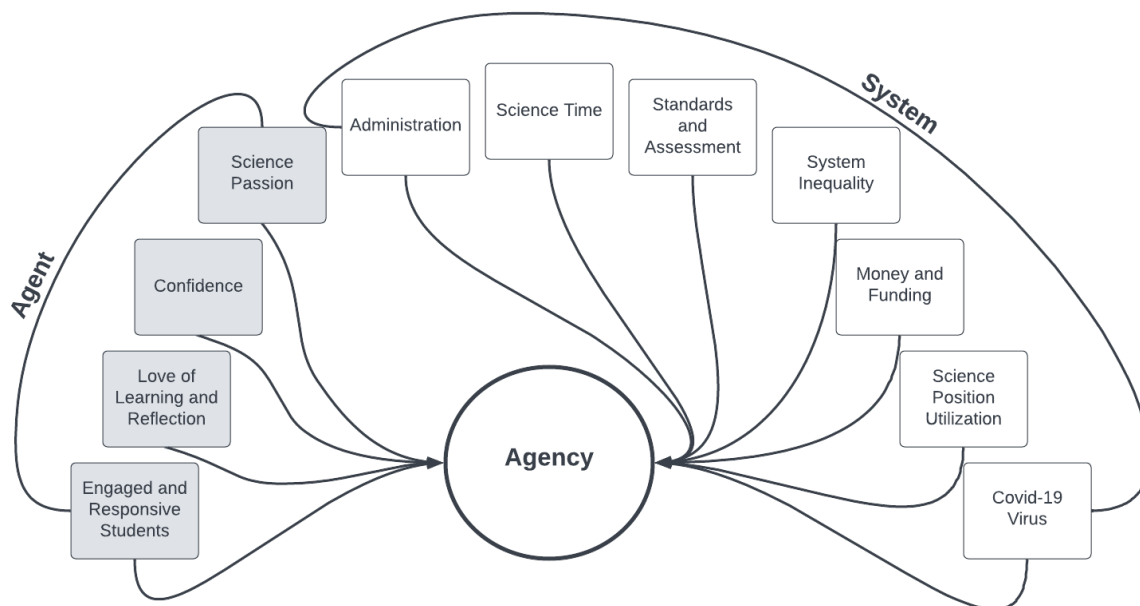
What is important to point out though is that not all of these influences were expressed

with the same level of prominence or with the same type of influence on their teaching (with

engaged and responsive students, administration, and science time expressed as increased

influences and therefore discussed first in the following sections); and the teachers talked about

the influences in two categories (personal dispositions of the agent and structures).

It is important to note that agency is complex and complicated in part because all these

influences thread through each other in various ways. Although in Figure 5 I have shown direct

arrows from the influence to agency directly and unidirectionally, and I describe these influences

individually, ideally this figure would be drawn as a complicated web with arrows linking,

looping, and threading all of the influences together. Due to the nature of this study and the tacit

ways agency is expressed this is one constraint of this visual. As the teachers described,

influences on agency are not each in their individual vacuum of sphere of influence, they afford and constrain each other in both patterned but also moment-to-moment ways based on a host of complexity and contextuality.

As agency becomes more and more theorized and schools of thought emerge across the field of science education research, considering the teachers' conceptualization of agency around the more myopic scale of the classroom can provide researchers with more emphasis on the personal lived experiences and thus the humanity of those they are researching. When given the opportunity and the space to consider and reflect on their agency, the teachers have a clear sense of their agency, what affords it, what constrains it, and can describe how they enact and express it. A valuable perspective to consider as agency is more and more theorized in the science education research literature.

The structure-agency dialectic was emphasized within teachers' conceptualization.
Although I conceptualize agency through a more ecological theorization of agency that sees agents and structures as indiscriminate from one another (see chapter two), the teachers conceptualized agency through a structure-agency dialectic that ultimately influenced how they enacted their agency.

The structure-agency dialectic is a common narrative within science teacher agency research (Archer, 2003; Giddens, 1984; Rivera Maulucci et al., 2015). The recursive relationship between structures and agency is referred to as a dialectic to highlight the back-and-forth interrelated nature that exists; the agent affects and is affected by the structures and system, just as the system and structures are affected by and affect the agent (Archer, 2003; Giddens, 1984). Although this conceptualization considers that structures and agents are so intimately intertwined as being unable to be considered without the other (Doty, 1997); individually intertwined and

interrelated entities, not entities that are indiscriminately separate from one another. Within the science education research literature agency is critical as a phenomenon because it contributes to the creation, recreation, and transformation of social structures (Hays, 1994). Agency is made possible through social structures at the same time as it is limited within the bounds of structural constraint; the capacity of agents to affect social structures varies with the accessibility, power, and durability of the structure (Rivera Maulucci et al., 2015). Currently structural barriers to teacher agency remain and teachers are often considered to be implementors of policy instead of professionals that express their agency to make changes to the systems in which they work (Liou et al., 2019). Material, cultural, social, and symbolic constraints diminish the status and priority of science teaching (Rivera Maulucci et al., 2015). Structures that affect the capacity of teachers' agency can be material (layout of classroom, technology available, textbooks chosen, etc.); social (norms and patterns of relationships in schools); or knowledge structures (how schools organize information into subjects, curricula, and standards).

What is significant in these findings is that the teachers describe the structures and agents as influencing one another but that they are discriminate from one another, and that the structures feel outside their control and are instead more influenced by the administration than the teachers. It is more difficult for teachers to enact their agency in structurally transformative ways if they feel that those structures are separate, discriminate, from themselves as agents, and that those structures are powerful entities that perhaps are best changed by others that they consider having more power and influence (i.e., the administration).

Jane herself described the intertwined and influencing (yet not indeterminate) nature between structure and agent when she said,

the [agency] constraints are the amount of that word autonomy that your administration gives you but also I think probably self-confidence enters into there and just feeling like you know what you're doing and your decisions are valid enough to go ahead and make them without having to check in or get the okay from somebody. (Jane, third interview)

In this excerpt Jane not only described the way she sees structure and agent as concomitant factors that affect each other, but this excerpt also includes one of the major aspects to her structural reality that she feels influences her science teacher agency and influences the structures she must work within, a reality though that is out of her control—her school's administration.

Perhaps this structure-agency conceptualization is why the teachers focused so much energy on describing the influence of the administration on their science teacher agency, because they see the administration as the more influential factor that can transform educational structures. Rather than see themselves as equally powerful to transform those structures, they conceptualize their agency as affecting the classroom and the administration's agency as affecting the broader structures they work within. This conceptualization therefore has powerful implications for how teachers envision possibilities of enacting transformative change within the science education system, and implications for considerations to leverage a shift in their conceptualization so that they theorize their agency as equally powerful, indiscriminate from, the structural factors they engage with.

Interestingly the factors that the teachers described as influencing their agency were expressed as similar influential factors despite the professional lived experience differences. In other words, teachers that taught in rural schools discussed the weighty influence of their administration just as did teachers who taught in schools in rural locations. The same was true of

teachers from schools that were located in communities with higher and lower socioeconomic backgrounds. Despite the various configurations of locations, the teachers expressed that administration was heavily influential to them expressing agency.

Teachers' use of the term agency shifted over time. Perhaps part of the reason the teachers were able to conceptualize their own agency so readily and completely is because they were given time and space to do so. The teachers used and reflected on the term "agency" more readily over the time of the research process resulting in reflections and considerations about the meaning of the term and how they utilize the term. The teachers began to consider theorizing their agency as the research process went on. By taking part in the research, and because of their growing awareness of agency, and their agency in particular, they expressed that they now planned to take more action within their science teaching practice. Their enactment of their agency clarified and increased over the time of being a research participant.

As a reminder of an example that demonstrates this, in an email to me Delilah reflected that through the process of this research her practice had changed, and she realized she needed to advocate more strongly for science education in her school and district if she wanted to see the changes she wanted. Delilah described her reflective practice even including the term agency in her reflection and saying she now knows how she wants to proceed to make those changes when she goes back to being a science teacher (Delilah, Electronic mail September 22, 2021). By being part of this research Delilah was given the time to consider agency in general, her agency more specifically, and that time generated in her a desire to consider ways of moving into action to make changes she wants to make in the future. Delilah expressed the idea that agency can involve the idea of projection and implies anticipation (Cuzzocrea & Mandich, 2016) and that by giving her the space and time to reflect on her agency, that influenced her agency.

Maya described that by reflecting about agency over the research process, her teaching practice was "brought into focus" and she is "able to see things with more clarity because [she] seldom stops to examine" (Maya, fourth interview) what [she] does as a science teacher. Maya communicated that the research process changed her thinking about her science teacher agency by giving her the time and space to consider her agency, giving her the language to consider her agency, and centering her voice throughout the process (Maya, fourth interview). By having the time to be reflective and be heard in those reflections, she was able to clarify her science teaching practice in ways that would not have been possible without that time and justification to do so.

Just as reflection has long been seen as an important part of a teacher's becoming (Cubero-Pérez et al., 2019), science education researchers have theorized that reflection is also a part of agency (Hinostroza-Paredes, 2021; Leijen et al., 2019). By giving the teachers the time and space to reflect on their agency, and by centering their discourse about their agency, the teachers were able to constructively determine how they conceptualized agency. By participating in research designed in such a way as to center the teacher experience and voice, the teachers were able to practice what Windschitl (2002) termed constructivism in practice, meaning they were able to start to negotiate the dilemmas they faced and consider the ways in which they would like to try to solve or transform those tensions. In other words, the teachers use of the term agency evolved over the research process, and therefore the way in which they constructed their practice therefore changed as well. By becoming aware of their own agency, their capacity towards transformative autonomous social action, the teachers' practices evolved as well.

Agency is Expressed Moment to Moment

Currently the field of science teacher research often considers agency to be expressed as a binary, as either a transformative or a reproductive way (Engeström, 1999; Laurendeau & Sharara, 2008; Rivera Maulucci et al., 2015; Sewell Jr, 1992). Agency is ultimately considered to be transformative of the system in which the actions are made, or reproductive of that system. However, the teachers within this case described a different way of thinking about the consequential nature of enacting agency. The teachers described agency as being enacted in moment-to-moment problem-solving expressions with very little consideration if the system would ultimately be transformed or reproduced.

The teachers expressed that their agency was expressed on a classroom scale and enacted in service to their students. Determining their students' needs and goals was the undermining factor in how agency was enacted; needs and goals based in moment-to-moment considerations. The teachers expressed that instead of predetermining their agency to either be transformative or reproductive on the system in which they work, they expressed their agency in ways that prioritized the ways their students were affected by their agency enactments. The teachers did not express that they had an agenda about the outcome of their agency as perhaps transforming or reproducing systemic change in education. Instead, the teachers' agenda on the enactment of their agency was in moment-to-moment consideration for how it will affect their students.

As Delilah described it, her focus on what she is trying to do, the reason she enacts her agency, is to bring to the fore STEM education opportunities for her students (Delilah, fourth interview). In this excerpt Delilah described that she was acting in the moment to arrange virtual field trips with a local not for profit organization that she felt could provide effective science learning experiences for her students during the educational disruption of COVID-19. She did not express a consideration that these actions were ultimately going to transform or reproduce the

education system. Instead, Delilah is enacting her agency in a moment-to-moment way so that her students' needs will be provided for.

This kind of moment-to-moment enactment of agency puts the prioritized perspective more on a short-term how the students will be affected perspective and less on how the system is to be potentially affected from the enactment. The science education research body of literature often frames agency with transformative and reproductive outcomes (Engeström, 1999; Laurendeau & Sharara, 2008; Rivera Maulucci, Brotman, & Fain, 2015; Sewell Jr, 1992). Whereas the teachers describe their agency as a moment-to-moment enactment based on the needs they see in their classroom.

Problem solving student needs prioritizes teacher agency. Of the needs they see in their classroom, teachers commonly orientated to problem solving students' needs as their prioritized reason for enacting their agency. The teachers expressed their agency in ways that they saw as helping to problem solve their students' needs; they were largely not trying to problem solve the needs they saw within the system of education. The teacher's priority is on problem solving to meet student needs in moment-to-moment ways, on a classroom scale.

The teachers expressed their agency in ways that problem solved the amount of time that science got in their classroom schedule, the science resources and perspectives available to their students, the science-based pedagogical and curricula decisions they made to meet their students' needs, the professional learning experiences they felt would best serve their classroom needs, and ways in which they felt they needed to adjust their classrooms to keep their students safe in lieu of the pandemic. Teachers have long been considered skilled problem solvers, Joyce and Harootunian (1964) described teaching *as* problem solving; that the act of teaching is a series of problem solving acts. More recently, Songer (2021) calls out the imperative for science teachers

to train a new generation of problem solvers thus, setting up teachers as the ultimate models of problem solvers. To teach how to be a problem solver it seems necessary to be adapt at being a problem solver yourself. The teachers within this case seem to have identified with their role as a problem solver and enact their agency in ways that problem solve what they identify as their students' needs. In their moment-to-moment enaction of their agency the teacher priority is therefore not on whether their agency is going to be transformative or reproductive, but instead whether their agency will solve the (often student-based) problem they see before them.

Pervasiveness of the administrative role in teachers' expressions of agency.

I highlight that the teachers described that for the administration to promote science teacher agency most effectively, the administration needs to leverage the competing attributes of actively supporting by providing resources, assistance, or guidance *and* leaving the teachers alone to utilize their own autonomy. The teachers described this dual nature of what they need from the administration. Sometimes they need to just be left alone to do what they do, they need to be trusted that they can meet the needs and expectations in highly professional ways, even if those ways look a little different from another teacher. At other times the teachers need the administration to actively engage and provide support by offering resources, guidance, or help in some way. Being left alone or being engaged with are competing directions for the administration. However, the teachers provided the clue for the administration to know which lever (e.g., leave alone or engage) to press on at which time—deeply listen to the teachers and what they are asking for.

That is, when expressing their thoughts and experiences concerning their administration and their science teaching agency the teachers were often expressing a tension between wanting interventions and direct support but also wanting freedom and autonomy. The teachers within the

case expressed a clear desire to be respected and trusted, yet there is also a desire to be actively intervened by the administration in the ways in which the teachers want and need to feel supported. The teachers want the administration to be able to be actively supporting in engaged ways, or, be supporting by letting the teachers work autonomously. The administration can know which way to be engaged by listening to the teachers' voice and the ways in which they are advocating for their own and their students' needs.

Talking about the administration was the only time a teacher refused to answer my question when asked, thereby, expressing the potential tension for teachers around this topic. This initial refusal, and thus the expressed tension, could have been because of the lack of privacy for the teacher during this interview. Where the teachers sat for their interviews was their choice. Although the interviews were held remotely—often through internet software like Zoom and/or Google Meet—the teachers decided where they would be during their interview time.

Perhaps the teachers' problem solving is not self-identified as system transforming because of the continued emphasis the teachers placed on the administrative role in their professional life. Although the teachers were quick to describe enacting their agency in ways that solved the problems in their classroom for their students, the teachers were more reticent to describe ways in which they were enacting their agency to solve more systemic-science education problems. Because the teachers described the consequential role of the administration affecting their science teacher agency, perhaps the teachers envisioned the administration's agency as more responsible for transforming the structures of the science education system and thus the teacher's role as more narrowly focused on the classroom needs?

Although the teachers did not speak to this question directly, they did talk about the influence of the administration repeatedly on their role as a science teacher that expresses

agency. For instance, Deborah in the first interview described that it was a turnover in administrative staffing that generated her position. The very nature of her being able to teach in the way that she does, her role as a science specialist, was created because of a change in administration personnel within her district. Her position was continued because of the persuasion that her administration continues to put forth to the school board on behalf of her position. The administration is seen by the teachers as a powerful force in the system in which they work, perhaps as more responsible for systemic transformation than they are as teachers. The administration plays a crucial part in science teacher agency and is an important role to consider as teachers currently enact their agency in moment-to-moment problem-solving ways.

Systemic educational changes, such as pandemics, highlight teacher agency. Historically changes have affected the science education system in notable ways, for example, the adoption of the Next Generation Science Standards (NGSS Lead States, 2013) by many of the states in the U.S.. Along with the addition of the NGSS there are also other systemic cultural influences on teacher agency including the current discourses within teaching and learning call for education that does more to address systemic issues around justice, equity, diversity, and inclusion (Calabrese Barton & Tan, 2020). This push to do more to address the inequities within education have in some cases provided less mental space or time to consider science education when not in the framework of science injustices. How inequalities play out in the science classroom is therefore an influence on science teacher agency and can determine what one teaches as is the case with Deborah, Calliope, and Jane; how one positions themselves in their professional niche (i.e., elementary science education) as is the case with Delilah; and what mental space one has for science education as is the case with Amelia.

Along with the overarching contextual backdrop of justice and equity issues, the outbreak of the COVID-19 pandemic in 2020 caused elementary science teachers to deal with unprecedented upheavals and changes to the education system, including science education. The teachers within this case described their resulting feelings of frustrations, fears, and freedoms that this educational upheaval produced. The teachers described their agency as being expressed in moment-to-moment ways, and the pandemic created an inordinate prevalence of moments the teachers needed to navigate. These pandemic-inspired moments underscore the consequential nature of science teacher agency.

COVID-19 underscores the complicated but also important role of teacher agency. The teachers described that during a global health pandemic they enacted their agency in a myriad of ways often in moment-to-moment problem-solving ways orientated to serving their students. The teachers didn't just problem solve how to get their students to adhere to the new safety and health protocols prescribed by their school administration. In addition, they enacted their science teacher agency in ways that made sure science was still being taught despite the challenging circumstances having to teach remotely and science education being deprioritized during the pandemic in elementary schools (Fauzi & Khusuma, 2020). The teachers described how their lived experiences, beliefs, and identity played a role in how they enacted their science teacher agency to accomplish teaching science under such a challenging situation as the pandemic.

The COVID-19 contextualization underscored teachers' willingness to express their agency in service of their students. The teachers also expressed however that their desire to express that agency was leveraged based on the type of science teacher identity and beliefs they held, and the type of lived experiences they had. Because the pandemic upended so much of the

traditional educational norms what came across despite the upheaval was what the teachers prioritized in their actions. What did they continue to teach, in what ways?

The teachers showed through their agency that they held strong identities as science teachers (Avraamidou, 2014a), believed that science should still be taught even during these times (Biesta et al., 2015; National Academies of Sciences, 2020), and drew on lived experiences that gave them the confidence and self-efficacy to try to still teach science in ways that enabled them to express their agency (Avraamidou, 2018; Nolan & Molla, 2017; Richmond, 2016). The teachers' discourse expressed that they were of course affected by the systemic changes caused by the pandemic, and yet they also affected science education change within their classrooms and schools. The agency from the teachers within the case provided their students with science at a time when many were going without, and provided modeling and mentorship to other teachers considering the ways they could teach science during a pandemic.

The pandemic caused the teachers more stress, frustration and anxiety (Collie, 2021; Ozamiz-Etxebarria et al., 2021), but it also highlighted the consequential nature of science teacher agency (Jenkins, 2019; Van der Heijden et al., 2015). The teachers identified themselves as change agents and they described their resonance around the term change agent. They were indeed change agents making sure they problem solved the pandemic in ways that met the need to continue teaching science.

However, once again, if teacher agency is focused on their students, then teachers need more systemic support focused on the teacher themselves to achieve the desired changes. There is space in the science education research body of knowledge for further consideration on ways of determining the most effective ways of encouraging and supporting teacher agency. The global health pandemic highlighted the consequential nature of science teacher agency, it also

highlighted the increased pressure teachers are working under, and this research highlights that teachers are focusing their agency-related capital on their students. Therefore, the science education system needs to be more cognizant of supporting the teacher so that the teacher can in turn support their students.

CHAPTER 8

CONCLUSION

K–12 in-service science teachers face many challenges across their professional life. Some of the systemic challenges they navigate include disruptions that are not unique to science instruction, such as the global pandemic (Collins & Steele, 2020), deprofessionalization (Buchanan, 2015), and the dehumanization of the teaching profession (Carter Andrews et al., 2016).

Science teachers in particular face unique challenges, such as science knowledge and practice that are changing (Van Noorden, 2014), enacting science-related reforms (National Research Council, 2012), anti-science sentiment (e.g., Deniz et al., 2008; Eder et al., 2011; Glaze et al., 2015; Hufnagel, in press; Skoog & Bilica, 2002), and educational systems that underprioritize science by dedicating fewer hours and monetary resources compared to other subjects like English and mathematics (Banilower et al., 2018). Teachers navigate administrations' goals and students' needs, which are not always aligned, in addition to the sociohistorical contexts in which they are situated (Lemke, 2001). Even structures that are not aimed at science education, including sweeping policy reforms like the No Child Left Behind Act in the USA (U.S. Department of Education, 2001), influence the kinds of science education proposed, enacted, and supported (Griffith & Scharmann, 2008), of which teachers of science are at the crux (Spillane & Callahan, 2000).

In-service science teachers face numerous challenges, and they navigate those challenges through agency expressive actions (Coffman, 2015; Cohen et al., 2020; Ryder et al., 2018). Agency, the capacity of actors to critically shape responses to problematic situations (Biesta & Tedder, 2006, 2007; Emirbayer & Mische, 1998), is a critical component to understanding

teachers' decisions and actions (Arnold & Clarke, 2014; Martin, 2020; Richmond, 2016). Furthermore, as a person positions themselves and others through discursive actions to work out a moral or social structure, agency impacts and is impacted by those moral and social structures (Harré, 2012). Hence it is not surprising that teacher agency affects and is affected by the educational system and structures in which they work (Giddens, 1984; Gutiérrez & Calabrese Barton, 2015; Willmott, 1999). Therefore, understanding science teacher agency is important to understanding the success of our science educational systems (Biesta et al., 2017; Leander & Osborne, 2008) since agency is consequential (Pyhältö et al., 2014).

The findings presented in this work contribute to the growing body of knowledge about how and why teachers take particular instructional and professional actions. Elementary teachers have a particularly difficult set of challenges to contend with to teach science at the highest levels (Zembal-Saul, 2009); using reform-based science teaching strategies in elementary classrooms requires an almost herculean effort of professional skills and negotiation of agency (Martin, 2019).

Contribution of These Research Questions

This research project is informed by agency-related research across the disciplines. Although I frame how this work will contribute to science education research in particular, I am informed by researchers' theorizations and methodologies across the social science fields to do this work effectively. My work adds to the current research in a number of ways including (a) prioritizing what teachers themselves count as agency; (b) deeply attending to lived experiences including those experiences less often noted or less often attended to; and (c) describing the agency in a less binary way (transformative vs. reproductive (Rivera Maulucci et al., 2015)),

instead focusing on identifying and describing agency as a spectrum of agency expressed differently within different places, spaces, and times.

Prioritized what teachers themselves count as teacher agency. Although in-service elementary science teachers have verbalized their own ideas for what is affording and constraining their teaching of science (Banilower et al., 2018), researchers are not describing or communicating the ways in which the teachers themselves believe these affordances and constraints on their science teaching are affecting and affects their science teaching agency. If in-service elementary science teachers are indeed research participants and not subjects of the research, then their opinion of their conceptualization of agency should be a prioritized part of the data informing how professional agency is conceptualized within this group of professionals.

One way that this research tried to support the teacher was by centering their voice throughout the research process. When given the opportunity teachers appreciated their voice being centered in the research. They appreciated the time to consider weighty questions about science education and their teaching practice, the space to reflect, and the respect to listen to their opinions and experiences even if they were not fully formed before the research began. As Delilah said in interview three, "So the motivation of how much of how much of an agent of change do I want to be I'm not even sure that a lot of teachers ask themselves that." Delilah is expressing that teachers are usually not afforded much time to consider their agency. But when their voices are heard and respected, they appreciate the time and space to consider the questions and then consider ways they can continue to grow and transform. As has been mentioned before, Delilah points out that the "research results…changed my practice. I realized I needed to advocate more strongly for science education in my school and district if I wanted to see the changes I was moaning about…but now I know how I need to proceed" (Delilah, Electronic mail

September 22, 2021). By centering the teacher voice, the teachers expressed consequential expressions of agency that affect their practice, and thus their classroom, and thus their students. The teachers expressed that this research process was a powerful professional learning experience; a rare opportunity to be heard and respected for their professional ideas and experiences.

My work gathers, *prioritizes*, and then communicates what teachers themselves believe should and does count as agency. I am a reflexive researcher-in-action and thus am part of the research, so my personal conceptualization of agency is something I have acknowledged and critiqued up front. However, I have attended to the conceptualization of agency based on the discursive practices of the research participants and their expressions of agency in the discourse—implicitly and explicitly. This work adds to the current conceptualizations of agency by communicating what teachers themselves count as agency in their professional role as science educators.

Deeply attended to teachers' lived experiences. Lived experiences are often underattended to in science education analyses (Miller-Rushing & Hufnagel, in press). A lack of diversity and failing to attend to these diversities likely means that we are conceptualizing agency too narrowly or drawing misleading conclusions about how agency functions in science education. Through this research I attended to lived experiences in two ways. One way in which I did this was by noting and considering a diverse range of lived experiences not often considered in current. The underattended to (nonprofessionally-related) lived experiences that were asked and considered included but are not limited to—race, language, religion, socioeconomic status, gender, ethnicity, sexual orientation, and age. Many of these lived

experiences are rarely if ever considered and attended to in current science education research (Miller-Rushing & Hufnagel, in press).

The second way in which I addressed lived experiences throughout this research was by going beyond noting the teachers' lived experiences, in addition, I attended to these lived experiences within the analysis and discussion of the data. Calling out the diverse lived experiences of the research participants and attending that those experiences as possibly contributing to their expressions of agency is the first step in encouraging research participants' full identities, experiences, and backgrounds be considered as an important part of how they, and the research community, conceptualize agency. This research prioritizes describing those who are understudied (including elementary teachers in general) and attending to how their particular lived experiences inform their conceptualization of agency.

Described agency as a spectrum. Agency is often described as reproductive or transformative (Engeström & Sannino, 2013; Laurendeau & Sharara, 2008; Rivera Maulucci et al., 2015; Sannino et al., 2016), work is severely limited that deeply describes a more wholistic and robust spectrum of agency constructs within one analysis. This way of often describing agency as either reproductive or transformative sets up a false binary to understanding agency's full spectrum of possible expressions. Often reproductive agency refers to agency that engenders the structures currently in place, and transformative agency considers agency that changes or transforms, the current structures (Rivera Maulucci et al., 2015). As I conceptualize agency as positioning oneself or others in discursive actions to work out the moral and social structures in which they engage, those positions, or their positioning are not always able to be connected immediately to outcomes that are reproductive *or* transformative. Instead of a binary state our actions are part of an entwined practice of knowing and becoming (Barad, 2003). Often the

attempts made by agents to position themselves and others to navigate their systems might not be able to be directly linked to reproduction or transformation and in trying to label them as such discounts the mangle of practice, the complexity of life's actions and their consequences, that one is always engaged in (Pickering, 1993).

It is understandable that this binary setting up agency as either reproductive or transformative has occurred. There is a strong narrative across the educational system that there needs to be a change in schools regarding science education (Michaels et al., 2008; National Research Council, 2012) and that teachers are the crux of that change (Leander & Osborne, 2008; Lukacs & Galluzzo, 2014). With the best of intentions, encouraging teachers to be reflective problem solvers and change agents (Donnell & Harper, 2005) has also encouraged science education researchers to try to identify ways that teacher agency is imparting that change. Although I too want to strongly support and encourage teachers to be autonomously driven agents of change, this focus on agency as transformative or reproductive limits researchers from fully conceptualizing the nuance of agency. This limitation of the conceptualization is then counterproductive to then actually understanding agency's transformative aspects and potential.

Limitations of This Research

Just as all research does, this research project of course has limitations (Queirós et al., 2017) leading to potential impacts on the findings. Even the very nature of the research topic is challenging in that it is based on conceptualizations of agency in educational spaces that are being affected by confusions and by complexity about agency (Leander & Osborne, 2008). Vähäsantanen et al. (2020) support this claim when they comment that, "despite intensive research on professional agency in educational contexts, we lack a fully elaborated

understanding of agency in academic contexts" (p. 2). This research is also challenged in that it is based on using discourse analysis, yet discourse will always be wrought with limitations, and thus the assumptions and concealments undergirding how agency is discursively expressed must be deconstructed and the contextualizations must be considered as indeterminate from, and thus essential to, agency (Wight, 1999). These current limitations make agency in educational settings a ripe space for current research such as this dissertation.

As much as I did throughout earlier sections of this research to call out my reflexivity and positionality, researcher bias and situational positioning is certain to influence these results especially since I am choosing to center the data in this research on co-constructed discursive interview events in which I played an active role in the meaning making (Mishler, 1986). I attempted to mediate that bias by calling back to my reflexivity, discussing early findings with colleagues, but also by member checking the findings at multiple stages of the research process. I found it imperative to ask the teachers themselves what they thought of the findings and then incorporated their edits and suggestions into the data and the findings. So, although my position as the researcher was part of co-constructing the data with the research participants, the participants ultimately had multiple opportunities to comment, correct, and mediate my belief in the meaning I thought they were trying to convey.

That said, the findings are based on data from six individual teachers and are thus not generalizable. Teachers that each come from their own unique backgrounds and lived experiences. Had a different set of teachers made up the participants of this research it is likely that alternative results would have been highlighted. For example, out of this group of six teachers there were no novice teachers that had been teaching for less than five years. Perhaps if I had had a few more teachers new to the profession, or even included pre-service teachers into

the case, the data might have produced different results. Or, had this research included teachers from marginalized or underrepresented ethnic or cultural groups, the data produced might have also been different. The participants within this group were likely interested in science and science education and thus a group of teachers not so interested in science would not have produced the same results. This research is based on a case of data built from the unique grouping of these particular teachers. This research has many examples and details to deeply support the findings based on these participants, but would in all likelihood have produced an altered case of data had different teachers made up the research participants.

Although I spent over four hours co-constructing discourse with each participant, perhaps if I had been able to spend more time with each participant, then perhaps I would have been able to analyze data that would have led to different findings and results. The type of data gathered was limited in that I was unable to spend more time with each teacher, and our time together was restricted to online and remote interactions due to the nature of the COVID-19 pandemic. Perhaps spending more time with each teacher in their natural teaching setting would have produced different results including more longitudinal understanding of how they conceptualize agency as well as understanding more contextualization of them as the unique humans they are, and the systems they work within.

Although these limitations are present, their presence in this research speaks to the need for further research on elementary science teacher agency. By clarifying the epistemological stance and schools of thought around agency, by producing a richer body of literature on the subject, by deeply listening to more teachers share their conceptualizations of their agency the research literature on elementary science teacher agency will be strengthened.

Perspectives and Considerations

By participating in this research process, I have gained new and alternative perspectives and considerations on the way elementary science teacher agency is conceptualized than the perspectives and considerations I held before this process. Along with answering the research questions in this project in the most rigorous way possible, I also found myself considering perspectives on agency as yet unconsidered in this work, and largely absent from the current research literature on elementary in-service science teacher agency. Implications of the findings such as the influences on expressions agency and how teacher agency is centered on the student and not the teacher are spaces I think need to be considered before moving on to recommendations for future research on in-service science teacher agency.

Influences on expressions of agency. The teachers expressed that they conceptualized science teacher agency as highly contextual and complicated based on an individual's lived experiences (Miller-Rushing & Hufnagel, in press), identity, values, and the context that they live and work within (Richmond, 2016). The teachers expressed that their agency was enacted in moment-to-moment decisions because what problems they are prioritizing solving are highly contextualized based on their own personal dispositions and motivations as well as the system that they are working within. They highlighted that both—the personal and the system-level contexts were both always in flux and could influence the ways in which they enact their agency in complex ways. To understand the actions that teachers take demands a broad consideration for both the personal and a sociocultural contextual awareness. Some days the teachers were willing to "stir the pot" (Calliope, third interview) and other days they choose not to. Therefore, what counts as agency is not a finitely measurable capacity with some teachers having more than others. Instead, agency is an "affirmed capacity of human beings to shape the circumstances in

which they live" (Emirbayer & Mische, 1998, p. 965); a capacity of all human beings, and thus all teachers to enact agency in ways that they see fit.

   Influences and dosing effect of lived experiences on teacher agency. As teachers enacted and expressed agency discursively throughout the case, it also became clear that the teachers were able to describe what influences their expressions of agency and that those influences were described similarly across lived experiences like urban or rural settings, school population size and diversity, socioeconomic backgrounds of the teachers, or even teachers' previous work history. Teachers described that their expressions of agency were influenced and promoted, but I contend there is space for further research to consider that there might be a tension between what teacher's self-report as most important in different domains for them and the accumulation of those lived experiences in those domains. In fact, there could be a dosing effect of lived experiences. In other words, there might be an accumulation of lived experiences that supersede a notion about what is "most" influential on how and why agency is expressed. Perhaps if teachers experience an accumulation of agency-supporting lived experiences over time than that accumulation might be more influential than a ranked order of individual factors of influence.

   Another consideration is that instead of an overall dosing effect across a combination of influential factors, perhaps it is when the influential factor is dosed. For example, if a teacher experiences an administration that is highly supportive of teacher agency, and encourages a teacher to be creative, take risks, and to be a change agent at the start of their career then feasibly that teacher will go on to take more risks and to express their agency because they have had the previous experience of being trusted to enact their agency in the past. Or, inversely, if a teacher early on in their teaching career experiences an administration that demands compliance instead

of creativity and critique that teacher might go on to believe they are less capable of expressing

agency because they have had foundational experiences which lead them to believe trying to

express agency is futile and ineffectual. Therefore, instead of looking for which factor is of most

influence, perhaps it is experiencing influential lived experiences at certain time periods that

ultimately become influential on expressions of agency.

If a teacher experiences an accumulation across a combination of influential factors over

time, or experiences influential factors at certain sensitive time periods that are ultimately

agency-supporting then perhaps a teacher's expressions of agency would increase and therefore

their persistence and resilience would also increase because they are able to critically and

creatively problem solve as they see fit. This research cannot answer those wonderings at this

time, but it does underscore that teachers report that their agency is influenced by lived

experiences across their professional and personal life and that these highly contextual and

interrelated experiences should be considered when regarding teacher agency.

Agency can be promoted through both personal and systemic influences. I identified

that these teachers routinely described being motivated to teach science in ways that expressed

their agency, even during the challenging disruptions due to the COVID-19 pandemic. The

teachers described personal dispositions and motivations as well as broader system-level

dynamics that promote their agency (see chapter five of this dissertation). However, the point

that I think needs to be highlighted in this research is that the teachers described that enacting

their agency is easier when, a) they experienced support from their administration to express

their agency autonomously, b) when their students showed increased motivation and engagement

for science, or c) when they felt their students needed them to get their science education needs,

or even wants, met. Knowing what the teachers describe as primarily promoting their agency can

influence those interested in supporting the science education system to engage more effectively and efficiently.

The teachers described a feedback loop wherein they were more motivated to teach science the more they saw student engagement, and yet they also realized that students would be more engaged and motivated if their instruction was high-quality, student-led, engaging instruction. Often elementary teachers are described as being resistant to science (Lumpe et al., 2012) and yet these teachers push against that stereotype and made choices to incorporate science learning activities even when the administration and system they worked in were letting them know science was not a priority during the pandemic. For example, one teacher who self-described as having science identity, but little to no science *teaching* identity remarked, "I definitely found that my science activities were the most (or even only) engaging thing for many of my first-grade students during remote learning" (Jane, first interview). This teacher went on to apply to and subsequently attend an intense science-related professional development experience during her summer. A choice she says she made directly because of the engagement she saw from her students with science during early stages in the remote learning environment. The teachers expressed that serving their students is an impetus to enacting agency and is made even easier to do again and again when the students show their positive engagement in those enactments.

The teachers described that when they were able to make the changes they felt were necessary to meet the needs and goals of their students they considered that they were expressing agency. Although the teachers often brought up examples of ways they engaged in school-system committees, professional learning experiences, or professional collaborations these actions were primarily aimed at meeting their students' needs. Although Calliope expressed supporting

teachers through her agency as an officer in her teacher's union, she also described her actions in ways that showed she too deprioritized her own needs as a teacher to meet the needs of her students. Overall, teachers expressed increased willingness to express enactments of agency when they felt the changes would be serving their students.

Along with engagement from students and desire to serve students as promoting their science teacher agency, the teachers described the administration as having a consequential effect on how teachers enact their agency. If their administration is genuinely supportive of their autonomous efforts to enact their agency, then the teachers expressed that they feel more capable to make the creative and critical problem-solving decisions they feel are necessary to serve their students. The teachers described numerous ways their administration could support their enactments of agency but called out that the support needs to be genuine and a just right middle ground between letting the teacher do their thing without interruption and engaging in supportive ways. Overall, the teachers wished that the administrators would listen to the teachers and support effectively when asked and let them be to do their job the other times. However, the ways in which the administration engages with their teachers is consequential for how the teachers feel they can express their agency.

Teacher agency centers students not teachers. As previously outlined in chapter two, similarly to Biesta and Tedder (2006, 2007); Emirbayer and Mische (1998), teachers described agency as the capacity of actors to critically shape responses to problematic situations. Teachers discursively described that these expressions of agency were most often targeted at solving problems they felt would best serve their students. The teachers also expressed that they were willing to be creative and critical of their own lived experiences and the structures they work in to achieve meeting their students' needs. The teachers expressed agency to make changes in the

classroom such as putting new ideas into practice, engendering needed resources, making professional decisions for their students' benefit, advocating for science education for their students, and even using their agency to promote their students' agency.

The teachers did not express that these actions were necessarily intentionally transformative or reproductive, but instead agency was identified around ways of meeting needs and problem solving, on a classroom scale. This framing of agency pushes back against some of the literature that agency should be conceptualized as intentionally transformative action (Bang & Marin, 2015; Paris & Lung, 2008) on a system-wide scale (Rivera Maulucci et al., 2015; Vähäsantanen et al., 2018). But, whether agency is enacted with an intent to be transformative or not, teacher agency is consequential for the science educational system (Arnold & Clarke, 2014; Martin, 2017; Moore, 2008) and what the science teachers themselves count as agency I contend needs to be considered when theorizing about science teacher agency, which is not commonly considered at this time.

Teachers working with their administration and serving their students is of course *part* of the position, but where in the educational system is the system serving the teacher? Especially in the elementary science teacher profession (a profession often made up of middle-aged white women who have grown up in an American culture that often ascribe their gender to such self-sacrificing standards) what ways are policies, structures, or systemic supports working to serve the teacher, a role within the classroom that is immensely consequential for student science learning (Davis et al., 2019; Duschl et al., 2007; National Research Council, 2012). In the current neoliberal times when teacher attrition is at staggering levels and teachers are struggling to voice their autonomy and agency in an increasingly regulated educational system (Bartell et al., 2019)

understanding how the system, including the administration and the students within that system, can support teacher agency and resilience could be an important contribution to the field.

Future Research Recommendations

Understanding science teacher agency and how to facilitate and support it will be essential for the successful implementation of science reforms and changes in standards, policies, and recommended practices. It is critical that this work happen. Currently, "teacher agency is often conceived as a slogan to support school-based reform, despite attempts to locate it in wider theoretical discussions of agency" (Priestley et al., 2012, p. 5). Precisely because teacher agency is critical to achieving the science education reforms and ambitious science teaching goals vital for student science literacy success, agency must be more than a slogan and must be effectively understood and supported. The science education research community must be careful not to wield the under-developed concept of agency on teachers of science as yet another expectation for them to practice and master.

Instead, I encourage the science education research field to first look inward and advance the understanding, communication, and use of this critical concept with what I hope is a long-term goal towards supporting autonomously-driven transformative agency of our teachers of science. I encourage science education researchers to consider the full humanness of science teachers as they work to further conceptualize and theorize teacher agency. To do so requires attending to, a) the full range of expressions of agency, b) the combination and accumulations of teachers' past and current lived experiences (Miller-Rushing & Hufnagel, in press), their identity, values, and context (Richmond, 2016), and c) centering the teacher voice within those conceptualizations (Purdy, 2013).

Attend to the full range of ways agency is expressed. If the goal is to support science teacher's critical role as autonomously-driven agents of change, which is my personal goal, then at this still developing stage of the research on in-service science teacher agency all spectrums of agency need to be considered and described. The same person can express agency in dramatically different ways depending on the multitude of variables described earlier. Therefore, one example to consider when considering current assumptions in the research about teacher agency, instead of limiting the expressions of agency to either falling into a reproductive or transformative category, I encourage future research to describe the rich nuances across the spectrum of ways in which agency can and will be expressed. In that way agency is not reduced to a binary expression but instead can be fully explored in the myriad of enactments across time and space.

Attend to the full range of teachers' lived experiences. The science education research community could also consider filling gaps in understanding how the science education system could do more to support teachers within the system by fully attending to their past and current lived experiences. The educational system, including its teachers, is currently focused on addressing student needs, often in a systemizing and managerial way (Darling-Hammond, 1997). But, if teachers are the best and most lasting source of significant change within a classroom (Andere, 2015; Holt, 1970), what ways can the system be set up to better serve the teachers and thus support their consequential teacher agency that will inevitably serve the students? Teachers are humans who come to the classroom with a wide range of personal and professional lived experiences, beliefs, and values. The science education research system could therefore attend to the full humanness of those teachers when conceptualizing their agency and help to determine how those humans could be better supported by an often unwieldy and bureaucratic system so

that their full potential as classroom change agents can be enacted. In other words, to actually serve the students, we need a system that equitably serves the teachers and the students. To achieve a system like this is work that needs a full range of perspectives and efforts, including those from the science education research community.

Amplify teacher voice in science education agency research. What counts as professional teacher agency is highly debated (Arnold & Clarke, 2014), to date researchers are solely framing what counts as agency (Miller-Rushing & Hufnagel, in press). It is a common formula in current journal articles for researchers to communicate their theoretical and/or operational framing of agency, then go on to describe how the data they collected does or does not fit into this frame. Perhaps researchers' framing is an iterative process that is informed by the data as it is being collected and analyzed, but these steps in the research process are not explicit or coherent at this time in the science education research literature (Miller-Rushing & Hufnagel, in press). Even if this is so, yet not widely communicated, the current research is not highlighting what teachers are saying they believe should count as their expressions of agency.

Considering how science teacher agency is discursively expressed in elementary school classrooms, by those that lead those classrooms, provides opportunities to explore ways in which science education is being afforded and constrained at a critical time when student's science literacy is being developed and established (McClure et al., 2017). Elementary teachers are not sought out for their science teaching knowledge and ideas. This group of teachers could be especially influenced by research attention centering their voice and experience and thus could help to influence the science education research community that is still considering schools of thought around science teacher agency. Elementary science teachers play a foundational role in how students consider and feel about science, understanding their conceptualization of their

science teacher agency could provide the field with much needed nuance and contextualization of teacher agency in ways that could then move to supporting that agency more effectively.

Agency is an important topic across science education research. While this research centers on studies of teachers of science in elementary classrooms, the analysis and findings have implications for teaching and teacher education more broadly, as all teachers are on the front lines of policy enactments and navigating a host of issues in their classrooms, such as educational disruptions, teaching for social justice, using reform-based pedagogies, addressing issues that are politicized outside of science (i.e., climate change and evolution), and so forth. By centering the teacher voice in the science education research, it helps to further understand the deep contextualizations and complexities that contribute to understanding teacher expressions of agency, which will help the entire field to move forward and fill research gaps more quickly and effectively.

As elementary science teacher agency is being conceptualized by science education researchers, the voice of the teachers themselves about how elementary science teacher agency is conceptualized might be a powerful way to contemplate elementary science teacher agency more effectively and authentically. The goal of amplifying the teacher voice is to not only support the teacher's own reflexivity—a powerful way of promoting agency for change in a teacher's own practice; but amplifying the teacher voice within the research also promotes the full range of conceptualizations concerning science teacher agency. To garner this full range of science teacher agency conceptualization requires deeply attending to the voices of those teaching science, especially those teaching elementary science who are often forgotten are students' first formal science teachers.

The teachers described that it was helpful that their voice be centered in such a way as to encourage their willingness to share authentically and deeply. The research questions in this project were not about analyzing the most effective methodology to center the teacher voice in science education research. As such, based on the teacher expressions within this case, there is not adequate data around how to design a research project that centers teacher voice in a way that encourages science teacher agency. Although I argue that identifying methodology to achieve centering the teacher voice in research projects on teacher agency, might be a useful consideration for future research on teacher agency. However, I can say that what I tried to do to achieve centering the teacher voice was to have the teachers feel like they could talk to me in confidence, have the teachers know they had anonymity over their discourse, built trust in the relationship with me as a researcher, and I designed the research to take place over a longer period of time so the teachers and I had extended engagement time in order to co-construct meaning together. I cannot say which pieces of the research design were more helpful than others. Perhaps if I had designed the research differently, I would have perhaps gotten even more honest and authentic sharing. What I can say is that the findings underscore that teachers appreciated and valued being centered in the research, with time to reflect and be listened to.

Currently, much of the research on science teacher agency is often coming to the teacher with an expectation of learning how the teacher expresses a pre-conceived and pre-defined (by the researcher) notion or phenomena of agency. Instead, this research process intended to have limited preconceptions or notions of how to conceptualize agency so that it was the teacher voice of how they conceptualized and operationalized agency which was to be primarily considered. What counted as agency for the teachers became a central tenant as the research was progressing

and staying open to the teacher voice clarified and centered the answering of that question. As Cong-Lem (2021) called out in their research that,

> Policymakers and teacher trainers can be informed of ways to support teacher agency development, such as providing contextually informed professional development and creating a mediational space for teachers to engage in self-reflexive or collaborative practices, which in turn promotes their agency for change and development. (p. 729)

Creating a mediational space for teachers to engage in self-reflection can help to promote teacher agency, but the research process must first center the teacher voice as part of that reflexive work to fully consider their professional knowledge and experiences as part of understanding science teacher agency. Deeply listening to how the professionals who are engaged in the day-to-day work of teaching science conceptualize agency could be a space for science education researchers to consider.

Clearly, conceptualizing agency in such a way is no easy task. As the field continues to try to understand this consequential but also complex and highly contextual expression, knowing that researchers have great potential to express agency themselves, and are able to, "critically shape their responses to problematic situations" (Biesta and Tedder, 2006, p.11), I have tremendous faith in the future directions of agency research.

APPENDIX A

Teacher Attributes and Lived Experiences (responses based on answers to a survey)

This survey helped to record the teachers' lived experiences. I made clear this data was kept in the strictest of confidentiality and answering any question was optional. I gathered school diversity data online.

Research Participant Survey Responses of Lived Experiences

	Amelia	Jane	Delilah	Maya	Deborah	Calliope
Current grade teaching	4th (generalist)	1st (generalist)	5th (generalist)	5th (science only)	K–6 (science only)	2-3 (science only)
# Years teaching that grade	6	3	3	10	7	22
# Years teaching overall	18	12	12	37	11	22
Teaching certifications	Gen Elem (K–8)	Early Elem (K–3)	Gen Elem (K–8)	Math (5-8); Science (5-8)	Science (5-8); Biology (9-12); Physical Science (9-12)	Math (5-8); Science (5-8)
Current age	53	55	52	67	54	59
Raised in what country	USA	USA	Canada	USA	USA	USA
Raised in what state	ME	MA	n/a	NY	NY	MA
Learning differences	None	None	Yes	Yes	Yes	None
Mental health differences	None	Yes	Yes	None	None	None
Physical health differences	None	None	Did not answer	None	None	None
Race or region of origin	White (European, Middle Eastern, North African)	White (European, Middle Eastern, North African)	White (European, Middle Eastern, North African)	White (European, Middle Eastern, North African)	White (European, Middle Eastern, North African)	White (European, Middle Eastern, North African)
Ethnicity	Not Hispanic or Latino	Not Hispanic or Latino	Not Hispanic or Latino	Latino	Not Hispanic or Latino	Not Hispanic or Latino
Religious affiliation	Christian	Nature/	Christian; Buddhism;	No religious affiliation	No religious affiliation	Christian

		Pagan/ Wiccan	No religious affiliation			
Sexual orientation	Heterosexual	Heterosexual	Pansexual	Heterosexual	Heterosexual	Heterosexual
Gender identity	Cisgender female	Cisgender female	Androgynous	Cisgender female	Cisgender female	Cisgender female
Gender expression	Cisgender female	Cisgender female	Cisgender female	Cisgender female	Cisgender female	Cisgender female
Spoken languages	English	English	English; French; Other	English	English	English
Current household income	$120,000	$50,000	$110,000	$90,000	$180,000	$140,000
Household income Growing Up	$30,000	Middle income	$100,000	$10,000	$45,000	$14,000
Highest educational degree attained	Masters	4-year college BA/ BS	Doctor of Jurisprudence	Masters	Masters	Certificate of Advanced Graduate Study
# Of science classes taken in college or university						
Biology	4	3	20	20	20	6
Ecology/ evolution	2	2	0	6	0	2
Chemistry	2	1	4	9	4	2
Physics	2	1	0	2	4	0
Geology/ Earth	3	0	2	0	0	0
Environmental Science	3	0	1	6	0	0
Oceanography	2	0	0	0	0	0
General/ combined/ integrated	2	0	0	0	0	2
Engineering	0	1	0	3	20	0
TOTAL	20	8	27	46	48	12
Previous professional background	None	Preschool teacher	Lawyer, human services worker	Adjunct faculty	Science Industry	Medical Technologist
# Of professional	10	12	12	20+	20+	12

learning experiences/ professional development (PD) in science						
Types of PD	Outdoor Science, Inquiry, Place-based	Outdoor classroom, NGSS, inquiry, other pedagogy	Pedagogy, NGSS, math and science curriculum development, inquiry/ observation, workshops	NGSS, place-based, citizen science, pedagogy	Teaching NGSS, STEM, etc.	Computer Science, STEM
Membership Affiliation	None	National Science Teaching Assoc.	State science teaching assoc.; National Science Teaching Assoc.	State science teaching assoc.; National Science Teaching Assoc.	National Science Teaching Assoc.	National Science Teaching Assoc.
Other Notes	In same school as Jane	In same school as Amelia				
School Descriptors						
Rural/ Suburban/ Urban	Rural (55 people/ sq mi)	Rural (55 people/ sq mi)	Rural (191 people/ sq mi)	Rural (63 people/ sq mi)	Urban (3,443 people/ sq mi)	Suburban (606 people/ sq mi)
# Of students	169	169	322	208	764	321
% Of students on free or reduced-price lunch	15%	15%	20%	46%	0.8%	15%
Grades in school	K–8	K–8	3-5	K–8	K–6	2-3
Teacher: student ratio	7:1	7:1	15:1	9:1	11:1	14:1
% Students proficient in reading/math	62% / 52%	62% / 52%	65% / 54%	27% / 17%	81% / 71%	62% / 62%

APPENDIX B

Miller-Rushing's Research Overview

METHODOLOGY
• Qualitative Descriptive Case Study: 6 teachers (grades K–5) make up a small group with which to analyze the case—elementary science teacher agency during a time in which the educational system is in disruption. The subject of the case are the teachers in the group, and the analytical frame of the case study is agency expressed discursively. I will examine across the case to identify patterns and describe rich points of elementary science teacher agency.

METHODOLOGICAL FRAMEWORK
• Discourse analysis: Discourse analysis provides a way of orientating to the data that underscores that agency is expressed in multiple discursive ways (Martin, 2016) including the saying, being, and doing (Gee, 2010); while highlighting a professional vision (Goodwin, 1994, 1997); and attending to a process that is interactional, contextual, intertextual, and consequential (Hufnagel & Kelly, 2018).

DATA ANALYSIS
• Discourse Analysis: I will be highlighting and examining the multiple contextual and cultural meanings occurring in the saying, being, and doing (Gee, 2010); being mindful to consider agency as it is expressed at various spaciotemporal envelopes—microgenic to ontogenic (beyond a micro *or* macro level analysis) (Wortham, 2012)

Research Questions	**Data Sources**	**Examples**	**Contribution**
1.How do K–5 teachers conceptualize and position their own science teacher agency?	• Researcher notes and memos • Artifacts- reflective teacher journals • Transcriptions of video recordings of teacher semi-structured individual interviews	Interview Questions (see Appendix C)	What counts as professional teacher agency is highly debated (Arnold & Clarke, 2014), to date researchers are solely framing what counts as agency. My work considers what teachers themselves believe should/does count as agency.
1a. In what ways do the teachers' lived experiences and identities contribute to their science teaching professional agential positioning?	• Researcher field notes and memos • Artifacts- reflective teacher journals • Transcriptions of video recordings of teacher semi-structured individual interviews • Questionnaire surveying teacher background, lived experiences, and positional identity	Teacher Attributes (See Appendix A, C)	Lived experiences are often underattended in analyses (Miller-Rushing & Hufnagel, in preparation). A lack of diversity and failing to attend to these diversities likely means that we are conceptualizing agency too narrowly or drawing misleading conclusions about how agency functions in science education.

| 2. As K–5 teachers negotiate a disrupted educational system, in what ways do they position their science teaching agency, within their case as well as across cases? | • Researcher field notes and memos
• Artifacts- reflective teacher journals, teaching calendars, lesson plans, and student work samples
• Transcriptions of video recordings of direct teaching (if available), and teacher semi-structured individual interviews | Attribute Map | Work in in-service (especially K–5) teacher professional agency is limited (King & Nomikou, 2018). Agency is often described as reproductive or transformative (Rivera Maulucci, Brotman, & Fain, 2015), work is severely limited that deeply describes a more wholistic and robust spectrum of agency constructs within one analysis. |

APPENDIX C

Example Survey and Interview Questions

Survey Questions. Focus on surveying teacher background, lived experiences, and positional identity. Informed by Miller-Rushing and Hufnagel (in press).

- What grade are you currently teaching (School year 2020-2021)?
- How many years have you taught that grade?
- How many years have you been teaching overall?
- What teaching certification(s) do you currently hold?
- Your current age
- In which country were you raised?
- In which state did you grow up in (primary one if more than one)?
- Do you have any learning differences?
- Do you have any mental health differences?
- Do you have any physical or health differences?
- What race, or region of origin(s) do you feel describes you?
- What ethnicity do you feel describes you?
- What religion(s) do you belong to?
- What is your sexual orientation?
- What gender do you identify as?
- What gender do you express publicly?
- What language(s) do you speak?
- What is your current household income?
- What was your household income growing up?
- What is your highest educational degree attained?
- How many science classes have you taken while in colleges or universities?
- Any previous professional background before teaching? If so, please describe.
- How many science professional learning experiences or professional development opportunities have you taken while teaching?
- What were the topics of the professional learning experiences/professional development? (E.g., specific content like bio/chem/geology content like bio/chem/geology, pedagogy, pedagogy, specific curriculum, NGSS, phenomena, inquiry, specific curriculum, etc.?)
- What science teaching memberships do you belong to, if any?
- We will be talking a lot about your teaching identity in the interviews, but is there anything else about how you were raised, or your general identity that you would like me to know?
- Considering the questions above, which ones do you feel most impact the decisions you make concerning science teaching? (Drag and drop to prioritize this list. Items at the top mean they are most important to you, ones at bottom mean least important to you)

Interview 1. Interviewer-interviewee relationship building; generating descriptions and narrations to follow up on in subsequent interviews. Informed by Vähäsantanen et al. (2018) and Eteläpelto et al. (2013).

- Sociocultural conditions:
  - Describe your students generally, the student body of the school.
  - Describe your colleagues generally.
  - Describe administration generally.
  - Describe your science teaching environment (standards used, curriculum, materials available, resources, etc.)
  - Describe your weekly/monthly science teaching schedule
  - Describe what supports science teaching in your school, what makes it more difficult? Who or what has the power to make these moves?
  - Describe your work culture
    - Now vs pre-pandemic
    - What do you hope the culture will be post pandemic?
  - Describe your school's science teaching practices
  - Describe how your school supports your science learning. (Professional learning experiences?)
- Professional Description:
  - Narrate your path to teaching. To science teaching specifically.
  - Describe your work history and experience?
  - How do you describe yourself?
  - How do you describe your teaching identity?
  - How do you describe your science teaching identity?
  - How do you think others describe you?
  - What qualities do you have that you think make you move to action?
  - What kinds of commitments do you have professionally? As a science teacher specifically?
  - What are your science teaching interests?
  - What goals do you have for yourself? For the classroom/students? For the school?
- How do you identify yourself?
  - What makes you, you as a teacher?
  - As a *science* teacher?
  - What motivates you as a science teacher?
  - What are your strengths as a science teacher? Weaknesses?
  - What are your science teaching beliefs?
  - What duties do you have to teach science? What duties do you wish you had, and didn't have?
  - What rights do you feel you have to teach science? What rights do you wish you had, and didn't have?
  - In what ways do you prioritize science teaching? In what ways do you constrain your science teaching?
    - In what ways do you feel that these actions are yours or someone else's?
    - In what ways do you feel you can make decisions regarding your work?

Interview 2. Focus on RQ 2 (As K–5 teachers negotiate a disrupted educational system, in what ways do they position their science teaching agency, within their case as well as across cases?)

- Describe how this unit/lesson came to be taught in this way?

- o How were goals developed?
- o What necessitated the material used?
- o Were any changes or modifications made to the unit? Why/not?
- o In what ways did the written unit plan (not)match the way it worked in practice?
- What other policies or systems in place affected this unit? (Admin?)
  - o How did the pandemic affect this unit?
  - o In what ways did the newly adopted NGSS standards affect (or not) this unit?
  - o Has your teaching changed as standards, policies, or systems have shifted?
  - o Do you like/not how these systems have changed your teaching priorities?
  - o In what ways were your colleagues responsible for the unit being taught in this way?
  - o In what ways was your administration responsible for the unit being taught in this way?
  - o On a scale of 1(low) -10 (high) how active were you in preparing this unit?
- Your role in the unit/lesson
  - o What decisions did you make regarding the unit? Priorities?
  - o In what ways do you feel you can influence the unit? Learning outcomes for your class?
- Your role in the larger school community.
  - o Do you feel your professional opinion is heard or taken into consideration? Describe.
  - o In what ways do you bring up your opinions or questions in your work community?
  - o In what ways do you collaborate with others in your work community?
  - o How is your way of science teaching similar to or different than your colleagues?
  - o If you have an idea that you would like to trial, describe what you would do? What do you think would happen?
  - o Have you ever tried to enact a new science teaching idea?
    - ▪ Describe it.
    - ▪ Why did you want to try it?
    - ▪ In what ways do you believe it was successful or not?
  - o Are there other ideas you would like to try?
  - o What are your ethical or moral principles of your job as a science teacher?
  - o Have these changed or shifted with the recent disruption to education?
  - o Do you feel your principles match the principles of your school community?
  - o Do you realize your professional goals? Often? Rarely?
  - o Do you feel that you are able to advance in your own professional goals?
  - o In what ways does science teaching interest you? Do these interests match what you teach?
  - o If you had a magic lamp and could make 3 wishes related to science teaching, what would they be? Why?
  - o What do you want younger teachers to know about science teaching?
  - o What do you want to tell your younger self about your beliefs and practices related to science teaching?
  - o What do you want to tell your future self?

Interview 3. Focus on RQ 1 (How do K–5 teachers conceptualize and position their own science teacher agency?)

First Read: "Agency is practiced when professionals and/or communities exert influence, make choices, and take stances in ways that affect their work and/or their professional identities. Agency is a continually shifting interaction between agents and the systems that they work within, both affect each other. Agency can be action or inaction, but it is purposeful. Just a few examples of agentic teaching moves include deciding to attend a professional learning experience; prioritizing teaching a certain lesson; utilizing a pedagogy you think works best for your students; refusing to take part in curriculum planning; asking the principal to reconsider weekly class schedules."

- What other examples of agentic teacher moves can you think of?
- What ways do you wish you could be more agentic? Less agentic?
- Is agency a capacity that some teachers have in more quantity than others? Why?
- Does your ability to be agentic change? Based on what?
- What structures and systems make it harder to be agentic? Easier?
- Is a teacher doing the same lesson over and over agentic? What agency is that teacher prioritizing?
- What about a teacher who chooses not to participate in staff training, in what ways are they being agentic?
- Describe a teacher leader in your school. In what ways do teacher leaders act agentically?
- In what ways do new teachers to the profession act agentically?
- In what ways do seasoned teachers act agentically?
- What role does creativity, entrepreneurship, willingness to try something new or different, have in agency?
- How is agency relational? To yourself, to others, to your school system?
- How do your goals and values affect your agency?
- How does your identity affect your agency?
- What beliefs do you hold about your agency?
- What is helpful for you to enact your agency?
- What constricts your agency?
- In what ways do you reflect about your agency?

Interview 4. Focus on RQ 1a (In what ways do the teachers' lived experiences and identities contribute to their science teaching professional agential positioning?) This interview will be building off the attributes collected as part of the survey.

- How did you decide to work in the kind of school community you work in?
- In what ways does _____ (fill in blank with each line from survey) affect/not your science teaching agency?
- How do you feel you fit into the school community?
- In what ways do you not fit into the school community?
- What do you think makes you unique to teach science in the way you do?
- What do you want people to know about you that you think they don't know?

- In what ways has this research process changed your thinking about your teaching practice?
- In what ways has this research process solidified your thinking about your teaching practice?

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BIOGRAPHY OF THE AUTHOR

The researcher of this work, Anica Miller-Rushing received her B.A. from Mount Holyoke College and her M.Ed. from Boston College. Anica volunteered for the Peace Corps, taught environmental education in Southern Maine, taught as an elementary teacher in diverse schools, taught teacher professional development, and now teaches preservice education students in higher education settings. During her dissertation work Anica continues to coordinate a state-wide residential environmental education network along with additional national science education consultant projects. Anica's current research aims to support the potential of K–12 teachers of science to serve as transformative systems-level change agents through her research focus on in-service science teacher agency and identity. Anica specifically enjoys researching and supporting the agency of elementary teachers in their science teaching practices and professional learning agendas. Anica also enjoys sailing around and exploring beautiful Downeast Maine with her family. Anica is now a candidate for the Doctor of Philosophy in Education with a concentration in STEM Education at the University of Maine in May 2022