Teacher Leadership and Science Instructional Practice:

Teaching Elementary Science in a Time of Crisis

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Abstract

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This study explores the challenges that elementary science educators face when teaching science in a time of crisis, as well as how to best provide elementary teachers with ongoing support for their science teaching during the novel COVID-19 pandemic. Using a phenomenological approach, this research focuses on elementary science teachers, educators, and formal and informal leaders to understand their experiences during the pandemic and how to best support them during remote and in-person science teaching. Using data collected from questionnaires, semi-structured interviews, and focus group discussions, findings discuss the specific experiences and challenges faced by elementary science first-year teachers, early career teachers, and leaders. Following the transactional model of stress and coping (Lazarus & Folkman, 1984) and the buffering effect of social support (Cohen & McKay, 1984), first-year and early career elementary science teachers used multiple coping mechanisms to handle the stress of science teaching during the pandemic, including problem solving and collaborating with other educators. From a distributed leadership perspective (Spillane, Halverson, & Diamond, 2001b), district-level elementary science curriculum specialists and coaches act as leaders in science education. When faced with constraints and challenges due to the pandemic, these district-level leaders used this opportunity to reimagine what their leadership work could look like, including rethinking what supports they can offer classroom teachers when they cannot

easily access classrooms, how to design effective science curricula for remote teaching, and how to collaborate with other educators in new ways.

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Chapter I: Introduction

Background and Context

As our understanding of how students learn is continually deepening and as educational reforms strive to better prepare students with the twenty-first century skills necessary to enter the workforce, there is a need to improve science education for students of all ages (National Research Council, 2012). Since the 1950s, educational policy in the United States has increased its focus on science education under the premise that science education is essential for making future members of American society more competitive in the global economic market. Since the impetus of the Soviet Union's launch of Sputnik in 1957, the U.S. has engaged in a variety of educational reforms to improve science education, which were ultimately intended to keep America competitive globally (DeBoer, 1991).

In its foundational document from 2012, *A Framework for K-12 Science Education*, the National Research Council (NRC) outlined the foundation on which the current standards for K-12 science education are based. Building on previous science standards, the NRC (2012) explicated that the goal of K-12 science education should now be to prepare all students to possess a wonder and interest in science, to become critical consumers of knowledge, to have the necessary knowledge to understand contemporary societal issues, and to be prepared with the skills necessary for a variety of professions, including careers in science, technology, engineering, and mathematics (STEM). Currently, K-12 science education is not achieving these goals (NRC, 2012).

More specifically, there is a need for improving science education for elementary school students. As described by the NRC in its 2007 report on K-8 science education, the foundations of science education are changing to be guided by the principle that children are capable of learning science and engaging in scientific thinking, even at a young age (NRC, 2007). Because children are naturally curious and develop their own understandings of how the natural world works before starting school, the prior knowledge of young children can be built upon through elementary science education to help children develop scientific understandings (National Academies of Sciences, 2021). The NRC (2012) also described how K-12 science education should develop in all students an appreciation for science. If the goal of science education is to teach students to be critical consumers of knowledge and to develop critical thinking skills, science education must begin at the elementary level. The NRC defines the goal of elementary science education as "to develop critical basic knowledge and basic skills, interests, and habits of mind that will lead to productive efforts to learn and understand the subject more deeply in later grades" (NRC, 2007, p. 34). Elementary science should provide the foundation for students to become scientists or, if they do not enter a scientific profession, to become scientifically literate, critically thinking citizens. However, as described by the National Academies of Sciences, Engineering, and Medicine in 2021, students in preschool through fifth grade are not receiving sufficient meaningful opportunities to learn science and engineering, compared with opportunities to learn mathematics and language arts. Because there is a continued need to provide elementary students with frequent and consistent science learning experiences (National Academies of Sciences, 2021), we must therefore consider how elementary teachers teach science, with the intention that all elementary students continue studying science and develop critical thinking skills, possible interest in pursuing a STEM or STEM-adjacent career, and a curiosity about how the world works.

The COVID-19 Pandemic

In March of 2020, K-12 education was substantially impacted by the global COVID-19 pandemic. The immediate impact on education during the Spring of 2020 when the pandemic began was that schools abruptly closed down and shifted from in-person learning to an online learning format. This online learning format has been given multiple names, such as *online learning*, *distance learning*, *distance teaching*, *distance education*, or *remote learning*, all referring to the learning experiences when children are at home and teachers are teaching from their homes via an online video conferencing platform, such as Zoom and Google Meet. For this paper, these terms are used interchangeably to refer to any learning situation that is conducted virtually, through a computer, without teachers and students physically being present in the same room together. This sudden shift to remote learning in the Spring of 2020 was done out of necessity when it was no longer safe to continue school in person. Therefore, this emergency mode of online teaching was different from online learning experiences that were designed to be online, such as a virtual college course, and brought brand new challenges and stressors for K-12 educators who suddenly were expected to continue teaching but in completely new ways with little or no training on online instructional pedagogies, educational technological tools, or virtual curriculum resources (Hodges et al., 2020).

While continuing the school year in the Spring of 2020, educators faced new challenges daily regarding how to do their jobs effectively. Teachers were building the plane while flying it, in terms of how to adapt their curriculum and associated activities to be feasible online, and how to use and provide the necessary workbooks and materials to students when they were learning from home. Moreover, administrators had to make quick decisions about how much instructional time is devoted to each subject during online learning, how much time young children should be spending at their computers learning on a given day, and which subjects should offer synchronous learning experiences (teachers and students working together at the same time on a lesson) and which could be asynchronous (teachers assign assignments for students to complete on their own at any time).

In the Fall of 2020, the 2020-2021 academic year began with schools and districts making their own decisions about how to safely continue education. While most agreed that learning in-person is superior to online learning, some schools attempted to reopen for in-person learning, with many safety measures in place. Some of the major impacts of safely reopening in the Fall of 2020 were that not only were students and teachers required to wear masks all day, but classrooms became socially distanced, meaning that everyone was expected to stay six feet apart from one another, students were not allowed to share materials, and students and teachers were expected stay as a "pod" to limit the number of people they were exposed to. Teaching in socially distanced classrooms put many constraints on how to teach: what does collaboration look like, or does it exist at all? How do we allow students to use tangible materials if they cannot share them? Teachers thus had to learn how to teach in yet another new way, as this became the "new normal" for teaching in the 2020-2021 academic year, and was considered preferable to teaching from home.

Elementary Science Teaching

Despite the importance of elementary science for increasing young students' interest in science and providing students with a foundation for science learning later in life, many elementary school teachers do not teach science in their classrooms or do not teach it in a way that aligns with the current beliefs about how children learn science, even under normal circumstances before the pandemic (Berg & Mensah, 2014). Current best practices for science instruction include building on students' prior conceptions of scientific topics, planning activities in which students generate evidence, helping students create and test explanations and models of scientific phenomena, and requiring students to interact and write about their ideas and observations during investigations (NRC, 2007). Because elementary teachers are generalists, they must teach all subjects, and there are various factors that affect what they choose to teach. Moreover, elementary teachers must have both the content knowledge and the pedagogical content knowledge (PCK) for all subjects that they teach (Anderson & Clark, 2012; Appleton, 2006). PCK can be defined as knowledge about how to transform content into understandable information for students (Appleton, 2006). Teaching elementary science is a complicated practice that requires a deep understanding of content, an ability to engage in inquiry and other scientific practices, PCK, recognition of students' misconceptions, an understanding of who their students are, the ability to implement a given curriculum, and more.

While many elementary teachers do hold positive attitudes towards science and science teaching, they may face other issues that inhibit or impact their science teaching, such as limited professional development (PD) in science (Trygstad et al., 2013). Mathematics and literacy skills are predominantly emphasized at the elementary level and elementary teachers often feel more pressure to teach mathematics, reading, and writing than science and do not have enough classroom time to focus on teaching science (Berg & Mensah, 2014; Trygstad et al., 2013). Nationwide, time dedicated to teaching elementary science has been decreasing for the last 20 years (Blank, 2013). Despite the establishment of standards focused on inquiry, elementary teachers are not using inquiry-based curricula that align with the science standards due to a lack of funding for new materials or a lack of awareness of available materials (Sandall, 2003). Oftentimes limited funding for resources, lack of sufficient PD in science, and emphasis on other subjects negatively impact elementary science education.

Elementary Science and STEM Specialists

To ameliorate many of the issues that prohibit elementary classroom teachers from teaching science, many elementary schools instead use a model in which science is considered a special subject and is taught by a teacher who only teaches science. In this model, the teacher who only teaches science is an expert, or specialist, in elementary science content and science teaching practices. Abell et al. (2007) differentiate between a generalist or classroom teacher who may take the lead on science within their school from a science specialist; a science specialist only teaches science, typically has a background in science, and has science pedagogical content knowledge. Because of their background in science, science specialists often have stronger content knowledge in science than classroom teachers, and specialists have more opportunities to plan and teach science, and therefore more opportunities to improve upon their science teaching practice (Brobst et al., 2017). Compared to classroom teachers, Schwartz et al. (2000) suggested that elementary science specialists are more effective in terms of implementing high-quality science instruction that is aligned with current science education reforms, and that science specialists hold more sophisticated definitions of scientific inquiry and more constructivist views of science learning, which they implement into practice in their classrooms. However, even if schools follow the specialist model, most schools lack instructional leadership for elementary science, and elementary science specialists receive less support than generalist teachers do for teaching literacy and mathematics (Abell et al., 2007).

For the context of this paper, the terms *elementary science teacher*, *elementary science specialist*, and *elementary STEM specialist* are used interchangeably to refer to teachers or specialists who solely teach science and/or STEM to elementary-aged children and who do not teach any other academic subject.

Science Professional Development and Teacher Learning

To better understand how and why students learn science content and develop both positive attitudes towards science and scientific habits of mind, we must examine how teachers learn to teach science and continually refine their science teaching practice. Teachers receive PD throughout their careers to further develop their practice and grow professionally, either sponsored by their school or sought out individually. Moreover, there is a need for ongoing PD to support teachers in the adoption and implementation of the new science standards, the *Next Generation Science Standards* (NGSS), so that teachers learn how to develop new curricula and how to teach, and assess students' three-dimensional science learning (Reiser, 2013; Windschitl & Stroupe, 2017). While historically PD has failed to positively influence teacher learning, new reforms in science PD have constituted elements of high-quality PD that promote teacher development through changing teaching practices (Supovitz & Turner, 2000) and that focus on content knowledge, support teacher change over time, and provide opportunities for teacher collaboration and reflection (Luft & Hewson, 2014; Ring et al., 2017). However, research has shown a correlation between the quantity of high-quality PD that teachers receive and the effects of PD experiences on influencing teaching practices (Supovitz & Turner, 2000). Because of the administrative pressure to teach literacy and math and the emphasis on assessments, the focus of elementary teachers' PD is typically not on science (Banilower et al., 2007). Additionally, the PD that elementary teachers do receive may not be effective in influencing their practice, as traditional models of PD consist of a single workshop or a few workshops in succession that are disconnected from teachers' classroom practices, the school context, and other PD sessions. Therefore, without intensive and sustained high-quality PD, elementary teachers will not be supported in their ongoing refinement and growth of science teaching practices (Chen & Mensah, 2022).

In addition to formal PD, teachers learn to teach science and improve their practice from other in-school opportunities. When science instructional coaches are not present and science PD is insufficient to help teachers improve their science practice, teachers can step into the role of instructional leaders and share their knowledge of science instruction with their peers through mentoring, coaching, and collaboration (Chen & Mensah, 2022). Through observation, reflection, and collaboration, teachers continually refine their science teaching practice throughout their careers by learning from their colleagues. This mode of inservice professional learning allows for teachers to situate their learning in the context of their school, their classrooms, and their practice. In these learning situations, teachers become instructional leaders for their peers as they are able to share their pedagogical knowledge that is situated in their school specifically with their colleagues.

School Leadership

To better understand how to improve elementary science education, it is vital to understand the processes through which schools generate instructional change. On a school-wide level, many community members are involved in instructional change in different ways. School leadership, which has traditionally been conceptualized as the school principal individually, has expanded to include other school members, in both formal and informal roles, who act as leaders. Spillane (2005) uses a working definition of leadership that describes how leadership activities must be tied to the core work of the organization and be designed to influence the motivation, knowledge, or practices of others in the organization. Lambert (2002), on the other hand, defined a leader as someone responsible for the learning of his or her colleagues. These definitions move beyond the traditional administrative leadership roles to incorporate teachers and other staff members who collaborate and share their expertise and experiences within a school as well. Schools are interconnected organizations with many people serving in leadership roles, including teacher leaders, principals, district coordinators, school board members, community members, and beyond. Therefore, because schools are not organized in a way in which leaders act alone, to understand school leadership and how it impacts teaching and learning, we must examine all leaders, how they lead, and how they interact (Neumerski, 2013; van Schaik et al., 2020).

Recently, school reform initiatives have led many schools to hire school-based instructional coaches to improve teaching, in place of traditional models of professional development that are often isolated sessions that are not situated in the context of teachers' everyday practice, lack ongoing support for teachers, and are ineffective (Anderson & Wallin, 2018; Knight, 2008). Instructional coaches enact a variety of roles, ranging from mentoring teachers to providing teachers with additional classroom resources, to specializing in curriculum, to helping teachers use the best instructional practices, all in the hopes of improving teaching and learning (Anderson & Wallin, 2018; Knight, 2008). To improve elementary science teaching and learning, it is imperative to know how science leadership functions, not on an individual level, but on a school-wide level that considers the interactions and the social and situational context in which all leaders, including instructional coaches, curriculum writers, and curriculum specialists, are understood.

Problem Statement

The COVID-19 pandemic disrupted education in unprecedented ways for all teachers, administrators, students, and parents; everyone encountered a variety of challenges as we adjusted to a new normal of learning starting in the Spring of 2020. However, elementary science education, in particular, faced unique challenges in having meaningful science learning experiences when school abruptly moved to remote learning and then back to learning in schools while maintaining a social distance. These challenges were unique to elementary science teaching and learning because elementary science curricula are grounded in hands-on, collaborative investigations involving a variety of materials and student-to-student interactions, which became nearly impossible during remote learning and in a socially distanced classroom. Additionally, elementary science is traditionally marginalized in many schools, which has been exacerbated by the constraints of the pandemic. Therefore, there is a need to understand the experiences, challenges, and coping strategies of elementary science educators and teachers who specialize in teaching elementary science in order to better understand how elementary science educators handled the stress of the pandemic and continued to provide quality science learning experiences to young learners. Further research is warranted to understand how elementary science education teachers, instructional coaches, curriculum specialists, and leaders were impacted by the pandemic, how they overcame the challenges they faced, and what supports they relied upon, which has implications for supporting other educators during the pandemic and in future times of crisis.

Purpose and Research Questions

The purpose of this study is to explore the challenges elementary science teachers and elementary science leaders faced during the COVID-19 pandemic, how they overcame these challenges using supports and coping strategies, and how educators can thrive as science professionals and continue to provide high-quality science instruction and professional learning in a time of crisis.

To carry out the above purpose, the following research question is addressed: *What are the various challenges that elementary science teachers and leaders face during the COVID-19 pandemic, and how are they overcoming the challenges they face?* To gain a deeper understanding of the various experiences of different science educators during the pandemic, the overall research question is divided into four sub-questions, listed below:

1. How do first-year and early career elementary science teachers continue to learn to teach during the COVID-19 pandemic?
2. How are first-year and early career elementary science teachers coping with the stress they face while teaching during the COVID-19 pandemic?
3. How are district-level elementary science educators and coaches impacted by the COVID-19 pandemic?
4. How are district-level elementary science educators and coaches overcoming the challenges they face to serve as elementary science leaders during the COVID-19 pandemic?

Organizational Overview of the Chapters

In the following chapter, Chapter II, I provide an overview of the literature that supports the findings and conclusions of this study. This chapter covers the following topics: the impact of the COVID-19 pandemic on the educational world thus far, research on crisis pedagogy, and social-emotional learning for teachers. This chapter also discusses the various ways in which inservice teachers continue to learn to teach: through professional development, mentoring and coaching, informal learning, teacher collaboration, and independent learning. Finally, this chapter also dives into the theoretical frameworks guiding this study: the transactional model of stress and coping (Lazarus & Folkman, 1984); the buffering effect of social support (Cohen & McKay, 1984); and distributed leadership (Spillane et al., 2001b).

In Chapter III, the methodology used in this study is discussed in detail. For this study, I use a phenomenological approach centered around the phenomenon of teaching and/or leading in elementary science during the COVID-19 pandemic. In this chapter, I provide a rationale for the study design, describe the participants, outline the data sources and how they were analyzed, and discuss the confidentiality, reliability, validity, rigor of the study, and the role of the researcher.

Chapters IV and V both discuss the findings of the study, constructed as two separate papers in manuscript format. Chapter IV focuses on the first two research questions about first-year and early career elementary science teachers. The findings draw on the transactional model of stress and coping (Lazarus & Folkman, 1984) as a framework to explore the experiences, challenges, and coping strategies used by these teachers during the pandemic.

The second chapter of findings, Chapter V, focuses on district-level curriculum writers, curriculum specialists, and instructional coaches in elementary science. This chapter illustrates the challenges these educators face during the COVID-19 pandemic and how they are overcoming these challenges, using a distributed leadership framework (Spillane et al., 2001b) to analyze their work as educational leaders.

In Chapter VI, this chapter concludes with a summary and synthesis of the major findings from Chapters IV and V. Based on the findings, I provide implications and recommendations for practice in elementary science education, as well as implications for future research on elementary science education during a time of crisis.

Chapter II: Review of the Literature

The purpose of this study is to explore the experiences, challenges, and coping strategies of elementary teachers, educators, and leaders during the COVID-19 pandemic. To frame this study, I selectively and critically reviewed the following topics: teaching in times of crisis and teacher learning. I retrieved my sources from online databases from the Columbia University Libraries and Google Scholar.

Teaching in Times of Crisis

The COVID-19 Pandemic and Crisis Pedagogy

While the COVID-19 pandemic was new to the world at the beginning of 2020, researchers have already begun to try to understand the impact of this global pandemic on education through new studies. Remote learning, sometimes called distance learning, refers to classes and instruction that happen when students and teachers are not physically in the same space. In the case of the COVID-19 pandemic, remote learning was used out of emergency or crisis and the urgent need to maintain schooling, which is distinctly different from online learning which was designed to be remote, such as an online college course (Hodges et al., 2020). While generally online learning provides a degree of flexibility to students and teachers, the transition to remote learning in the Spring of 2020 was unplanned and rapid due to the school shutdowns, and thus distinguished as "emergency remote learning" by Hodges et al. (2020). Khanal (2021) argues for using crisis pedagogy during emergency remote learning, a pedagogical approach that is crisis-aware, and that utilizes learning activities designed to best support students during this tumultuous time. Within remote learning, instruction may be synchronous, meaning teachers and students are online together during the class time and able to communicate directly, or instruction may be asynchronous, meaning the teachers and students are not online together, but instead the teacher has shared an assignment or classwork for students to complete independently, often on their own time.

Studies have begun to examine the implications of the COVID-19 pandemic on education and the experiences of both students and teachers during remote learning. For example, Niemi and Kousa (2020) looked at the experiences of teachers and students at a high school in Finland during the beginning of the pandemic. In the Spring of 2020, the high school transitioned with no warning to online learning for two months, from mid-March to mid-May. The teachers felt that aspects of the transition were smooth because their students all had internet and devices for learning from home and the teachers were familiar with educational platforms they could use to support their instruction. However, the teachers faced challenges in that they did not have experience with the necessary pedagogical skills for teaching online and they missed the in-person interactions with their students (Niemi & Kousa, 2020). The students faced even more challenges because they felt fatigued, lacked motivation, and felt overwhelmed by a heavy workload, and they similarly missed face-to-face social interactions (Niemi & Kousa, 2020). The researchers described how not only was there a need for different pedagogy and types of assessment during online learning, "both teachers and students need to find new ways to strengthen social relationships in distance education" (Niemi & Kousa, 2020, p. 368). Furthermore, the authors emphasized the need for explicitly teaching teachers the necessary skills for distance learning in their preservice teacher education programs, and the need for ongoing support for teaching remotely throughout teachers' careers (Niemi & Kousa, 2020).

In a study on the experiences of 200 educators who taught across a variety of grades between primary school and higher education, van der Spoel et al. (2020) found that while the quick transition to remote learning left teachers feeling unprepared to teach online, teachers' experiences with remote learning depended on their prior experiences with using technology. Teachers with a medium amount of prior experience with technology had more positive experiences teaching remotely than those teachers with little or extensive prior experience with technology. The researchers also found that teachers believed a negative impact of the COVID-19 pandemic on their teaching practice was the lack of interaction with others (van der Spoel et al., 2020). However, one positive consequence of shifting to remote learning was that teachers were forced to change their educational practice, providing them with opportunities to reevaluate and reflect on their current teaching practice, which included the intention to continue incorporating more technology into their teaching to motivate students and differentiate instruction (van der Spoel et al., 2020). While the Spring of 2020 brought many challenges to both teachers and students due to the sudden shift to emergency remote teaching, teachers simultaneously found unanticipated opportunities to reflect on their teaching practice and grow as educators.

Overall, teachers faced a plethora of challenges during the abrupt shift to remote teaching and learning, and they continued to face challenges as they moved from the Spring of 2020 to the following academic year. Hartshorne et al. (2020) listed some of the challenges teachers are facing during the pandemic, which is not an exhaustive list: "content for online spaces, learning new delivery tools, understanding online pedagogy, engaging parents, addressing student mental health issues, and attempting various pedagogical strategies to address both synchronous and asynchronous teaching and learning" (p.138). During the Spring of 2020, teachers may have been in survival mode for remote teaching. The goal for the following academic year (2020-2021) was to support educators so that they can thrive as teachers while still in a pandemic. However, teachers need a great deal of support and new forms of professional learning to achieve this goal. Hartshorne et al. (2020) examined five themes of professional development for preservice and inservice educators during the pandemic: (1) best practices and resources for building supportive communities to help educators problem solve issues they are facing during COVID-19, (2) new models of online professional development and teacher education, (3) online teaching experiences for preservice teachers as fieldwork, (4) digital tools for teachers, and (5) equity concerns about the digital divide and access to technology, access to teacher professional development, and mental health of teachers and students. From these five themes, the authors identified key findings to facilitate teacher learning that is needed during the COVID-19 era. For example, within the fourth theme of digital tools, the authors found that teachers now need to be prepared to make decisions about when to use synchronous and asynchronous instruction to facilitate meaningful learning. Of particular importance to this study, within the first theme, the authors described how teachers are using innovative ways to build communities with other educators, such as using hashtags on social media platforms to seek help solving issues in the moment. In the second theme, the authors found that not only were teachers in need of PD on designing effective remote instruction, but teachers were also in need of unstructured, socially-connected, and learner-centered teacher preparation and PD. Moreover, social isolation due to the pandemic had negative impacts on both students' and teachers' mental health.

In elementary schools, teachers faced more and different challenges compared with teachers of older students. For instance, during online learning at the beginning of the pandemic, elementary teachers had more difficulty with planning, implementing, and evaluating their lessons because elementary lessons needed to be structured differently for online learning environments (Fauzi & Khusuma, 2020). Teachers also had more difficulty collaborating with their students' families at the beginning of teaching online, and overall, 73.9% of the elementary teachers believed that online learning was not effective for their students (Fauzi & Khusuma, 2020).

The COVID-19 Pandemic and Crisis Pedagogy for Elementary Science Teaching

While the COVID-19 pandemic and the shift to remote learning brought challenges to all educators, science education in a remote world presents a unique set of challenges that are worth examining at a closer level. Based on their reflections on the COVID-19 pandemic as a global crisis and the responses and solutions during this time, Lee and Campbell (2020) generated an instructional framework to be used by science and STEM educators in which educational experiences are grounded in real-world and societal issues, like the pandemic, as anchoring phenomena. This framework is based upon (1) data science and computer science, (2) the convergence of knowledge and practices across multiple disciplines, and (3) ongoing support for science and STEM teachers who must integrate and teach STEM subjects. Therefore, STEM teacher educators must generate professional learning opportunities for teachers that support and extend their teaching practices so that they can develop their students' problem-solving skills regarding complex societal issues. This framework is of use to elementary science because it provides suggestions to create new interdisciplinary, phenomena-based science learning experiences, as well as ideas about how to best support teacher learning in science during the pandemic.

A crisis such as the COVID-19 pandemic is only solved through interdisciplinary problem solving at the intersection of science, mathematics, engineering solutions, and data science. The COVID-19 pandemic disrupted society and normal ways of life, and thus to mitigate the impacts of the pandemic, professionals in STEM fields are finding solutions to slow the spread of the virus, creating new vaccines and medical treatments, and determining how to safely return to normal life and social interaction. These solutions rely on interdisciplinary knowledge. For example, designing effective face masks to slow the spread of the virus requires engineering skills, scientific understandings of human biology and virology, mathematics understandings of exponential growth, and technological abilities to use computer models.

Therefore, due to the pandemic, the Lee and Campbell (2020) called for K-12 STEM education to be reimagined, and that “teachers should play key roles in envisioning how to engage students with data science and computer science through the convergence of multiple STEM subjects to make sense of phenomena and complex societal problems, make informed decisions, and take responsible actions” (p. 933). The authors described the new role that science and STEM teachers must take on by integrating the STEM subjects in learning activities, instead of treating them as siloed disciplines, in order for students to develop robust decision-making skills towards taking action. While the current global pandemic has highlighted the need for interdisciplinary problem-solving skills and knowledge of the STEM disciplines, more research is needed to understand the day-to-day challenges faced by science and STEM educators who are teaching these skills and knowledge during this time.

Teacher Social-Emotional Learning

Social-emotional learning (SEL) in education has recently become a popular concept to address during the COVID-19 pandemic. SEL refers to teaching students explicitly about emotions, how to manage and feel their emotions, and how to respond to others’ emotional needs. While teachers are incorporating SEL teaching into the classroom for students to help manage their emotions during the pandemic (Darling-Hammond & Hyler, 2020), it is essential to consider teachers’ emotional well-being and how they are managing their emotions as teachers during the pandemic. While teaching before the pandemic could be considered a stressful profession, the pandemic has exacerbated the stress and anxiety that teachers manage daily. Roman (2020) used a trauma-informed perspective to assess preservice teachers' levels of stress during the pandemic. While preservice teachers displayed a range of stress levels from low to extreme stress, more importantly, some preservice teachers did not engage in their course activities, indicating disengagement overall with their teacher education coursework during the pandemic.

Therefore, teachers should be prepared with the necessary tools to manage their emotions and be taught teacher SEL in their teacher preparation programs. Hadar et al. (2020) examined to what extent teacher education programs prepare future teachers with the necessary teacher social-emotional skills to deal with extreme circumstances that are volatile, uncertain, complex, and/or ambiguous (VUCA). The COVID-19 pandemic is one such circumstance, but other events might include natural disasters or technological developments that disrupt normal life and education. By looking at the experiences of student teachers during the pandemic, the researchers found that the student teachers had difficulty managing the stress they experienced during the pandemic and had difficulty coping (Hadar et al., 2020). The researchers argued for the prioritization of teachers' social-emotional learning as a part of the teacher education curriculum. They describe how if the ultimate goal is to teach and support students' social-emotional skills in the classroom, it is on teacher education programs to help future teachers develop these skills to manage their emotions through explicit practices, such as mindfulness (Hadar et al., 2020). Furthermore, this work cannot just begin and end at the preservice level, but it must continue as part of teacher learning for inservice teachers as well to develop and maintain these SEL skills.

Teacher Learning

While the journey to learn how to teach science may begin for elementary teachers during their teacher education programs, their science methods coursework and field placements are critical spaces for learning to teach science. Teaching in field placements is an ongoing process as teachers continually refine and modify their practice, either consciously or unconsciously. Because preservice teacher education programs cannot prepare teachers for all aspects of the realities of entering the classroom and because learning to teach is an ongoing process, teacher education for inservice teachers who are working in classrooms is necessary to continue teacher learning.

Professional Development

As educational reforms and initiatives perpetually call for higher standards of student learning, teachers need to continually grow and develop to meet these demands. Moreover, the COVID-19 pandemic has disrupted education in a way that has called for new pedagogical strategies and curricula. For current teachers to continue to learn how to teach during the pandemic and to adapt to new forms of education, there is a need for professional learning for inservice teachers. Opportunities for inservice teacher learning include professional development (PD), mentoring and coaching, teacher collaboration, informal learning moments and interactions, and independent learning.

Inservice PD engages teachers in learning as they are working in classroom contexts. Traditional models of PD typically use an outside expert who does not have a detailed knowledge of the school's context to provide teachers with a workshop that is disconnected from teachers' classroom practices and from other PD sessions. Because these experiences are not highly valuable to teacher learning, there is a need for higher quality PD (Guskey, 2002). A variety of newer models of PD that incorporate opportunities for reflection and feedback are based in the teachers' school context, provide teachers with explicit models of teaching, are collaborative, focused on student learning, treat teachers as professionals, and provide support after the PD to help teachers implement new knowledge and skills (Erdas Kartal et al., 2018; Penuel et al., 2011; Svendsen, 2020; Wilson & Berne, 1999).

Furthermore, Wilson and Berne (1999) argued that learning requires some amount of disequilibrium; teacher learning occurs when their assumptions are challenged, so PD must be more substantive and intellectually rigorous to make considerable changes in teachers' practices and beliefs about learning. Feiman-Nemser (2001) outlined a long-term model of PD along a professional learning continuum. Instead of discrete workshops and trainings, the professional learning continuum uses sustained PD through ongoing conversations and creating communities of practice. This model connects teacher learning experiences throughout preservice education, the induction years, and inservice PD.

Recent developments in science-specific PD provide a consensus view of high-quality science PD that models inquiry, incorporates teachers' classroom teaching and experiences with current students, focuses on content and skills, is intensive and sustained, and is connected to other aspects of school change (Supovitz & Turner, 2000). Because of the recent push to improve science learning through the use of inquiry and engaging students in authentic scientific practices, these types of high-quality PD will encourage teachers to use inquiry-based pedagogies (Supovitz & Turner, 2000). Research has also shown that major changes in teachers' science teaching practices, nature of science views, science content knowledge, and classroom culture occur after long-term PD programs that span multiple weeks or even years (Erdas Kartal et al., 2018; Pringle et al., 2020; Supovitz & Turner, 2000). For example, Penuel et al. (2007) emphasized the need for longer PD programs for the implementation of new earth science curricula. This reform-oriented model of PD allowed for in-depth exploration of the content and pedagogies, collaboration with colleagues from their school, time for teachers to plan classroom implementation of the curriculum, and support for curricular implementation, such as modeling classroom activities and setting up equipment in their schools (Penuel et al., 2007). Pringle et al. (2020) described the effectiveness of a comprehensive, five-year PD model that improved middle school teachers' disciplinary content knowledge and ability to enact reform-based instructional practices by creating a safe space for teachers to learn and reflect together and by gaining the support of the goals of the PD from school administration and leaders.

Different models of science PD have different affordances and drawbacks for elementary science teacher development. Feiman-Nemser's (2001) professional learning continuum model of PD can be considered high-quality because of its coherence in stated goals from preservice education to ongoing teacher learning during classroom teaching. In addition, this model supports sustained teacher learning over time. Following Lave and Wenger's (1991) theory on situated learning, learning happens in the context in which it is applied through participation in communities of practice. This continuum model may be effective in teacher learning because learning is dependent upon context, so it provides cohesive PD across different contexts of teacher learning, from university settings into the classroom. Along this continuum, preservice teacher education provides opportunities for teachers to begin to develop their science teaching practice, but most preservice science methods coursework can only cover limited science content in the time given. Therefore, this continuum provides inservice teachers with science PD that aligns with their preservice education and expands teachers' content knowledge, skills, and PCK. The continual development of elementary teachers' science understandings, skills, and PCK as they are working in classrooms is necessary for teacher growth and learning.

Mentoring and Coaching

In the 1980s and 1990s, with the goal of decentralizing authority within schools, sharing decision-making processes, and tapping into the resources that teachers have, schools increasingly began to position teachers as master, lead, and mentor teachers (Mangin & Stoelinga, 2010). Within the last twenty years, subject-specific coaches have become increasingly popular, as new reforms have emphasized the need for school-based support for instruction (Knight, 2008). Instructional coaches may act as leaders who are intended to focus on instruction, be situated within the school, and encourage sustained collaboration among teachers (Mangin & Stoelinga, 2010). While intended to help teachers improve their practice, few studies exist on how coaching improves instruction, nor do many studies exist on coaching from the teacher's perspective (Neumerski, 2013). Schools oftentimes do not know how to best utilize their coaches or how to explicitly define the coach's role (Neumerski, 2013). Most research on coaching has focused on the characteristics of good coaches, although some studies that have looked at the effects of coaching on instruction have found mixed results (Neumerski, 2013). A small portion of the literature around coaching has shown that instructional coaches are capable of causing teachers to implement new practices, but how they achieve this is not well understood (Neumerski, 2013). While coaching and mentoring may be a way for teachers to learn in the context of their classrooms with sustained support over time, more research is needed on how instructional coaches can help teachers improve their practices.

Informal Learning

In addition to formal district-sponsored PD, PD sought out by teachers, mentoring, and coaching, teachers learn through informal contexts, which may include conversations with administrators, team planning meetings, interactions with other teachers, experimentation in their classrooms, and beyond. Marsick and Watkins (2001) emphasized the importance of informal learning in how adults learn and define both informal and incidental learning in contrast with formal learning. While formal learning is highly structured and typically classroom-based, informal learning is not highly structured and the responsibility of the learning is on the learner. Incidental learning, which is a type of informal learning, is the byproduct of another activity, such as an interaction with a co-teacher. Informal learning, in this sense, while not highly structured, is intentional. Teacher learning may occur informally in communities of practice through collaborative planning among teachers (Eshchar-Netz & Vedder-Weiss, 2020), and the literature on informal learning has characterized it as integrated into daily routines, not highly conscious, influenced by chance, an inductive process of action and reflection, and connected to the learning of others (Marsick & Watkins, 2001). Informal communities of practice, mentoring, and coaching serve as good examples of the ways in which teachers learn informally through collaboration, reflection, and action.

Much of the informal learning that proceeds in schools is dependent upon the environment and the school's culture. Collaborative and collegial learning environments are more likely to provide informal school-based learning opportunities to teachers. Jurasaite-Harbison and Rex (2010) examined how school culture cultivates opportunities for teacher informal learning. Because informal learning proceeds through interactions among teachers and through reflection on practice, the researchers believed that teacher learning is contextually situated and "a school culture that encourages and supports teacher learning through creating opportunities and providing a stimulating context for teacher change" (Jurasaite-Harbison & Rex, 2010, p. 268) is essential to generating educational reform. The researchers emphasized the importance of acknowledging informal learning as an integral component of teacher professional development and they identified aspects of school culture that can help or hinder informal teacher learning, including the school's mission, classroom environment, traditions, and professional relationships (Jurasaite-Harbison & Rex, 2010). The findings indicate that opportunities for collaboration among teachers are not sufficient; teachers need a physical and social environment that promotes interactions, the acknowledgment of collaboration as an explicit goal for teachers and administrators, the value of informal learning as important to their work, and institutional and national policies that create a stable and positive learning environment to learn informally (Jurasaite-Harbison & Rex, 2010).

While establishing a firm binary of formal versus informal learning may be an overly simplistic and reductive representation of how teachers learn that is dependent upon time, space, and content, the distinction may be productive in thinking about why and how leadership functions among many actors, such as teachers who do not hold formal leadership positions. Spillane (2005) emphasized the importance of informal routines, such as lunchroom conversations, as sites for leadership within elementary schools, which highlights the need to analyze teachers' and school leaders' social networks centered around instruction. To understand the practice of leadership as it related to teaching and learning and how elementary teachers continue to learn while they are working in schools, it is necessary to consider all situations in which leaders and followers interact and formal and informal learning occurs.

Teacher Collaboration and Networks

It is often assumed that in terms of teacher learning, collaborative environments and interactions, such as collaborative PD and team planning meetings, lead to greater teacher learning and therefore improved instruction. To enact change in schools, many schools rely on collaboration among teachers in the form of co-teaching, implementing instructional changes, and co-planning curricula. Schools and administrators also rely on existing teacher relationships within the school, referred to as teacher networks, to enact reform. However, it is important to consider the conditions under which teacher-to-teacher collaboration leads to supportive environments and therefore teacher learning, professional growth, and school change.

Researchers have challenged the idea that participation in collaborative PD will benefit all teachers equally. There is variation in the degree to which teachers adopt and adapt strategies taught during collaborative PD, and how quickly, how frequently, and the quality of adoption depends on teacher characteristics, such as their curricular knowledge, pedagogical knowledge, and their ability to reflect on instruction (Brownell et al., 2006). Therefore, the assumption that collaboration among teachers is universally helpful for all teachers to improve their instruction and enact change must be examined in more detail.

When trying to enact any school reform or school-wide teacher learning, it is essential to consider the existing social relationships among teachers and other staff within the school. The establishment of teacher collaboration within a school depends on the schools' structural environment and individual factors, including the teacher's attitude towards collaboration and seeking out teachers they view as having expertise (Schuster et al., 2021). Moreover, two teachers are more likely to collaborate if they share similarities, such as the same gender and professional roles (Schuster et al., 2021). The structure of these social relationships has an impact on enacting change in that they can support or constrain change within a school (Daly et al., 2010). Social networks can impact the implementation of a reform in that teachers who interact more within grade level or teaching teams are able to enact reform more deeply in terms of time, content, and focus, than teams of teachers who interact less frequently (Daly et al., 2010). While collaboration can lead to change on the schoolwide level and to teacher learning through informal and incidental learning, the types of existing teacher-teacher relationships and personal attributes of individual teachers impact the quality and depth of change.

Independent Learning

In addition to collaborative learning interactions, teachers also initiate independent learning on topics that interest them or on topics that they feel they need further education on, oftentimes in different times and spaces. Independent teacher learning can be understood as learning activities that teachers seek out independently, with no relation to their organization. Teachers may initiate learning independently using blogs, social media, online courses, professional learning sites, as well as books, conferences, and workshops. There is little research on independent teacher learning; however, some studies have looked holistically at formal, informal, and independent teacher learning. For example, Jones and Dexter (2014) examined how middle school math and science teachers learned to integrate technology into their classrooms. Teachers learned through formal PD in professional learning communities (PLCs), which provided a space to discuss ideas, and informally through interactions such as email exchanges. Independently, teachers sought out lessons and resources online to help with their technology integration, spurred by the inadequacies of their school-based formal learning. The researchers argued that by only supporting formal PD activities, the school district did not take advantage of the valuable knowledge its teachers collectively had, from their diverse experiences and independent learning (Jones & Dexter, 2014). To understand how teachers learn to teach, it is important to acknowledge all of the different spaces and contexts in which teachers learn-- formal, district-sponsored PD, mentoring and coaching, informal interactions with colleagues, and independently seeking out resources outside of school-- and consider the affordances and drawbacks of each.

Theoretical Frameworks

The data collected throughout the course of this research was informed by and analyzed through the lenses of the transactional model of stress and coping, the buffering effect of social support, and distributed leadership as theoretical frameworks. These lenses were used as analytic frameworks for understanding how educators experience, evaluate, and manage stress and the impacts of stress on their practice, as well as how multiple educators can share leadership during a time of crisis.

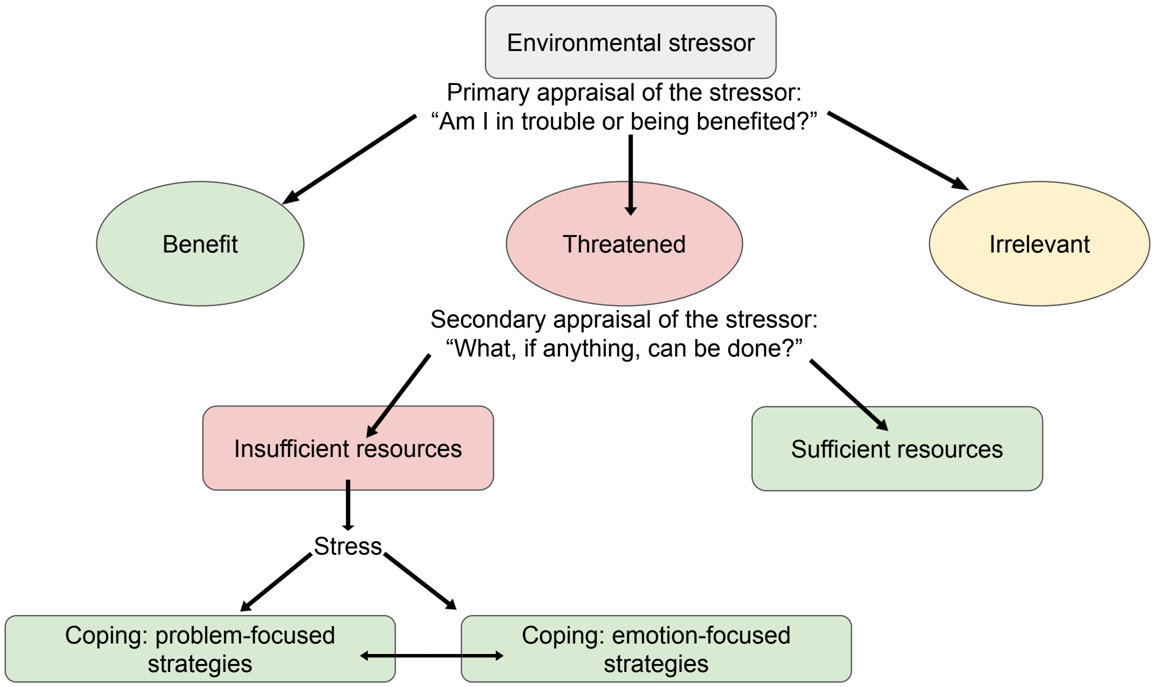
Transactional Model of Stress and Coping

The transactional model of stress and coping, developed by Lazarus and Folkman (1984), provides a theoretical framework for understanding how individuals respond to and attempt to manage psychological stressors using cognitive appraisals. Figure 2.1 represents the process of appraising a stressful situation and coping with the stress of the situation, defined by Lazarus and Folkman (1984) and described in more detail in the subsequent sections.

Stressors

As described by Lazarus and Folkman (1984), psychological stress is "a particular relationship between the person and the environment that is appraised by the person as taxing or exceeding his or her resources and endangering his or her well-being" (p. 19). Lazarus and Folkman's definition of stress emphasizes that it is the relationship between the person and the environment that causes stress to an individual, which incorporates individual differences in how people perceive stressful situations and the nature of the event.

Figure 2.1
Lazarus and Folkman's (1984) transactional model of stress and coping



Appraisals

Cognitive appraisals of the stressor are the ways that people categorize an event in relation to their well-being (Lazarus & Folkman, 1984). As an individual interprets a stressor, the individual goes through two cognitive appraisals: primary and secondary. In response to an event, an individual will first go through a *primary appraisal*, which involves the individual evaluating the event to determine if it is stressful, beneficial, or harmful (Lazarus & Folkman, 1984). Harmful events can be described as being a harm/loss in which some damage has been done, a threat in which harm or loss is anticipated, or a challenge that offers positive potential growth to tackle the challenge. When faced with a threat or challenge, individuals will undergo a *secondary appraisal* of the event, in which individuals evaluate what coping mechanisms are available to them and how effective they would be (Lazarus & Folkman, 1984). Challenge and threat are not mutually exclusive; for example, while some may view the COVID-19 pandemic as solely a threat to humans' well-being, others may view it as a threat, as well as a challenge one is eager to grow and learn how to adapt to. Additionally, the relationship between one's perception of the event as a threat and challenge can change over time (Lazarus & Folkman, 1984).

Multiple factors influence the appraisal processes. Primarily, two characteristics of an individual are important in determining the outcome of the appraisal processes: 1) the commitments of what is important to the person, as these underlie the decisions people make and will guide the person into or away from particular situations; and 2) the personally-formed or culturally-shared beliefs a person has, which function as a lens for how one evaluates events that happen or are about to happen (Lazarus & Folkman, 1984). Therefore, how one perceives an event, such as the COVID-19 pandemic, and whether it is a harm/loss, threat, or challenge is dependent greatly upon the individual and their commitments and beliefs.

Coping

Lazarus and Folkman (1984) define coping as "constantly changing cognitive and behavioral efforts to manage specific external and/or internal demands that are appraised as taxing or exceeding the resources of the person" (p. 141). This definition is process-oriented in that it depends on the specific context and conditions of what the person is coping with and is constantly shifting based on the relationship between the person and the environment. Coping can change as the stressful event unfolds over short or long periods of time as the person reevaluates or reappraises the stressor. Coping strategies available to the individual allow the individual to effectively deal with the stressor.

Lazarus and Folkman (1984) describe two main forms of coping strategies: *emotion-focused strategies* and *problem-focused strategies*. *Emotion-focused strategies* include and use cognitive processes to lessen emotional distress (such as avoidance) and can change the meaning of the situation, without actually changing the situation. Similar to problem solving, *problem-focused strategies* use a variety of problem-oriented strategies to define the problem, consider solutions, choose the best solution, and put the solution into action. These strategies can be directed at the environment (like problem solving) or inward to oneself. These two forms of coping strategies are not mutually exclusive; that is, one can use both problem-focused and emotion-focused strategies during one stressful experience, but the strategies used may support each other or hinder each other during the coping process. Effectively using these coping mechanisms allows an individual to shift their appraisal of the event from perceiving the event as more threatening than challenging, to more challenging (Lazarus & Folkman, 1984). People who are more challenged than threatened can function better during the event, as they are less overwhelmed, have a positive attitude, and are more capable of drawing on their resources (Lazarus & Folkman, 1984).

Coping is also determined by the secondary appraisal, asking oneself, "What can I do?" and the resources available in the stressful experience play a role in how people cope. Lazarus and Folkman (1984) list the categories of resources available to people for coping: being healthy and energetic, positive beliefs about oneself and staying optimistic, problem-solving skills such as seeking out information and weighing possible solutions, social skills (being able to communicate effectively and appropriately with others), social support from others, and material resources, such as money. Lazarus and Folkman describe how the resources for coping are often sufficient; however, people fail to draw on the available resources due to personal and environmental constraints, such as declining social support because of fear about how other people may perceive them.

Research has used the transactional model of stress and coping to model stress management programs to study the impact of the coping strategies on educators. Mazloomy Mahmoodabad et al. (2014) provided elementary teachers with a stress management program, which included methods of reducing stress based on the transactional model of stress and coping. The researchers found that compared with teachers who received a traditional stress management program, teachers who received the stress management program based on the transactional model of stress and coping had a greater decrease in stress after the program. The program they received emphasized coping strategies that incorporated emotional regulation (*emotion-focused strategies*) and problem management (*problem-focused strategies*). Therefore, the transactional model of stress and coping provides an effective framework for considering how educators are processing the stressors associated with the COVID-19 pandemic and the effectiveness of their coping methods.

Buffering Effect of Social Support

The buffering effect of social support theorizes that having interpersonal relationships can help to buffer against the negative effects of stressful life events. Cohen and McKay (1984) described how according to the buffering hypothesis, psychological stress will have worse effects on people with little or no social support and those who have stronger social support systems will have lessened or no harmful effects when faced with stress. Because early research on the buffering hypothesis had inconsistent results, Cohen and McKay defined what social support is, how to measure it, and the mechanisms by which it operates, and ultimately proposed a multidimensional model of social support and the buffering process.

In their model, Cohen and McKay (1984) describe how a stressor or stressful event could potentially elicit a stress appraisal, following Lazarus and Folkman's (1984) transactional model of stress and coping, but prior to the person evaluating their ability to respond to the stressor. The actual experience of stress can be defined as the negative affect, elevation of psychological response, and behavioral adaptations that occur in response to a threatening situation (Cohen & McKay, 1984). There are a variety of supports that can be helpful when faced with a stressful event, both psychological and non-psychological. Non-psychological supports are tangible supports, like money and forms of assistance, whereas psychological supports can be categorized as appraisal supports or emotional supports (Cohen & McKay, 1984). Appraisal supports are those that shift the appraisal process of an event, such as social support that can help someone reevaluate a situation as less threatening or provide better coping strategies. Emotional supports relate to a person's feelings about themselves and through social support, it can increase one's self-esteem and feelings of belonging, thus increasing their immunity to stress (Cohen & McKay, 1984).

In their refined buffering hypothesis, Cohen and McKay (1984) posited that different stressors and stress experiences elicit the need for different types of support, and thus to buffer a stressor or stress experience effectively, the interpersonal relationships must provide the right type of support that is needed. Additionally, the timing of the support plays a role as social support can buffer in between the stressor and the stress experience, or in between the stress experience and the onset of a pathological response (Cohen & McKay, 1984). During the ongoing stress of the COVID-19 pandemic, therefore, teachers who are experiencing stress will need different types of support at different times.

Moreover, Dalgard et al. (1995) found not only support for the buffering hypothesis in that social support buffered the risks of developing depression when faced with negative life events, but the researchers also found that personality impacts the need for social support during negative life events. People who view themselves as the most important factor in controlling what happens to them do not need as much social support to cope with negative events as people who see themselves as powerless in influencing what happens to them when faced with external events (Dalgard et al., 1995). Therefore, the individual, as well as their social resources, impact a person's mental health risk when faced with negative life events.

Research has examined the role of social support as a buffer against workplace stressors. For example, Frese (1999) longitudinally studied the buffering effect on 90 male blue-collar workers who worked in steel and automobile companies in Germany. To test the match hypothesis that buffering is highest when there is a match between coping requirements and the available supports, Frese measured the work stressors of the workers through observations, peer ratings, and the target individual's perceptions of the stressor. Frese found that a higher relationship between stressors and psychological dysfunctioning when social support is low, and a lower relationship between stressors and dysfunctioning when social support is high, supporting the buffering hypothesis. Not only does social support buffer the negative effects of stressors on health, social support at work buffered social stressors (social anxiety and irritation specifically), over other types of non-social stressors (physical and psychological stressors) (Frese, 1999).

Taken together, the transactional model of stress and coping and the buffering effect of social support provide a lens for examining how people cope with a stressful and threatening event which considers available resources, including social support and emotion-based and problem-based coping strategies.

Distributed Leadership

The data collected throughout the course of this research is also informed by and analyzed through the lens of distributed leadership as a theoretical framework (Spillane et al., 2001b). A distributed perspective on leadership is not a prescriptive method to effectively organize leadership within an institution; it functions instead as an analytic framework for understanding how leadership is distributed throughout an organization. Compared to more traditional approaches to understanding leadership, distributed leadership (DL) offers a systemic perspective that focuses on *how* leadership is distributed. A distributed perspective attends to not only the *what* of what school leaders do, but more importantly to the *how* and the *why* of leadership practice. DL is theoretically rooted in distributed cognition, which describes how human cognition cannot be separated from an individual's environment and how human activity is distributed across individual actors, artifacts or tools, and situations (Spillane et al., 2001b). DL is also rooted in activity theory (International Congress for Research on Activity Theory, 1999), which posits that to think and act, actors rely on pre-established cultural, social, and historical norms, even when acting alone (Spillane et al., 2001b). These theoretical underpinnings emphasize the centrality of social context in distributed leadership practice. However, DL maintains a tension between social context and individual agency and judgment, as some activity is more distributed in material and social situations than other activity (Spillane et al., 2001b).

When utilizing DL as a descriptive theoretical lens, it is helpful to consider its two main components: the leader-plus aspect and the leadership practice aspect. The leader-plus aspect includes all people involved in leadership practice, both formally and informally, in an organization (Neumerski, 2013). The leadership practice aspect foregrounds interactions among leaders, followers, and their situation (Neumerski, 2013). The leadership practice aspect includes three components: interactions between leaders and followers, context, and leadership tasks (Neumerski, 2013). According to Spillane and Diamond (2007), leadership practice is constructed from the actions and interactions of leaders and followers, which cannot be extracted from their particular place and time, and are situated in particular tasks.

From a distributed perspective, leadership is grounded in activity and not centered around individuals or specific roles. Human activity is not grounded in an individual's skills and knowledge, but activity is instead distributed or stretched over people and context (Spillane et al., 2001b). It is important to move away from focusing on individual leaders, as well as understanding the notion that leadership does not necessarily have to be shared equally or democratically to be distributed (Bolden, 2011). While different authors may vary in their opinions on DL, most authors agree on certain premises about DL, such as leadership as an emergent property from a group of interacting individuals and the openness of the boundaries of leadership (Bolden, 2011).

DL provides a productive framework for thinking about school leadership as a distributed practice that is spread over social and situational contexts within a school. A distributed perspective on school leadership describes leadership as involved in "the identification, acquisition, allocation, coordination, and use of the social, material, and cultural resources necessary to establish the conditions for the possibility of teaching and learning" (Spillane et al., 2001b, p. 24). Analysis of school leadership must focus on leadership tasks, not the work of leaders, that are intended to empower others and cause a major change in the nature of teaching and learning (Spillane et al., 2001b). Spillane et al. describe how leadership tasks can be conceptualized as macro, or large-scale organizational tasks, and micro, the day-to-day work of leaders. Leadership practice and its relationship to instruction and instructional change can be analyzed through the big-picture macro functions and their breakdown into smaller micro-tasks of school leaders. For example, DL allows us to examine the larger, macro leadership functions by understanding how school leaders define and execute micro-tasks that work towards the larger goals, while leaders are interacting with others in the process.

Limitations of a Distributed Perspective

While DL offers a useful lens for understanding how leadership is distributed in a school among leaders, followers, interactions, and context, there are some drawbacks to using this theoretical frame. One such drawback is the insufficient consideration of power dynamics in the school when using DL. Power is inherently implicated within the discourses and practices of leadership and power may not necessarily be distributed in the same way that leadership is (Bolden, 2011). Therefore, it is essential to take power dynamics into account when analyzing how leadership is spread out through a school.

In addition to its negligence of power dynamics within a school context, DL also creates some ontological and methodological challenges. By not challenging the fundamental building blocks of leadership, such as the terminology of leaders and followers, DL sustains the assignment of the centrality of leadership on individuals (Bolden, 2011). Furthermore, DL does not question the existence of leadership itself as a concept, despite current literature on leadership as a social construction (Bolden, 2011). Previous research methods have focused on key actors in leadership roles; there is a need to not only look at leadership on a school-wide level, but there is a need for research methods that examine organizational outcomes, such as teacher learning. If DL is to be used as a productive theoretical framework, more connections to school improvement, leadership development, and instructional change need to be made.

Relationship of Theoretical Frameworks to Science Education

The frameworks of the transactional model of stress and coping, along with the buffering effect of social support, and distributed leadership provide lenses to better understand the experiences of science educators during the COVID-19 pandemic. While these frameworks are useful to understand the experiences of all educators during this time of crisis, they are particularly useful in understanding the challenges that science educators face and how they overcome these challenges through coping and leadership practices. All educators experienced stress during the pandemic and had to develop their own means of coping, but elementary science educators faced a unique set of challenges as a result of the pandemic. Under normal circumstances, science is marginalized throughout elementary education and the subject is not prioritized by schools and administration (Mensah, 2010; Rivera Maulucci, 2010). As a result, science teachers are constrained by the limited resources available to them in a variety of forms: cultural, materials, and social resources (Rivera Maulucci, 2010). Elementary science teachers in particular lack strong support and science instructional leadership (Abell et al., 2007), thus inducing stress. This marginalization and stress experienced by elementary science educators were exasperated because of the pandemic in that instructional time devoted to science was further reduced and priority was given to literacy and mathematics learning. There is generally a need for greater support in various forms for elementary science teachers, but this need has been compounded by the pandemic. Therefore, these frameworks provide a lens for understanding the unique stressors and coping mechanisms particular to elementary science educators, and how many educators act as leaders who may enact change and teacher learning in science education during the pandemic.

Chapter III: Methodology

Introduction and Overview

This chapter describes the methodology used to address the research questions and is organized into the following sections: (a) rationale for using a qualitative approach, (b) setting and participants, (c) methods of data collection, (d) research process and role of the researcher, (e) data analysis methods, (f) issues of trustworthiness, (g) ethical considerations, and (h) limitations of the study.

Rationale for Qualitative Approach

The nature of studying the experiences of, emotions felt, and challenges faced by elementary science educators during the COVID-19 pandemic lends itself to qualitative research. Litchman (2012) defines qualitative research as a way of knowing about human behavior and beliefs in natural and social settings. Following a constructivist philosophy, qualitative research provides in-depth descriptions of the human experience through the construction of multiple realities by the researcher, who is the primary instrument of data collection (Litchman, 2012; Merriam, 2009). Qualitative research is interested in understanding how the participants understand the world, especially in educational contexts (Merriam, 2009). Key components of qualitative research include studying a few elements closely to build thick description and holistic understandings; flexible research design that is capable of changing; data collection and fieldwork in natural settings; inductive thinking that builds theories rather than testing existing theories; and the essential role of the researcher because realities are constructed through her viewpoint (Litchman, 2012). Because of the unique ways in which educators are re-adjusting their roles, the uncertainty they face, the complicated emotions they feel, and the context-specific challenges they face, qualitative research provides a means to understand science teaching during a unique time of crisis that takes into account the complexities of science teaching and learning, the ways in which educators attempt to overcome challenges and learn to cope with stress, and uses an interpretive perspective that views education and learning as ongoing processes.

The methodology best suited for qualitatively studying the experiences of elementary science teachers, district-level elementary science curriculum specialists, and elementary science instructional coaches during the COVID-19 pandemic is a phenomenological approach. A phenomenology examines the lived experiences of participants experiencing a shared phenomenon and aims to define the essence of the phenomenon by describing what the individuals have experienced and how they have experienced it (Creswell, 2013). A recent study by Sadovnikova et al. (2022) used a phenomenological approach to understand the features of teachers who experienced crisis during the transition to online learning because of the pandemic. By comparing an experimental group of teachers experiencing a professional crisis to a control group, Sadovnikova et al. characterized the perceptions, emotions, and personalities of those teachers who experienced a crisis. Similarly, by studying a group of educators' experiences with the phenomenon of teaching science during a time of crisis, I hope to define the essence of teaching elementary science during a pandemic by identifying the challenges science educators face and how they are overcoming these challenges.

Setting and Participants

The sample of this study was four elementary science or STEM teachers or specialists and four district-level elementary science educators. The science or STEM teachers or specialists included in this study were teachers who specialize in and only teach science and/or STEM in the elementary grades (pre-kindergarten through sixth grade) and who are in their first year teaching elementary science or have six to eight years of experience teaching elementary science.

Elementary classroom teachers who taught science amongst the other content areas were excluded from this study as science is not the primary focus of their teaching. The district-level elementary science educators who participated in this study held more varied roles (to be described in more detail in Chapter V), but fit the requirements of not teaching students directly, but working with elementary teachers as science coaches, mentors, and/or curriculum specialists. Within the participants, I purposefully divided the sample into elementary science teachers and specialists, who work in classrooms directly with children, and district-level elementary science coaches, mentors, and curriculum specialists, who do not teach children daily but instead work with teachers. A list of all participants in the study can be found in Table 3.1.

Table 3.1
Summary of Participants

Participant	Sex	Role	Location	Years of teaching experience
Frankie	F	Director of STEM education programs Grades K-5	Los Angeles	6-8 years
Bailey	F	Science curriculum specialist Grades K-5	Seattle	10+ years
Paulo	M	Elementary science specialist Grades K-5	Florida	10+ years
Hazel	F	Elementary science curriculum specialist Grades PK-6	Los Angeles	10+ years
Inez	F	Elementary science teacher Grades PK-4	New York City	6-8 years
Emma	F	Elementary science teacher Grades 1-4	Philadelphia	6-8 years
Marisa	F	Elementary science teacher & special subjects coordinator Grades 2-6	Boston	6-8 years
Oscar	M	Elementary science teacher Grade 1	New York City	First year

To recruit participants, I shared a recruitment flyer (see Appendix A) to the listserv for elementary educators in the National Science Teachers Association (NSTA). Teachers and educators from across the country could participate, as schools nationwide have been impacted greatly and diversely by the pandemic. Interested educators were given a link that provided them with the information about any potential risks of this study and were asked to sign an Informed Consent Form (provided in Appendix B), before completing the online survey. The teachers and district-level educators were also notified of their rights as participants in this study as described in the Participants' Rights Form (provided in Appendix C).

Methods of Data Collection

To gain an in-depth understanding of the experiences and challenges that elementary science educators are facing during the COVID-19 pandemic, multiple forms of qualitative data were collected to support my findings over the course of seven months. Primary data was collected in the form of (a) a survey, (b) individual interviews, and (c) focus group interviews.

Surveys. An online 15-question survey was used to collect initial demographic information about the participants, using Qualtrics, a web-based survey tool. The survey also asked participants about their experiences with elementary science over two different periods of the pandemic: (1) the initial abrupt shutdown mid-year in March 2020 and (2) over the course of the 2020-2021 academic year. In the survey, I included both open-ended and multiple select question types and asked participants to indicate their format for teaching (remote, in-person, or hybrid), the challenges they faced, and the supports they needed during these two periods of the pandemic. The purpose of the survey was to gain an initial understanding of each educator's situation and context, and what they generally found challenging about their role during the pandemic, as well as to gain an understanding of the different formats and challenges of the abrupt change mid-year, compared with the planned situation for the following academic year. The survey questions are listed in Appendix D.

Individual interviews. Interviews were collected during this study for obtaining information that cannot be observed, such as participants' feelings, attitudes, and perceptions (Merriam, 2009). Interviews also provided abundant information about the participants' experiences and feelings through descriptions using their own language, with opportunities for probing for clarity, context, and causality. Therefore, interviews conducted during this study provided data on the participants' beliefs and perceptions about science education during the COVID-19 pandemic, as well as descriptive data about their experiences working in science education during these unprecedented times, the challenges they are facing, and how they are overcoming these challenges.

In-depth interviews were conducted once with each teacher or educator to understand the specifics of the participant's teaching context regarding in-person or remote teaching, what the participant found most challenging, their emotional experiences, and their methods of coping with stress on a professional level. All of the interviews followed a semi-structured format over Zoom, a video teleconferencing platform. The semi-structured interview format included predetermined questions, while also allowing for the flexibility to explore relevant topics as they emerged during the interview and as I deemed appropriate. Each interview lasted between 45 to 60 minutes. See Appendix E for the individual interview protocol.

The purpose of the interviews was to address the research questions on a deeper level; that is, to understand the unique experiences of each participant in their particular context, as every school has handled the restrictions of the pandemic differently, and to understand the challenges specific to each elementary science teacher and educator and their methods of overcoming these challenges and coping with the stress of teaching science during the pandemic.

Focus Group Interviews. Participants also participated in one focus group interview, with two or three other participants and the researcher. The focus group interviews followed a semi-structured format, were conducted virtually over Zoom, and lasted between 60 and 90 minutes. The participants were grouped based on availability and purposefully to have variety among the educators' roles, locations, and years of teaching experience. The purpose of the focus group interviews was to allow participants to meet other educators from across the country and to give them an opportunity to connect with other educators in elementary science. By doing so, my goal was to gain a deeper understanding of their experiences and challenges through hearing about their shared experiences and comparing and contrasting the experiences among participants as they discuss their specific circumstances in their schools during the pandemic. The purpose of the focus group interviews was also to triangulate the data and findings that were emerging. The focus group interview protocol can be found in Appendix F.

Research Process and Role of the Researcher

As a doctoral student in science education, I came to this research on elementary science education during the COVID-19 pandemic when my initial research project was disrupted by the shutdown at the beginning of the pandemic. I was collecting data in person at an elementary school through classroom observations that no longer were possible when schools closed abruptly in March 2020. While I have always been interested in research on elementary science education and passionate about the importance of science learning for young children, education in a time of crisis was a new research context that presented itself when my initial research project was no longer feasible. However, the context of education during a pandemic is a novel and challenging situation and therefore emergent research was and continues to be needed to better understand the impacts of the pandemic on education. Moreover, this work became more meaningful to me as I began teaching as a science specialist in an elementary school in the Fall of 2020.

In addition to the pandemic being the context for participants in their roles, the COVID-19 pandemic was also the context in which I conducted my research. Over seven months, I collected the data listed above in virtual formats. After sharing my recruitment flyer on the listserv of all elementary science educators who are members of NSTA, the participants signed the digital consent form and completed the digital survey. After the teachers and educators completed the survey, I selected eight participants to participate in individual interviews that were conducted on Zoom over three months. After that, I began the initial analysis process of the survey and interview data. While in the initial stages of data analysis, I held three focus group interviews over the next three months. Due to the pandemic, I was unable to observe participants in their teaching and coaching contexts, but conducting virtual interviews provided some benefits. Virtual interviews held over Zoom allowed me to connect with educators across the country easily and virtual focus group interviews provided opportunities for educators to meet one another and connect with other people doing similar work during the pandemic.

As a first-year elementary science specialist myself during the 2020-2021 academic year, I was able to more easily form bonds with the participants and build trust, as I could relate to the participants' unique and emotional experiences of working in elementary science. Many of the challenges my participants described related to teaching remotely or teaching in-person while abiding by the safety rules of COVID-19 were challenges I was facing myself, thus helping me to better understand my participants' experiences and relate to their struggles.

Data Analysis Methods

To thoroughly understand the ideas as they emerge throughout the study, I used inductive, qualitative data analysis that is informed by my theoretical frameworks of the transactional model of stress and coping and distributed leadership. Data analysis and synthesis was an ongoing, iterative process. As I collected each piece of data, I also engaged in a process of noticing themes and patterns, as well as questioning the data. I coded the data as it was collected to begin to understand the emergent themes and the missing pieces of information to be further explored to have deep understandings of the participants' lived experiences.

I used a constructivist grounded theory approach to data analysis. As a means of qualitative data analysis, grounded theory provides a method for analyzing social processes and for developing and testing abstract theoretical frameworks to explain the processes of interest (Charmaz & Belgrave, 2012). In particular, the constructivist approach to grounded theory "places priority on the studied phenomenon and sees both data and analysis as created from shared experiences and relationships with participants" (p. 349). From a constructivist perspective, how participants make meaning, and therefore the data analyses, are constructs dependent upon context, time, and place, as well as social interactions and epistemological stances. Therefore, constructivist grounded theory data analysis was useful in this study for developing a conceptual model from the data to understand the experiences of elementary science educators during a time of crisis working in schools. The data analysis and synthesis process for each method of data collection is described in more detail below.

Surveys, Individual Interviews, and Focus Group Interviews. To begin the analysis process, I edited and corrected the interview transcripts that were automatically produced from Zoom and I began with initial grounded theory coding of the transcripts for both the individual interviews and the focus group interviews. I broke the interview transcripts into fragments and assigned each fragment a code using qualitative coding software, NVivo. I created each code to summarize and categorize each piece of data, ideally in the words of the participants, using gerunds to describe the participants' actions, feelings, and processes (Charmaz, 2014). This process of initial coding was open to other analytic possibilities and remained close to the data (Charmaz, 2014). Part of the initial coding process to was realize where holes in the data may lie, which then informed what additional data to collect through follow-up focus group interviews. A key characteristic of initial coding from a grounded theory analysis compared to other qualitative research is that "grounded theorists aim to code for possibilities suggested by the data rather than ensuring complete accuracy of the data" (p. 120). By doing so, I was able to describe the range of variation in my participants' experiences as elementary science educators during the COVID-19 pandemic. Throughout the initial coding process of the interviews, I used constant comparative methods to find similarities and differences among the interviews of different participants, and 46 initial codes emerged, summarized in Appendix G. Survey data were also analyzed. The open-ended survey responses were coded using the coding scheme that emerged from the initial coding. Patterns among participants were also identified using the demographic survey data (type of educator role, years of teaching experience).

After I developed my initial codes, I subsequently found ten focused codes from grouping my initial codes for both the interview data and the survey data into broader, conceptual categories, also listed in Appendix G. Focused codes represent the most significant or the most frequent codes found in the initial coding process (Charmaz, 2014). These codes represent more conceptual categories of data than the initial codes and can be used to synthesize large amounts of data (Charmaz, 2014). Once the focused codes were identified, patterns among the data were synthesized into the major themes for the findings of the study.

Table 3.2
Overview of Data Collection and Analysis

Research Question	Data Source	Data Analysis
1. How do first-year and early career elementary science teachers continue to learn to teach during the COVID-19 pandemic?	Survey responses; individual interviews	Grounded theory analysis
2. How are first-year and early career elementary science teachers overcoming the challenges they face while teaching during the COVID-19 pandemic?	Survey responses; individual interviews; focus group interviews	Grounded theory analysis
3. How are district-level elementary science educators and coaches impacted by the COVID-19 pandemic?	Survey responses; individual interviews; focus group interviews	Grounded theory analysis
4. How are district-level elementary science educators and coaches overcoming the challenges they face to serve as elementary science leaders during the COVID-19 pandemic?	Survey responses; individual interviews; focus group interviews	Grounded theory analysis

Issues of Trustworthiness

Issues of trustworthiness in this study were addressed by the following measures described below. Instead of the criteria typically used to assess quantitative research approaches, Lincoln and Guba (1985) argue for using credibility, dependability, and transferability to assess the trustworthiness of qualitative research.

Credibility. The credibility of qualitative research refers to the accuracy of the data from the perspective of the researcher, participants, and data. To ensure the credibility of this study, data were triangulated through the collection of individual and focus group interview data and survey data. By collecting data from the participants during the individual interviews, data from the focus group interviews, and the initial survey data, I was able to create holistic understandings of the individual experiences of each science educator during the pandemic.

Dependability. Lincoln and Guba (1985) argue for consistency and dependability when comparing the data collected to the findings. Internal consistency of the findings was evaluated through the use of two forms of interviews, in which participants describe their perceptions of science education during the pandemic, their experiences with challenges, and their ways of overcoming these challenges. As a researcher, I noted any inconsistencies among the data collected, not to eliminate them, but as important pieces of information to be further understood through the collection of more data through follow-up focus group interviews. As initial themes emerged from the individual interviews, I was able to gain more information on the emergent themes by asking specific questions during the focus group interviews that provided more detail on what was shared during the individual interview. As another means of ensuring the dependability of my findings, I had ongoing conversations with my dissertation advisor about my data and the emergent themes in relation to my research questions and theoretical frameworks.

One of the benefits of being an elementary science teacher myself is that I am positioned closely to this research. From a qualitative research approach, the researcher is the major instrument of data collection and analysis, and my positionality as a science teacher and doctoral student in science education provided a lens for understanding the experiences of my participants. Rather than providing bias, I was reflective on my positionality being close to this work, on my experiences in science education, and on my beliefs about science learning. My perspective on the data and findings was a benefit to informing my research design and interpretation of the findings.

Transferability. The findings of qualitative studies are not generalizable as they are in quantitative research, but they are transferable to other situations. According to Lincoln and Guba (1985), it is the responsibility of the researcher "to provide the data base that makes transferability judgments possible on the part of potential appliers" (p. 316). In this study, the findings are applicable to other contexts because of the thick description I provided of the phenomenon studied, teaching and leading in elementary science during a pandemic, which is a phenomenon experienced by science educators nationwide during the COVID-19 pandemic.

Ethical Considerations

While I consider this study to be low risk, ethical concerns of the study were addressed by gaining approval from the Teachers College Institutional Review Board. I adhered to their procedures to decrease any potential or unintended risks to participants. Participants were informed of the study's intended purpose and their rights through the Participants' Rights form and by signing the Informed Consent form. I also maintained participant anonymity throughout the study through the use of pseudonyms. Data collected from the interviews and surveys are confidential and were secured on my password-protected personal computer, which was kept in a private place in my home.

In the following chapter, Chapter IV, I present the findings and analysis of the first two research questions, focused on first-year and early career elementary science teachers. Chapter V addresses the third and fourth research questions, focused on district-level leaders in elementary science. Both of the findings chapters are in publishable manuscript format.

Chapter IV: Findings

FIRST-YEAR AND EARLY CAREER ELEMENTARY SCIENCE TEACHERS: STRESS AND COPING STRATEGIES DURING A PANDEMIC

Abstract

Elementary science teachers face a set of difficulties unique to teaching science during the pandemic, including finding ways to allow students to safely collaborate and share the necessary materials for sense-making in science. Moreover, first-year and early career elementary science teachers are still in the beginning stages of their journeys to becoming elementary science educators, and understanding how science teachers are refining their teaching practice while coping with the stress of teaching during a pandemic is the focus of this study. Through the lenses of the transactional model of stress and coping and the buffering effect of social support, this study explores the challenges of first-year and early career elementary science educators during the pandemic and their ways of coping with stress as teachers. The findings indicate that first-year and early career elementary science teachers utilized a variety of strategies for coping during the pandemic, including relying on their prior teaching experience, seeking out collaboration and support, being flexible in adjusting their teaching practice, and embracing the positives of growing professionally during this time. This study has implications for how to support first-year and early career science teachers with coping mechanisms during the pandemic and during future times of crisis.

Keywords: coping strategies; elementary science specialists; first-year teachers; early career teachers

Introduction

Because of the COVID-19 pandemic, the educational world was disrupted in a multitude of ways for teachers, educators, administrators, parents, and students. Teachers and students had to abruptly shift from in-person classroom communities to teaching and learning from home while physically isolated, using online platforms and synchronous and asynchronous learning experiences when the pandemic began in the Spring of 2020. As the pandemic continued, educators were expected to shift from an emergency mode of remote teaching in the Spring to delivering quality instruction in the Fall of 2020, whether back in person at schools or continuing to teach online. While these expectations put high demands on all educators, elementary science educators in particular were presented with unique challenges of how to deliver high-quality instruction, either from home using an online platform or in-person, while students and teachers maintain a social distance. Because of the hands-on, collaborative, and materials-based nature of elementary science learning, elementary science teachers experienced difficulties and hurdles while teaching during the pandemic that other elementary educators who focus on literacy and mathematics did not experience.

This study explores the experiences, challenges, and ways of coping for first-year and early career elementary science teachers throughout the COVID-19 pandemic. These groups of teachers are of particular interest because as new and early career teachers, these educators are just beginning their journeys to becoming science teachers in the classroom and they are refining their science teaching practices when disrupted by the pandemic.

Literature Review

Becoming Elementary Science Teachers

Elementary science teachers or specialists play a unique role in elementary schools. While many elementary classroom teachers are generalists and teach all subjects, elementary teachers tend to not teach science because of limited instructional time devoted to science (Blank, 2013), pressure to have students succeed in mathematics and literacy, and limited background knowledge in science (Berg & Mensah, 2014). Therefore, many schools have adopted a specialist model in which science is taught by teachers who are not classroom teachers, but these teachers instead focus on science and only teach science to elementary students. The expectation of these teachers is that they have a background in and passion for science and that they have specialized science pedagogical content knowledge (Appleton, 2006; Ronan, 2014), thus being able to deliver high-quality science instruction that elementary students may not receive from their classroom teachers. For this study, the terms *elementary science teacher* and *elementary science specialist* are used interchangeably, both referring to an elementary educator who only teaches science and no other academic subject.

First-Year Teachers

While preservice teacher education and graduate school can be viewed as the beginning of the process of becoming a teacher, many elements of teaching can only be learned in the classroom as new teachers. The first years of teaching are formative in developing a professional identity and building a practice, both of which are ongoing processes (Chen & Mensah, 2022). Feiman-Nemser (2001) argue that the first few years in the classroom are formative to establishing a new teacher's attitudes towards teaching and will determine how effective the teachers will be throughout their career.

One of the ways to connect learning in preservice teacher education to inservice teacher professional development is through induction programs during the initial years new teachers are working in classrooms (Wong, 2004). Specifically, induction programs that are based upon university and school district collaboration can support new teachers when they first enter the classroom. Induction programs provide novice teachers with multiple layers of support, including working with experienced mentor teachers in their school, being observed by field advisors who provide feedback and creating a professional learning community with their peers (Wong, 2004). In addition to providing support, induction programs also give new teachers opportunities to test out teaching strategies learned in the university (Davis & Waite, 2006) and have been shown to improve teachers' classroom organization and teaching practices (Schaffer, 1992). In one study, Wong (2004) found that student performance on standardized tests and Advanced Placement class enrollment increased after the implementation of a district-wide, three-year comprehensive teacher induction program that focused on creating collaborative learning environments among peers and providing administrative support for new teachers.

While many states have adopted formal, statewide programs to support novice teachers, some of these programs are not based on well-developed understandings of teacher learning or lack the necessary resources (Feiman-Nemser, 2001). Induction programs are highly variable (Kearney, 2019) and many encounter issues with mentoring, such as reinforcing traditional norms and teaching practices, mentor teachers lacking enough time to productively work with new teachers, inconsistent understandings of mentors' roles, and the lack of quality mentorship, despite mentors being strong classroom teachers (Feiman-Nemser, 2001; Shanks et al., 2020). Oftentimes the act of mentoring alone does not support the goals and purposes of the induction program, and mentors rarely receive sufficient training in how to mentor effectively (Wong, 2004). While formalized, sustained training is necessary throughout the entirety of a teacher's career, programs designed specifically to support teachers during the early years of their practice are oftentimes ineffective.

Teachers also receive PD throughout their careers to further develop their practice and grow professionally, either sponsored by their school or sought out individually. While historically PD has failed to positively influence teacher learning, new reforms in science PD have constituted elements of high-quality PD that promote teacher development through changing teaching practices (Supovitz & Turner, 2000). However, research has shown a correlation between the quantity of high-quality PD that teachers receive and the effects of PD experiences on influencing teaching practices (Supovitz & Turner, 2000). Therefore, without intensive and sustained high-quality PD, novice elementary teachers will not be supported in their science teaching preparation as they begin their practice.

Early Career Teachers (4-8 years)

After the first three years of teaching in the classroom, teachers with four to eight years of experience teaching have completed the induction years, but are no longer novice teachers. These teachers with four to eight years of experience in the classroom are referred to as early career teachers. Learning to teach is an ongoing process that does not end after teachers graduate from their teacher education programs, nor does teacher learning end after the first year that teachers spend in their classrooms. This group of early career teachers is characterized by having some classroom experience, but these teachers are still developing their teacher identities and refining their teaching practice over time. These teachers are on the way to becoming expert teachers but are not yet veteran teachers. Teachers are in a second stage of experimentation prior to reaching their seventh year of teaching in which teaching patterns and instructional routines stabilize, along with confidence in oneself as a teacher (Feiman-Nemser, 2001). Therefore, there is a continued need to support teachers in schools on their ongoing professional learning journeys, beyond the first couple of years in the classroom, such as through a long-term model of professional development from preservice education, to the induction years, and into inservice teaching (Feiman-Nemser, 2001). Feiman-Nemser describes some of the goals of professional growth for teachers in the early career stage as deepening their content knowledge for the subject they teach, refining instructional strategies, and developing their leadership skills.

Lovett and Cameron (2011) describe some of the supports that early career teachers need to continue to develop as teachers: opportunities to talk with other teachers about what they are experiencing in their classrooms; opportunities to observe other teachers teaching; and opportunities to reflect on students' learning with others. While these interactions may have happened somewhat frequently in the pre-pandemic world, opportunities to observe others teach are nearly impossible during the pandemic, as are informal face-to-face interactions with other teachers or "hallway chats." To accomplish these learning goals, Lovett and Cameron also argue that the support for continued professional learning for early career teachers is dependent upon the school's environment and to what degree the school has a culture of ongoing professional learning. Early career teachers are also looking for advancing their careers and opportunities for leadership roles (Lovett & Cameron, 2011), so it is essential to continue to provide professional support for teachers in this stage of their careers.

Theoretical Framework

Transactional Model of Stress and Coping

The theoretical framework used in this study is the transactional model of stress and coping. The transactional model of stress and coping describes how stress is typically defined as an environmental stimulus, such as a natural disaster or serious illness (Lazarus & Folkman, 1984). However, as Lazarus and Folkman argued, it is essential to consider the relationship between the environment and the person when defining stress, including the person's characteristics and the nature of the event. Psychological stress is experienced during an environmental stressful event when a person appraises the resources available to them as not sufficient and therefore causing danger to their well-being (Lazarus & Folkman, 1984). The cognitive appraisal process involves a primary appraisal (determining if the situation is stressful, beneficial, or irrelevant to yourself) and a second appraisal (evaluating what can be done in the situation) of what coping mechanisms are available. Through complex interactions, the primary and secondary appraisals determine the amount of stress experienced, as well as the emotional reaction felt (Lazarus & Folkman, 1984).

Personal factors. For this study, it is important to consider the personal characteristics that influence primary and secondary appraisals of stressors. Personal factors impact appraisals in that they determine how a person understands the event, what they need for their well-being, and how they evaluate different outcomes (Lazarus & Folkman, 1984). Two personal factors impact appraisals: one's commitments and one's beliefs. Commitments, or what is important to a person, guide the decisions that people make. Commitments determine what is at stake in a stressful situation, which therefore creates motivation and guides people into or away from situations that are threatening, beneficial, or harmful. A person's beliefs are their personally formed or culturally shared beliefs and they serve as a lens through which a person evaluates what is happening to them. Beliefs related to personal control are beliefs about one's ability to control the outcomes of a situation, which are especially influential in ambiguous situations. Existential beliefs also give people hope in challenging situations. In conjunction with situational factors, personal factors determine whether a person will appraise a stressful situation as harmful, threatening, or challenging (Lazarus & Folkman, 1984).

Coping. In the transactional model of stress and coping, coping is defined as “constantly changing cognitive and behavioral effects to manage specific external and/or internal demands that are appraised as taxing or exceeding the resources of the person” (Lazarus & Folkman, 1984, p. 141). Coping is process-oriented and involves both emotion-focused coping and problem-focused coping. Emotion-focused forms of coping include cognitive processes to reduce emotional distress, such as avoidance and distancing, whereas problem-focused forms of coping focus on problem-solving efforts of defining the problem, evaluating possible solutions, and acting on a chosen solution (Lazarus & Folkman, 1984). During the secondary appraisal of deciding what can be done in a situation, people draw on coping resources that are available to them. These resources can be divided into four major categories: health and energy (the ability to cope when healthy and energetic), positive beliefs, problem-solving skills, and social skills (communicating and acting with other people to problem solve) (Lazarus & Folkman, 1984). Through these ongoing coping methods, people can change the outcomes of stressful situations in that they can change their appraisal of the stressor from more threatening than challenging, to viewing it as more challenging.

Buffering Effect of Social Support

The buffering effect of social support provides a lens through which we can examine the role of social support on stress. Per the buffering hypothesis, Cohen and McKay (1984) posited that psychological stress will have worse effects on the health and well-being of people with little or no social support than on those with strong social support. To account for the complexities of different types of social support systems and support systems, Cohen and McKay

(1984) generated a refined buffering hypothesis that describes how different types of stressors require different types of support for coping, such as tangible support, appraisal support, self-esteem support, and belonging support. Therefore, to be effective, social relationships must provide the necessary support to buffer the effects of the stressor (Cohen & McKay, 1984). The authors also emphasize that the buffering effects of social support can happen at different times-either between the stressful event and the stress experienced by stopping the stress response or between the stress experience and the pathological response by reducing or stopping the stress experience.

Purpose and Research Questions

For teachers with any amount of experience in the classroom, learning how to teach science successfully during the COVID-19 pandemic in socially distanced classrooms and remotely is a new and challenging experience. Because of the stress of being a science educator during the pandemic, it is essential to understand how science teachers are coping with and overcoming the challenges of teaching during a pandemic. Moreover, it is important to understand how first-year teachers and early career teachers in particular are overcoming these challenges, as these years are formative for teachers to grow, refine their teaching practice, and develop positive attitudes towards teaching.

1. How do first-year and early career elementary science teachers continue to learn to teach during the COVID-19 pandemic?
2. How are first-year and early career elementary science teachers coping with the stress they face while teaching during the COVID-19 pandemic?

Methodology

Research Design and Rationale

To best understand the experiences of its participants, this study followed a qualitative approach. By collecting qualitative data, this study takes an in-depth look at the unique experiences, teaching contexts, and beliefs of various elementary science teachers (Merriam, 2009). This study follows a phenomenological approach and within the phenomenon of teaching science during a pandemic, I focus on two cases, the case of first-year teachers and the case of early career teachers (4-8 years of experience). A case study approach is suitable for this research because a case study allows for an in-depth look at the experiences of the participants (Creswell, 2013), which is essential to understanding the complexities of teaching during the novel COVID-19 pandemic and the unique context in which each teacher is working. By following a case study approach, we can gain a holistic understanding of each teacher's experiences, while simultaneously focusing on the shared experiences of teachers at different points in their careers. Across both cases, all of the elementary science teachers share the common experience of teaching elementary science during the pandemic, which is a new experience with new demands for all teachers. These teachers in the cases of this study, early career teachers and first-year teachers, are cases of interest because these groups, teachers with 0-8 years of experience in the classroom, represent an important stage of teacher learning. While it is also important to understand the experiences of teachers with over eight years of experience during the pandemic, the focus on first-year and early career teachers for this study provides an understanding of the challenges that science teachers face during the pandemic from two levels of experience in the classroom.

Setting and Participants

The participants in this study are four elementary science teachers or specialists who teach primarily science to multiple classes of students in grades pre-kindergarten through fifth.

To better understand the experiences of teachers who work in different schools in different parts of the country, I recruited participants by emailing a recruitment flyer to a nationwide listserv for elementary science teachers and specialists. Out of the teachers who responded to the intake survey, four participants of interest were selected for the focus of this study. The participants are divided into two cases, two first-year teachers and two early career teachers. Table 4.1 provides an overview of the participants' teaching roles when the pandemic began in the Spring of 2020 and their roles in the Fall of 2020 for the following academic year. All names are pseudonyms.

Table 4.1

Overview of Participant Teaching Positions During the Pandemic

Participant	Spring 2020 (beginning of the pandemic)	Fall 2020 (beginning of 2020-2021 academic year)
Oscar	Part-time informal educator at a science museum	First-year elementary science teacher and fellow at in-person school
Inez	Teacher educator at a graduate school of education	First-year elementary science teacher at in-person school
Marisa	Remote elementary science teacher	Fourth year in role as elementary science teacher and special subject coordinator; back in-person at school
Emma	Remote elementary science teacher	Seventh year in role as elementary science teacher; back in-person at school

For the setting of this study, all four participants live and work in different parts of the country, but all work at independent schools. While the terms *private school* and *independent school* are often used interchangeably, independent schools can be considered a subset of private (non-public) schools that are non-profit, determine their own mission, select their own curricula, and are self-sustaining (Balossi & Hernandez, 2016; Kane, 1991). Independent schools often claim to provide more personalized learning experiences to their students due to smaller class sizes and high-quality teachers (Balossi & Hernandez, 2016). Independent schools are also characterized by more fluid organization and less strictly defined roles of teachers and administrators compared with that of public schools (Kane, 1991). When responding to the pandemic, both private and independent school administrations had the autonomy and flexibility to choose how to best provide distance learning and how and when to safely reopen schools for in-person learning, as well as the ability to make last-minute changes and communicate quickly with families (Squire, 2020).

Data Sources

The data in this study were collected from three sources: initial intake surveys, individual interviews, and focus group interviews.

Surveys. Participants first completed an intake survey online using Qualtrics software. This survey asked for participants' demographic information, their prior teaching experience, and their current teaching role. The survey also asked participants to share whether they are teaching remotely or in-person at the beginning of the 2020-2021 academic year, what challenges they are currently facing teaching science during a pandemic, how prepared they feel to teach science during the conditions of the pandemic, and what kinds of supports they might to feel more prepared.

Individual Interviews. Individual interviews were conducted with each participant to gain a more detailed understanding of each participant's unique experiences, challenges, and ways of working within the pandemic. The interviews lasted between 45-60 minutes and were conducted over Zoom, a video conferencing platform. The interviews were recorded, and the audio of the interview was transcribed automatically through Zoom. I then edited and corrected the transcripts from Zoom.

Focus Group Interviews. Each participant participated in a focus group interview with another two or three elementary science teachers. The interviews lasted between 60-90 minutes and were conducted over Zoom, a video conferencing platform. The interviews were recorded, and the audio of the interview was transcribed automatically through Zoom. The goal of these interviews was to allow participants to interact with other teachers in similar roles, but in different parts of the country and working at different schools. In doing so, these conversations allowed participants to compare and contrast their experiences, provided a way for participants to connect with other people who share similar challenges currently, and allowed for new themes to emerge in the data.

Data Analysis

I used a constructivist, grounded theory approach to analyze the data in this study (Charmaz & Belgrave, 2012). By allowing themes and ideas to emerge from the data through multiple rounds of coding, I was able to understand the stress of the pandemic on the participants as teachers and their means of coping in professional settings. During initial coding, I used the interview transcripts and survey data to find emergent codes to summarize and categorize the participants' descriptions of their experiences and challenges. Then, I grouped the initial codes into conceptual, broader focused codes. A full list of initial codes and focused codes can be found in Appendix G. Then, I used the theoretical frameworks of the transactional model of stress and coping and the buffering effect of social support to name the major themes within the findings.

Role of the Researcher. As a first-year elementary science specialist myself during the 2020-2021 academic year, my experiences teaching science during the COVID-19 pandemic were similar to those of the participants in this study. Many of the challenges the participants were facing I experienced firsthand, allowing me to form bonds quickly with the teachers during our interviews because of our shared experiences.

Findings

Case 1: First-Year Teachers

First-Year Teachers (Oscar and Inez)

In the case of first-year teachers, the two participants, Oscar and Inez, are both in their first year as elementary science teachers, but both have different backgrounds and prior experiences. Oscar graduated from his undergraduate program in the Spring of 2020 with a concentration in science. While in college, Oscar also worked part-time as a museum educator at a local science museum. While Oscar has no graduate experience in education and no student teaching experiences before his first year as a teacher, Oscar had experience in an informal education role, working with high school interns who worked at the museum, as well as elementary school-aged children who would visit the museum. His role as a museum educator also involved working on the museum floor and facilitating discussions with the visitors about the exhibitions and the related science topics.

The second participant in this case, Inez, was similar to Oscar in that the 2020-2021 academic year was her first year as an elementary science teacher. However, Inez has a more extensive background in formal education than Oscar. Inez worked as a high school science teacher for six years and a teacher educator for three years. Inez has her undergraduate degree in chemistry. Inez was working in a graduate school of education as a teacher educator prior to her role as an elementary science teacher.

As first-year elementary science teachers, Oscar and Inez learned to teach in a new role during the COVID-19 pandemic in different ways, grouped into three themes: (a) drawing on their prior teaching experiences, (b) relying on collaboration and support from their colleagues, and (c) embracing the positives of teaching during a pandemic.

Drawing on Prior Experiences

In 2020, Oscar was working part-time in informal education at a science museum while simultaneously working as a full-time student finishing his college degree. At the science museum, Oscar's role involved supervising high school interns who worked with elementary students visiting the museum. In the Spring of 2020, the museum was forced to close for in-person visits because of the COVID-19 pandemic and abruptly attempted to shift its programs to online museum learning experiences. Because of the hands-on, place-based nature of informal museum learning, the shift to remote work was difficult for Oscar. He described the nature of his work teaching while working remotely:

> We were trying to figure out how to transition a lot of very in-person work because we would work with objects, and it would be whoever would come up to you who you would try and facilitate scientific discussion with. So, trying to maintain the concept of having this like tangible experience in a fully online setting was difficult. And so that's what I was doing there. And we tried to do this thing where we were doing PowerPoint slides, but then it became... It felt a lot more like a presentation, rather than a visitor-guided experience.

The Spring of 2020 brought many challenges for Oscar in his role as an informal educator in that museum, visitor-guided experiences did not translate well to a remote format. When in-person at the museum, Oscar would facilitate visitor experiences using tangible resources at the museum that were led by the interests of the visitors. However, working with artifacts from the museum and letting the visitors guide the learning experience became a challenge for Oscar when teaching remotely.

Similarly, Inez was teaching full-time at a private graduate school of education in the Spring of 2020. In this role, Inez worked as an instructional fellow in the residency program with graduate students who were pursuing alternative certifications to teach. The alternative certification program is somewhat different from a traditional program in that the program is designed to support first-year teachers who are working in K-12 schools while pursuing their degrees. Inez would work with students by teaching courses and holding weekly professional development for students to practice rehearsing lessons and receive feedback on their teaching. Before the COVID-19 pandemic, Inez and her coworkers in the teacher education program would assess their graduate students through videos of them teaching and working with students. Inez continued to work at this graduate school in the spring of 2020 when the pandemic began, adapting her teacher education practice to an online teaching environment. While the school's typical form of assessment became impossible as the graduate students were not able to teach students in a normal capacity at K-12 schools because of the pandemic, much of Inez's work in the Spring of 2020 was focused on shifting the assessment structure for the graduate school program to be feasible within the constraints of the pandemic.

Unfortunately, due to the pandemic, both Oscar and Inez ultimately lost their jobs in the Spring of 2020 and sought out teaching roles as elementary science educators in private schools for the following school year. While teachers who were in the classroom in 2020 had to change their classroom teaching practice on a dime to adjust to remote learning in the Spring of 2020, Oscar and Inez did not have the same abrupt transition. Instead, they had similar experiences in that they began their current teaching roles during the pandemic. Rather than having to adjust their existing curricula and teaching style to fit within the constraints of a socially distanced classroom and distance learning, Oscar and Inez instead learned their current roles in a COVID-19 world. Oscar reflected on how he did not go into his elementary science teaching role, trying to adjust old beliefs and teaching practices to the pandemic, but instead came into his role feeling as if he had a blank slate:

> Being a new teacher, you don't have the same preconceived notions about what formal education should look like. So if I was, if I had been teaching last year in a regular school, I'd be like, oh yeah, this is what science should be looking like at the school. This is good. And then I would be super, super, super taken aback this year, now that it's so different. But coming into this, it seems like you're just working with this new thing as opposed to trying to pick from old things or trying to emulate old things because that's, I feel, that's a huge load as a science educator. And part of why I struggled at my old job when we were transitioning initially is because you want to emulate this thing that just simply cannot happen in the same capacity. And you'll, you'll be wrecking your brain for hours and days trying to get the same experience when maybe it's a better idea to make, to focus on a different experience.

Compared to the challenging work Oscar did at the museum to transition in-person learning experiences to the remote world, it felt liberating for Oscar to begin his work as an elementary science teacher without any strict preconceived notions about what elementary science should look like. On his journey of being an elementary science teacher, Oscar began learning how to teach science within the constraints of what is possible during the pandemic.

While Inez had taught for many years in various teaching positions, 2020-2021 was her first-year teaching science at the elementary level. Before the pandemic began, Inez was teaching graduate students about elementary science, so she began her role with strong beliefs about elementary science teaching, but she was able to put her ideas and beliefs into practice for the first time during a pandemic. She described how now teaching elementary students influences her ongoing work as a teacher educator:

> I think that for me as a teacher educator, like it gives me a new lens on what's possible in classrooms that I didn't have before. And let me look at like, really look at myself critically as a teacher educator and say like, okay, can you practice what you're preaching? Can you do the things that you think are appropriate for classrooms, and that you think are necessary in classrooms? Like what does teaching science for justice look like?... It's just like this extra criticality that I get to have for myself. I don't know. It's just like, it gives me evidence to back it up and say like, no team, this works.

Inez felt as though she was not a blank slate in terms of ideas about elementary science education coming into her teaching role; however, the elementary classroom experience she is getting, which backs up her beliefs about science education, is new for her and is something she is learning during the pandemic.

Adjusting elementary science curricula and teaching practices to distance learning environments and socially distanced classrooms is particularly challenging because of the hands-on and materials-based nature of teaching science to young children. However, Oscar and Inez came into their roles with more malleable ideas about teaching science that could be easily adjusted to successful teaching practices for the pandemic world.

As two new elementary science teachers, both Oscar and Inez lacked student teaching, formal mentorship, and graduate coursework in elementary science education. However, both relied upon their prior experiences and previous teaching roles and contexts. At the museum as an informal educator, Oscar learned how to facilitate online learning experiences, which helped him when teaching at his school, which required some hybrid learning:

> [Working remotely for the museum] posed this whole new question of what virtual science communication and facilitation could look like... Like there are a lot of things in science that people find really fascinating that they can't do at their home. So, let's see if we can make this more of an experience, a scientific experience, which is difficult when everyone's at their house. So, I think this really opened the door to my own understanding of how I could facilitate scientific discussion to people when they're not in-house or like, on-site in any capacity, which has translated really well to a hybrid learning right now.

At the museum, Oscar learned how to have scientific discussions with visitors who are not physically in the same space, which helped him when learning how to facilitate scientific conversations with his young students who were at home. Oscar also described how he drew on his background as an informal science educator in terms of his teaching style in the classroom:

> A lot of my teaching style in a formal setting is heavily influenced from my informal background. So, we don't, at least in first grade, we don't do things like grades. We don't

> have any formative assessment of any kind. And the science class that I want to teach is very student-driven and based around what they want… So, I guess, yes, in that capacity, [the pandemic] has impacted how I teach or would have taught, um, but I think overall, my teaching style has remained very similar to how it was.

Oscar acknowledged that while the pandemic may have limited his ability to teach typical hands-on science investigations due to students not being able to share materials, his overall student-centered teaching philosophy, which he developed at the museum, influenced his current teaching style as a formal educator.

Inez, while in her first year as an elementary science teacher, also drew on her prior teaching experiences in other grades when learning to teach elementary science during the pandemic:

> In my first few years as a high school teacher, like there were just like different kinds of, of pressures. Um, and I feel like I didn't, I definitely didn't have the lenses that I aspire to now, that I did at that point in time. Um, so I think that like doing this, it almost is like being, being back in the classroom for the first time to some degree, but like I, but not. Right. Like I'm comfortable in the classroom.

For Inez, there were certain elements from her prior teaching experiences that could support her in her current role so that she does not feel like she is a completely new teacher, such as lenses for being a critically reflective educator.

While neither Inez nor Oscar worked as formal elementary science educators before the pandemic, both were able to leverage their prior teaching experiences from other contexts to help them develop their personal approach and style of teaching elementary science during the COVID-19 pandemic.

Relying on Collaboration and Support

As Oscar and Inez navigated the challenges of teaching elementary science during the pandemic as first-year teachers, both relied heavily on collaboration with other science teachers and support from their co-workers. Both have one other elementary science teacher at their elementary school, working as teams of two. Inez and her co-teacher were both responsible for teaching science for grades pre-kindergarten through fourth and co-planned all science lessons, but Inez would lead teach the lessons for kindergarten, second, and fourth grades, while her co-teacher leads for junior kindergarten, first, and third grades. Inez described her strong relationship with her co-teacher:

> Being able to work with her on a day-to-day basis, like see her teach and be able to collaborate with her. Like we, this is one of like the most positive teaching relationships that I've ever had… Um, and like for her to also be, say, like, say things, like I learn things when I'm in your class, like we're learning from each other consistently. And like, there is nothing that feels better in a teaching career than being able to learn with your colleagues. Right. Um, it's just magic.

For Inez, one of the benefits of teaching in-person and co-teaching with another science teacher is to be able to constantly observe one another and learn with and from one another, give and receive feedback, and inspire one another in the classroom. Inez felt that she benefited greatly from having this positive relationship with her co-teacher, especially during a pandemic as a first-year teacher in a new role.

Oscar similarly had another science teacher he worked with who taught second, third, and fourth grade, while he taught only first grade science. While he did not co-teach with the other science teacher, he felt that this working relationship was also beneficial in that he could discuss lesson ideas with her and share emotional experiences of navigating their roles during the pandemic:

> What I have right now is the other science teacher that they hired around the same time as me has been a great support. Well, I think we bounce off each other really well. And since we're both in this new position of being hired at the same time and not having the old experience, it's been very, "What do you want, and how can we work with this?" And as the only two science educators in elementary school, it feels very like us against the world and I, there is a bit of a benefit to that, in a certain idea, because I have a lot of creative freedom to do something, but then also the anxiety of I'm not doing my job right. Very checks and balances around here, so that support has been phenomenal.

Because his co-teacher was also a newly hired science teacher, Oscar felt supported by the other science teacher, especially in sharing the same emotional experiences of being new and navigating a new role during the COVID-19 pandemic. Oscar also felt support from outside of the science department and that he could rely on classroom teachers for additional support. Oscar felt as though the classroom teachers at his school were supportive of him, especially in the challenges he faced in not having a science classroom to set up and use materials in and thus having to come into the homerooms to teach science. For example, when conducting a water cycle in a bag activity, Oscar described how the classroom teachers were open and supportive of Oscar leaving the students' baggies taped to the classroom windows to observe a model of the water cycle.

While collaborating with and leaning on other educators is a support often used by first-year teachers, this support was particularly important for participants teaching elementary science for the first time during the pandemic. The challenges of teaching during a pandemic, such as not having a designated science classroom and instead pushing into homerooms, created a greater need for first-year teachers to rely on others for support.

Embracing the Positives

While navigating any new job during the COVID-19 pandemic is certainly more stressful and anxiety-producing than normal, both Oscar and Inez had positive outlooks on their teaching situations. They learned to embrace the positives of enjoying teaching elementary science, of learning new technological tools, and of connecting science teaching to students' home lives when teaching students remotely.

One positive of the pandemic for both Oscar and Inez was that they ultimately found new teaching roles as elementary science specialists that they enjoy. Oscar and Inez have similar experiences in that they were not necessarily looking to leave their previous jobs, but both got let go because of the impacts of the pandemic on their places of work, and then both participants turned to working in independent schools as full-time elementary science teachers. Because of the COVID-related challenges of operating a museum safely, many museum educators were furloughed, and Oscar ultimately lost his job as an informal educator in the Spring of 2020. Oscar thus turned to working in a school for the 2020-2021 academic year. For Oscar:

> I only have this formal teaching job because of the pivot, because I lost my old job. I would have been at my old job for probably, I would have been there for a long time, honestly. The previous guy before me was there for six years and that is what I wanted to do. I wanted to work these programs, admittedly not for $16 an hour part-time, but um, so, yeah, like I have this job now. So, it's impacted me to move from informal to formal education.

Similarly, Inez lost her job because of faculty and staff layoffs at her graduate school due to budget cuts, and she turned back to being a classroom teacher, this time in a new role. She described how much she now enjoys working as an elementary science teacher:

> I am thrilled beyond measure to be teaching in an elementary school. Um, and I mean, like if it weren't for the pandemic, like I would probably still be working at [the graduate school]. Um, which was a job that I loved too. I love this in a much different way. Um, and in ways that I didn't expect to love it. Um, my kids are awesome. They're so fun. Um, and I truly, like, I didn't know that I would enjoy working with elementary-aged kids this much.

Both Inez and Oscar did not plan to be working as elementary science teachers but ended up in these roles due to layoffs during the pandemic, and both ended up loving their jobs and loving working with elementary students in science.

Another positive that Oscar and Inez shared in teaching science during a pandemic was learning new technological tools for teaching and learning how to teach online. While these teachers learned to use new technology out of necessity, they both felt these online learning tools, such as Nearpod and Seesaw, helped their overall teaching practice and that they could continue to use them after the pandemic. Additionally, Oscar sees a positive in rethinking how science education could work successfully in an online format:

> It's made me think a lot about the future of online learning in science. I think there's a huge market for that right now and in the future, because now this has provided so many options to people who could not physically go somewhere, like the Museum of Natural History. So whatever large institutions or schools come up with right now or have been for the past year, I think could absolutely be critical to how we teach science in a virtual setting in the future.

Oscar sees opportunities to reach a larger audience with virtual science learning experiences, both in formal and informal education. Additionally, Oscar views some aspects of teaching children while they are at home as positive. He described how one benefit of distance learning is being able to personalize the learning experiences to each student, based on the materials that each child has available to them at home.

Overall, after choosing to become elementary science teachers after losing their jobs because of the pandemic, both Oscar and Inez ended up in new roles that they love. Moreover, they are both able to find positive takeaways when teaching within the constraints of the pandemic and have found elements that could contribute to their future science teaching practice, even after the pandemic has ended and there is no direct need for teaching students who are learning from home.

Case 2: Early Career Teachers

Early Career Teachers (Emma and Marisa)

The second case focuses on two participants with four to eight years of experience teaching elementary science. Emma is in her seventh year teaching elementary science. Before moving to a formal teaching role, Emma gained informal education experience through teaching outdoor education and environmental education. She holds two Masters degrees, one in ecology and environmental science and one in teaching science. Marisa, who has been teaching elementary science for four years, holds a combination role at her school as both elementary science teacher for students in second through fifth grade and special subjects coordinator. She received her undergraduate degree in molecular and cellular biology, and two Masters—one in elementary education and the other in science teaching supervision. She also taught middle school science for four years.

The early career teachers in this case, Emma and Marisa, both shared the experience of working in a school before the pandemic, shifting to teaching science online during the Spring of 2020, and then transitioning to in-person in the Fall of 2021. For all four participants across both cases, the teachers were all working in person at schools during the Fall of 2021. They also had to teach science in a socially distanced classroom with students maintaining six feet apart and not sharing materials. There were times when schools had to close abruptly due to COVID-19 cases and thus all of the teachers had to be prepared to teach science remotely at the last minute.

The ways in which early-career elementary science educators were adjusting their teaching practice as a result of the challenges they faced during the COVID-19 pandemic included two themes: (a) adjusting to new teaching schedules, and (b) planning science curriculum far in advance.

Adjusting to New Teaching Schedules

In the Spring of 2020, Emma and Marisa had similar journeys during the transition to remote learning at the beginning of the pandemic when their schools shut down in March. As specialists, both participants struggled with the format for remote learning that their schools decided on for the Spring of 2020. At both Emma's and Marisa's schools, administrators decided that specials, which included science, would be asynchronous when the children were learning virtually. This meant that Emma and Marisa both had to not only adjust their curricula to be taught at home, but they also had to create new, asynchronous science lessons that students could complete without synchronous interaction or instructions from the science teacher. The lessons that they created involved recording short videos of themselves giving the instructions to their students and designing a meaningful science activity that students could complete at home with minimal adult supervision. Additionally, most of these activities were optional for students, as teachers and administrators did not want to overburden students with assignments during this tumultuous time and thus, they prioritized mathematics and language arts. Based on data Marisa collected between March 2020 and June 2020, Marisa's students completed about 20% of the asynchronous science assignments she shared with them during this time. Similarly, Emma described how almost 100% of students would log onto the virtual morning meeting with their homeroom teachers, but fewer than one quarter of students sent in science assignments to her. She questioned whether the incompletion of work was due to students completing the assignment but not knowing how to submit it, if students were missing material they needed to do the assignment at home, or if they were simply not doing the work at all. Because of the disjointed participation in these activities and because of the difficulties of creating asynchronous assignments for young children, both Emma and Marisa found that they were creating and teaching very few meaningful science learning experiences for their students. Therefore, it was difficult during the beginning of the pandemic to keep the momentum of science learning going and thus when students returned to in-person school in the Fall of 2020, both Marisa and Emma felt as though their students had learned little science during the spring of remote learning.

To safely return to in-person learning in the Fall of 2020, schools had to make many adjustments to the typical way in which they operated before the pandemic. As science teachers, both Emma and Marisa were given teaching schedules that were drastically different from their schedules before the pandemic. While typically science teachers would see each of their classes twice a week at different times, both Emma's and Marisa's schedules were adjusted so that they saw fewer classes at a time. They still saw each class daily, but the number of students they were in contact with face-to-face at a time was reduced. Emma typically teaches first through fourth grade, but in the Fall, her schedule changed to only teaching two grades, but teaching them every day for a month. After a month of teaching one class daily, Emma switched to a different class to teach for the next month. Emma described how this change came with some positives for her teaching practice and so she hopes her school keeps a similar schedule in place, even after things can return to how they were:

> Um, yeah, so I've actually loved the new schedule because I get to see the kids every day and I get to teach like each class for a month, every day and I get to really delve deeply into certain topics. And I have a lot of continuity. I don't have to refresh their memory. I'm less scatterbrained. So it's just like so much better for everyone. I wish they had done this sooner and I hope they keep it after COVID.

One of the positives of this new teaching schedule for Emma was that rather than having a couple of days in between each time she sees a class, teaching the same class daily provided continuity that helps young learners build upon each lesson. For Emma as a teacher, the new schedule allowed her to focus on one or two curricula and grade levels, rather than having to juggle plans for different curricula and different classes of students all at the same time.

Marisa's school gave her a new schedule, similar to Emma's, for the 2020-2021 academic year. She, and other specialists, taught five-week "intensive" units with each grade, teaching them daily lessons, and then rotated to a different grade for the next five weeks. Marisa had to limit her curriculum to around what she would typically accomplish in about two months of seeing a class twice a week. She described how:

> I've found that one five-week rotation with this current model is about equivalent to two months of our old schedule, which means that grades are only getting two months of

> science right now. Um, and so in terms of like adjustments that have had to be made, I really just decided like, what is kind of the, um, most engaging unit of that grade's year or which topic allows for a lot of connections to other areas of science and that's the one I've chosen. And so, I've picked like one unit and we are going all out.

While it may have been difficult to decide which units should be prioritized for the five-week periods that Marisa was teaching, this adjustment provided Marisa with an opportunity to be intentional and reflective about what concepts are most important for each grade to learn in science during this year. Just like Emma, Marisa preferred this schedule because she taught the same students every day, lending her lessons to have more continuity of content.

Despite some positives that Emma and Marisa saw in teaching the same students daily, both Emma and Marisa encountered issues related to time due to the nature of their new schedules. As a result of the pandemic, many teachers had to add extra responsibilities to their plates, such as covering lunch duty. Emma disliked her new schedule in that she was busier than in a typical year, leaving her less time to prepare for her classes. Because the science room has been repurposed into an extra classroom, Marisa had given up teaching in a science room and instead spent her days in the homeroom of the grade she is teaching in that rotation. As she was not teaching the entire day, Marisa spent time in the homeroom classroom, doing duties outside of her responsibilities as a science teacher, such as making copies to assist the homeroom teacher. Reflecting on how much of her day is spent teaching science during the pandemic, Marisa described how:

> I would not want another year like this one, where I teach 45 minutes a day. Um, that's hard. It's, it's hard for me, um, to kind of be an intern for the rest of the day. Um, I think that's a really negative way of looking at it, but it's, that's honestly how I feel for most of the day. Like I'm someone else's intern, which is hard, um, in Year like 10 in a school.

For Marisa, while she enjoyed being with only one grade for five weeks, she felt underutilized as a teacher with many years of experience and was eager to get back to spending the majority of her working day teaching science. While new schedules may lend themselves to benefits for students' science learning, as professionals these new schedules also provided Emma and Marisa with new challenges, such as Marisa feeling as though she was not using her time at work in the way she would like and Emma struggling with a busy schedule with little preparation time for her classes.

Planning Curriculum Far in Advance

As teachers who have been in the classroom for many years, lesson planning and preparing materials for specific lessons is a typical part of the daily work that Emma and Marisa do as elementary science teachers. However, while teaching in person during the 2020-2021 academic year, both Emma and Marisa had to prepare for the possible scenario of their schools suddenly shutting down because of the coronavirus and suddenly transitioning their teaching to an online learning platform with no advance warning. Both Emma and Marisa prepared kits of the materials they needed to teach science remotely, in the possible scenario that students would be learning from home. On top of planning for their in-person lessons, Emma and Marisa both prepared additional science units that were designed to be taught remotely and kits of the necessary lesson supplies for each student, so that all students can engage in hands-on science lessons remotely. Emma described how time-consuming it was to not only assemble a kit for each student, but also the additional planning required to plan another curriculum, with each material selected and purchased:

> We started in June planning what units would work well and what units were... We had to like readjust what units we did in person because certain units did work better at home. And then what supplies. And then we all ordered supplies. Our science department head let us order whatever we needed. And then at the beginning of the year, like in August or September, we started just collecting the supplies and putting them together into the baggies for each student and they're almost ready.

Emma and her colleagues planned a second virtual science curriculum and fortunately. They were able to purchase all of the materials that students would need at home, which they would use as units at the end of the year if their school did not have to go remote during the year.

At her school, Marisa also prepared kits of lesson materials to send students who elected to be remote and who were learning from home all year and to also send home with all students in case her school must suddenly go remote. Marisa described how in this preparation, she not only wanted to give students every possible material they would need, but packaging materials into kits also forced her to reflect on her lessons in a new way:

> Everything down to like a film canister, a packet of Alka Seltzer tablets for like a volcano thing, um, tape. We're giving them everything like the number of toothpicks they need for something. And so that has been really interesting. Um, making these like science kits has really forced me to be super thoughtful about, um, what's a demo, what's an activity, and what's a full-on investigation because if we're doing multiple trials, obviously they need like nine of something, um, versus just one. And so, um, I've, I've liked that kind of push to be really thoughtful about what is going to, what needs to be hands-on, what doesn't, um, like what can be done by an individual, what would typically have to be group work.

Because of decisions Marisa had to make about what materials and how much of each was going into each kit of science supplies, Marisa reevaluated the intentionality of which parts of her lessons should be investigations, demonstrations, or activities. Moreover, Marisa described that because she prepared entire kits of materials for five-week units far in advance, she not only had to plan the details of her units far in advance, but she also was restricted in how many changes she can make to the curriculum. While teachers typically have some flexibility to adjust their lesson plans based on the needs of their students in the moment, because she had to package specific materials in advance, Marisa felt a shift in how she teaches, as she was not able to make any major changes to her lessons as she is teaching that require different materials.

One positive of planning her units and preparing materials far in advance is that Marisa felt that more of her workday was freed up, providing her with more opportunities to reflect on how her lessons went and to make slight adjustments to her lesson plans:

> I know a lot of times like in under or, um, in preservice programs, right? Like they preach the planning piece and how important it is. And I think now more than ever, I am valuing my training around planning because now that I'm planned for five weeks at a time, the kids have everything. It really, um, frees up some time to really focus on, um, the day's learning and like how things went and then, um, like slight adjustments for the next day. And, um, it gives me a little bit more time for feedback and kind of being in the moment with students. So, I kind of like the forced, uh, pre-planning.

For Marisa, she attributed her ability to plan ahead and think through the development of a unit was due to her strong teacher education program. She felt that during this pandemic time more than ever, she relied on her teacher preparation in curriculum planning to help her plan ahead for her five-week intensive units and how to package all of the necessary materials. Because of the realities of the classroom and the responsibilities that teachers juggle in a typical school year, teachers are experts at adjusting lessons in the moment and planning on the fly, even though they might aim to lesson plan far in advance. However, one benefit to being forced into pre-planning lessons is that daily planning time was freed up to focus on other things, such as being reflective educators.

Discussion and Implications

As learning to teach is an ongoing journey that does not end at the end of a teacher education program or at the end of a teacher's first year in the classroom, it is essential to consider teachers at various stages of their careers and the challenges they face when looking at teaching during the pandemic. Moreover, all four teachers in this study, with different amounts of prior teaching experience, are experiencing the challenges of teaching during a pandemic for the first time in their careers. Science education in particular poses a unique set of challenges to teaching during a pandemic, as best practices in elementary science are designed to be hands-on, using a variety of different materials, and collaborative among students. No matter how long teachers have been in the classroom, science teachers have had to learn how to teach during the pandemic and readjust their teaching to be safe in in-person classrooms and feasible in virtual classrooms. Therefore, all four participants share insights into what can be learned from teaching elementary science during a pandemic.

Across the cases of first-year and early career teachers, the participants in this study have different views of the pandemic as an ongoing environmental stressor to them as teachers, and different perceptions of their appraisal of the stressful event that evolve over time (Lazarus & Folkman, 1984). Initially, when the pandemic began, participants perceived the pandemic as a threat that caused harm to their ability to teach science effectively. More specifically, the first-year teachers, Oscar and Inez, ultimately lost their previous education jobs in the Spring of 2020, and the early career teachers, Emma and Marisa, were both limited by the constraints of asynchronous distance learning to successfully teach science lessons to their students. As the pandemic proceeded, participants developed coping strategies to mitigate their initial negative view of teaching during a pandemic, into a view of the pandemic as less threatening to their teaching and more of a challenge that they could overcome and learn to teach within the constraints of the pandemic (Lazarus & Folkman, 1984).

Problem Solving and Being Flexible

Outside of coping with the general stress and anxiety of the COVID-19 pandemic on a personal level, participants used a variety of coping strategies to overcome the stress of teaching science during the pandemic. Participants used problem-focused strategies (Lazarus & Folkman, 1984) to solve some of the issues of teaching science and worked within the constraints of their teaching context during the pandemic. Inez and Oscar were challenged in that neither of them had formal teacher training or student teaching for elementary science roles and they had no direct mentors, but both of these teachers drew on the resources that they had available to them as educators. Both of these teachers entered new roles but utilized their prior teaching experiences in that they were able to successfully draw upon other teaching contexts and bring in elements, such as their teaching style and philosophies, into their current spaces. Marisa, who was challenged by not seeing students as frequently due to schedule changes, also problem solved by determining what she can teach in reduced instructional time and five-week units that are most valuable to students at each grade level.

In addition to problem solving, personal attributes also contributed to participants' ability to cope with stress while teaching during the pandemic. The participants' personalities showed that they were able to be flexible and able to adjust to new roles and new ways of teaching. Rather than reworking how science was taught before the pandemic, the teachers looked at teaching science during COVID-19 as a new way of teaching, rather than trying to work what has been done into the constraints of the pandemic. Certain lessons, schedules, lesson planning strategies, and teacher moves could not be translated into socially distanced classrooms and/or remote learning environments. Instead, participants were successful when teaching elementary science during the pandemic because they could rethink how things have been done and even abandon old ways of teaching science.

Relying on Relationships

Another important coping strategy for the participants as teachers during the COVID-19 pandemic is social support. In general, collaboration and connecting with other educators is an important support for teachers, especially new teachers (Wong, 2004). On top of that, social support provided a buffering effect for participants on the stress of the pandemic (Cohen & McKay, 1984). Having social support from other educators buffered the stress of the pandemic in that social support can help teachers re-evaluate the situation of teaching during a pandemic as less threatening, as well as helping teachers find better coping strategies (Cohen & McKay, 1984). As a new teacher, Oscar felt he relied heavily on his relationships with the other science teacher in the school and the classroom teachers as he navigated the challenges of teaching science, thus reducing some of the anxiety he felt. For Inez, having another science teacher to work with, co-teach, and learn with and from reduced the stress of navigating her new elementary science teaching role during the pandemic. Cohen and McKay (1984) described how people experiencing stressful events need different types of supports, including tangible support, appraisal support, self-esteem support, and belonging support, which can reduce the negative effects of the stressful event. However, it is clear how for participants in school communities, social support had a great buffering effect on how they experienced stress during the pandemic.

Because all of the participants in this study were first-year or early career teachers at independent schools, the teachers had certain supports from their school communities that many teachers in public schools lacked during the pandemic. While there was variability in different independent schools' responses to the pandemic, many independent schools had the flexibility to change their structures to be able to safely return in person when many public schools could not (Squire, 2020). While teaching in-person during the pandemic came with its challenges, the four teachers in this study had a different experience from teachers who taught entirely online from their homes. These participants had supports from their schools in that their schedules were adjusted to be safer than seeing many classes in a day and the financial ability to purchase more lesson supplies so that students do not share materials.

Embracing Learning and Growth

By using these coping strategies while working during the pandemic, the teachers in this study were able to use resources and supports that were available to them and had a somewhat positive view of the stressful situation. Positive beliefs about a stressful situation are a resource on which people draw to cope with a stressful situation (Lazarus & Folkman, 1984). The participants in the study viewed the stressor of the COVID-19 pandemic as not just a threat, but as having some degree of benefit to them as professionals. The participants perceived many positives to them as teachers, such as landing a new job that they can grow in professionally, being given new teaching schedules that they hope to keep, having more time to reflect on lessons, thinking critically about their lessons and teaching practice, learning new ways to lesson plan in advance, and discovering new technological tools for elementary science teaching. By seeing the pandemic as a challenge that they could overcome, the new teachers and early career teachers in this study experienced unanticipated learning as teachers during the pandemic. Because the teachers in this study were able to cope with the threat of the pandemic and ultimately see it more as a challenge and less threatening, these teachers were able to function well in their roles as elementary science teachers.

The findings of this study have implications for future teaching during a pandemic or during any time of crisis. The teachers shared a common experience of teaching elementary science during a pandemic for the first time with no preparation or professional development on how to adjust to the needs of their students during COVID-19. In general, the first year and the early years of teaching are formative to teachers' attitudes toward teaching and the development of their teacher identities (Chen & Mensah, 2020). However, the teachers in this study had an additional stressor of teaching during a pandemic; yet they were able to cope with the stress and ultimately continue to learn and teach science during this time. They relied on social support to buffer the stress experienced due to the pandemic (Cohen & McKay, 1984) and they used multiple problem-focused coping strategies and resources available to them to manage stress (Lazarus & Folkman, 1984) while teaching science during this time. For these teachers, these critical years of inservice teacher learning were not lost because of the pandemic. They gained experience in the classroom (both virtually and in-person) and thus developed their instructional skills and their skills as reflective educators, which are among some of the goals for professional growth for early career teachers (Feiman-Nemser, 2001).

Because of the uncertainty of the future, teachers need to be prepared with multiple ways to cope with the stressors of a crisis. In this study, teachers drew on coping resources that were available to them within the broader categories of positive beliefs, problem-solving skills, and social skills (Lazarus & Folkman, 1984). Because it is imperative that students continue to grow and learn, even during times of crisis, teachers should be prepared with and allow the development of multiple coping strategies and resources, such as developing their mindset on being flexible with changes, learning how to embrace unanticipated positive learning moments, and building strong relationships for collaboration and support. Teacher learning can support the development of these coping strategies by teaching these skills in teacher education programs and throughout inservice PD. An induction program that connects preservice learning to inservice learning could explicitly teach how to develop these strategies to support new and early career teachers as they enter the classroom (Wong, 2004). Moreover, induction programs can continue to develop professional learning communities among first-year and early career teachers, especially during times of crisis, so that teachers can rely on social support as a coping strategy (Wong, 2004). These coping strategies will help first-year teachers, early career teachers, and teachers at all points in their careers to be as prepared as possible to cope with and adjust to stressful events as educators.

Conclusions

While the COVID-19 pandemic can be considered a threat to elementary science education, first-year and early career elementary science teachers can overcome these threats using a variety of coping strategies. Collaboration and support from other educators were primary coping strategies for first-year teachers, and social support provided a buffering effect on the stress they experienced. These teachers also problem solved in that they lacked prior teaching experience as elementary science teachers and formal teacher education in elementary science, but they were able to draw on their prior experiences from other teaching roles (i.e., a museum educator and a teacher educator at a graduate school of education) to support their instruction during this time. Early career teachers were able to be flexible in that they could adapt to new job responsibilities, new types of schedules, and new ways of curriculum planning during the pandemic. Coping with the stress of the COVID-19 pandemic in various ways allowed teachers to move away from viewing the pandemic as threatening, to ultimately viewing the pandemic as a challenge that they could overcome. By overcoming the challenges they faced due to the pandemic, the teachers could continue their growth as early career science educators during the pandemic through learning new technological skills, reflecting on lesson plans and pedagogical strategies in new ways, and assuming new roles and responsibilities. In the future, a variety of coping strategies can be adopted and leveraged by elementary science educators who are in their first year in the classroom or in the early career stages of their careers to mitigate the stress of stressful events and times of crisis, such as the COVID-19 pandemic.

CHAPTER V: Findings

LEADING DURING CRISIS: EXPLORING THE CHALLENGES THAT DISTRICT-LEVEL ELEMENTARY SCIENCE EDUCATORS FACE DURING THE COVID-19 PANDEMIC

Abstract

During the COVID-19 pandemic, science education was disrupted in a variety of ways and science teachers were required to reimagine what meaningful science instruction could look like within the constraints of remote learning and socially distanced classrooms. Additionally, other science educators and leaders in science education were impacted in numerous ways. This study examines the experiences of district-level elementary science curriculum specialists and instructional coaches during the COVID-19 pandemic to better understand the challenges they face as leaders in science education, using a framework of distributed leadership. The findings indicate that these leaders in science education are managing their work time in new ways since they are restricted by how much time they can now spend in the classroom. They have shifted the work that they prioritize to now focus on rewriting science curriculum so that it is feasible in a COVID-19 world, as well as providing new types of professional development to best support teacher learning during these unprecedented times. These leaders in science education continued to grow professionally by connecting with educators virtually, learning new technological tools, and reaffirming their commitment to creating hands-on, meaningful science learning experiences for all children.

Keywords: elementary science; curriculum specialists; instructional coaches; leadership

Introduction

In a time of crisis such as the COVID-19 pandemic, it is important to consider how many players in education are impacted. While classroom teachers face many challenges when working directly with children either virtually or in the classroom during the COVID-19 pandemic, other educators in leadership positions face their own set of unique challenges while navigating the unprecedented time of the pandemic. Leadership in science education is shared among multiple formal and informal leaders, such as administrators, teacher leaders, and mentors. As leaders, elementary science curriculum specialists and instructional coaches play an important role in supporting elementary science teaching by designing and writing science curricula, coaching teachers on best practices for elementary science teaching, and providing teachers with professional development experiences in science. During the COVID-19 pandemic, the leadership work of these elementary science educators was also disrupted, in similar and different ways from elementary classroom teachers. Therefore, it is important to understand the challenges that elementary science curriculum specialists and coaches face as leaders in the work they are doing to support science learning for teachers and students in a time of crisis, and how they are able to overcome these challenges.

Literature Review

Mentoring and Coaching

To improve instruction, one form of professional learning for inservice teachers is through the help of subject-specific coaches. These instructional coaches are hired to formally support teachers' instruction in one subject and they act as leaders in their subject of expertise (Mangin & Stoelinga, 2010). While recent reform efforts have encouraged schools to hire instructional coaches with the goal of improving instruction, schools oftentimes do not know how to best utilize their coaches or how to explicitly define the coach's role (Neumerski, 2013). Most research on coaching has focused on the characteristics of good coaches (Frazier, 2020), although some studies that have looked at the effects of coaching on instruction have found mixed results (Bean et al., 2010; Neumerski, 2013). A small portion of the literature around coaching has shown that instructional coaches are capable of causing teachers to implement new practices, but how they achieve this is not well understood (Neumerski, 2013).

As no consistent definition exists, mentoring in education may refer to a variety of roles and relationships between mentor and mentee, such as an inservice teacher mentoring a preservice teacher (Ambrosetti & Dekkers, 2010) or a more experienced teacher mentoring a first-year teacher (Andrews & Quinn, 2005). In general, the goal of mentoring is to pair a more experienced teacher with a more novice teacher to support the mentee's professional learning through building a close relationship (Ambrosetti & Dekkers, 2010). However, mentors do not always receive formal training in how to mentor effectively and are thus not effective in supporting new teachers' growth (Wong, 2004). While coaching and mentoring may be a way for teachers to learn in the context of their classrooms with sustained support over time, more research is needed on the work of instructional coaches and the challenges they may face in supporting teachers.

School and Instructional Leadership

Traditional research on school leadership has studied individuals who are perceived to be good leaders and their attributes, such as leadership styles, personality traits, skills, charisma, etc. (Ediger, 1996; Goolamally & Ahmad, 2014; Holtkamp, 2002). Research has since moved away from an individualistic approach, which typically focused on the principal as being solely responsible for school and instructional improvement, to studying leadership through a practiceoriented approach that studies how leaders, followers, and social and material context interact (Nelson, 2022; Spillane et al., 2001b; Wilkinson, 2020). By diverging from characteristics of individual leaders to adopting a systemic perspective of leadership, recent research on leadership considers the collective social process that views leadership as a group activity, rather than individual actions (Bolden, 2011).

Within a school, instructional leaders include principals, administrators, teacher leaders, and instructional coaches, who all impact teaching and learning. In response to more nuanced understandings of how to provide teachers with effective PD, instructional leaders are intended to focus on instruction, be situated within the school, and incorporate sustained collaboration, thus creating more effective learning for teachers (Mangin & Stoelinga, 2010). The literature on school improvement describes several functions that are fundamental to instructional leadership, such as creating a unified instructional vision, building trust, facilitating collaboration, and monitoring instruction and innovation (Spillane et al., 2001b).

While literature exists on instructional leaders, their attributes, and what they do, there is little research on *how* instructional leaders improve instruction through their daily work (Neumerski, 2013). The literature around instructional leadership is primarily divided into three separate bodies of studies: those studying what principals do to improve instruction, those studying what teacher leaders do to improve instruction, and those studying what instructional coaches do to improve instruction (Neumerski, 2013). For example, scholars who advocate for culturally responsive school leadership, which underlines the need for transforming all aspects of schooling to be culturally responsive, focus on principals and administrators as leaders in isolation (Khalifa et al., 2016). Neumerski (2013) calls for research that focuses on how multiple leaders lead within a school system, as what is known about leading for one type of instructional leader could inform how to best lead as another type of instructional leader. While previous research has focused on what processes and structures are needed for instructional change, there is a need to know more about *how* changes are enacted in schools through the daily work of leaders (Spillane et al., 2001b).

Leadership Practice and Instructional Practice

While teachers may engage in a variety of leadership tasks, it is important to understand the relationship between leadership practice and instructional practice. Teachers' leadership tasks related to instruction may impact their students, other teachers, classroom materials, and more. Instruction must be understood as constituted of the interactions between a teacher, students, and the materials (Spillane et al., 2001b). Instructional change will not occur through the improvement of one element alone, such as increasing teacher content knowledge or providing better curricular materials (Spillane et al., 2001b). Additionally, providing opportunities for teachers to improve instruction does not guarantee actual teacher learning as learning is co-constructed between leaders, teachers, students, and their contexts (Neumerski, 2013). Therefore, a more nuanced understanding of the relationship between leadership practice and instructional practice that leads to instructional improvement and student learning is needed.

While a few studies exist that link teacher leadership and instructional change (Esch, 2018; Wieczorek & Lear, 2018), a small number of studies exist on teacher leaders who attempt to improve instruction; however, this research is similarly limited in looking at the *how* of teacher leaders and is instead mostly focused on teacher leader characteristics (Neumerski, 2013). Practitioner-based research on instructional teacher leaders has documented the daily struggles of teacher leaders, such as gaining teacher trust, and the need for both content knowledge and facilitation skills that promote trust and collaboration for collective instructional improvement (Mangin & Stoelinga, 2010). Newer research has focused on contextual factors that facilitate and constrain instructional teacher leadership, such as school administrators, school norms, school structures, and the degree of coherence across school and district goals (Mangin & Stoelinga, 2010).

Despite this gap in understanding how teacher leaders lead in their daily work, teacher leaders are thought to be most likely to promote instructional change and practice instructional leadership because they have specialized knowledge for improving instruction, have the most contact with classroom teachers, and are able to establish trust with teachers as they are not school authorities (Mangin & Stoelinga, 2010; Neumerski, 2013). Even without giving teachers formal leadership positions and titles, teachers must be at the forefront of instructional change.

Science Instructional Leadership

Leadership practice in schools cannot be separated from the context. Therefore, the structure of school leadership appears different depending on the subject matter. Spillane (2005) argues for the consideration of instruction as an explanatory variable when looking at school leadership and found that school leadership in elementary schools looks different depending on the subject areas. For example, while officially formal leadership routines, such as leadership team meetings and curricular committee meetings, did not privilege one subject over another, in practice, the number of leaders involved varied greatly. Literacy-related routines had many leaders involved, such as the principal, assistant principal, language arts coordinator, and lead teachers, while mathematics-related routines had a couple of lead teachers, and science-related routines, if they happened at all, were left to one or two classroom teachers. Following pressure for student achievement on assessments, leaders described reading and mathematics as priorities for improving instruction. Teachers also had advice networks that differed across subjects.

Spillane (2005) also found that teachers were more likely to seek out others for advice about literacy instruction than about mathematics instruction, and that school administrators were more prominent in advice networks that were not subject-specific. Because of the variability in how leadership practice is structured across subjects, it is necessary to focus on how leadership functions in relation to science instruction specifically.

Theoretical Framework

The data collected throughout the course of this research was informed by and analyzed through the lens of distributed leadership as a theoretical framework. A distributed perspective on leadership provides a framework for understanding how leadership is distributed throughout an organization, such as a school district, among many people.

Distributed Leadership

Compared to more traditional approaches to understanding leadership, distributed leadership (DL) offers a systemic perspective that focuses on *how* leadership is distributed. Rather than focusing on the structures in place to promote leadership and what leaders do, DL provides a framework for understanding *how* leaders enact change by viewing leadership, not as an individual practice focused on individuals such as principals, but by exploring the leadership practice of multiple individuals and how these leaders think and act (Spillane et al., 2001b). This model of leadership focused on activity and moves away from individual leaders or roles, as leadership does not necessarily have to be shared equally or democratically to be distributed (Bolden, 2011). From a distributed perspective, the social and situational contexts in which leaders think and act are considered, as well as individual agency and leadership tasks. Spillane et al. (2001b) differentiate between macro leadership tasks in a school, which are large-scale organization tasks, and micro-tasks, the day-to-day work of leaders. Because macro leadership tasks are not accessible to all types of leaders, it is essential to understand how micro-tasks can contribute to a large macro-task, such as building norms of trust and collaboration within a school (Spillane et al., 2001b). For example, within the macro-task of building norms of trust and collaboration, many leaders, including teachers, enact micro-tasks daily, such as finding time during the school day to collaborate (Spillane et al., 2001b). DL serves as a productive framework for understanding how the day-to-day micro-tasks of multiple leaders are executed in order to understand the large macro-tasks and thus illustrates the *how* of school leadership, not only the *what* of school leadership.

In science in particular, DL provides a useful framework for understanding science leadership in schools and informal learning environments. Spillane et al. (2001a) use a DL perspective to examine school leadership in elementary science instruction at an urban school. The researchers found that certain leaders found resources available to them to enact change in science teaching and learning, even though they perceived few resources that were easily and apparently available to them to support science instruction (Spillane et al., 2001a). Letourneau et al. (2021) used a DL framework to help create new types of inclusive STEM learning experiences at a science museum. Teams at the museum used a DL model to guide their style of collaboration to create a shared vision of change in their learning experiences, which relied on individual team members' expertise and supported risk-taking and experimentation. DL offers a framework for examining the micro-tasks of multiple leaders and how they can enact change in science education on a daily basis.

Limitations of a Distributed Perspective

While DL is a lens through which we can understand how leadership is distributed among leaders, followers, interactions, and context, there are some limitations to using distributed perspective on school leadership. Some of the drawbacks of this theoretical framework are that DL does not question the existence of leadership itself as a concept, nor does it examine the fundamental building blocks of leadership because it uses traditional leadership terminology, such as leaders and followers. Therefore, DL places the roles of individuals as central to leadership, rather than using language to emphasize a shared practice among many actors (Bolden, 2011). Another drawback of DL is that power dynamics are not critically considered from a DL perspective. Power is inherently implicated within the discourses and practices of leadership and power may not necessarily be distributed in the same way that leadership is (Bolden, 2011). Therefore, it is essential to take power dynamics into account when analyzing how leadership is spread out through a school, and more connections to school improvement, leadership development, and instructional change need to be made when using this framework.

Purpose and Research Questions

The purpose of this study is to examine how elementary science educators who work as district-level curriculum specialists or coaches are affected by the COVID-19 pandemic and how they are overcoming the challenges they face as they serve as leaders who support the work of elementary science teachers and specialists. Therefore, the research questions for this study are:

1. How are district-level elementary science educators and coaches impacted by the COVID-19 pandemic?
2. How are district-level elementary science educators and coaches overcoming the challenges they face to serve as elementary science leaders during the COVID-19 pandemic?

Methods

Research Design and Rationale

The design of this study follows a qualitative approach to holistically understand the experiences and challenges unique to district-level elementary science educators during the pandemic. A phenomenological approach was used to understand the phenomenon of being a leader in science education during the pandemic and to analyze the backgrounds, experiences, perceptions, challenges, and coping mechanisms of serving as leaders for elementary science teachers by working as district-level curriculum writers and coaches who support teachers in various ways. Creswell (2013) describes how a phenomenological approach can be used to explore a single concept by describing the similarities among participants' experiences with the phenomenon (what they experienced and how) and thus narrow down the shared experiences to a single essence of the phenomenon.

Participants

This case study focused on four participants, each with similar, yet unique, roles and experiences as leaders in elementary science teaching. The participants' demographics and roles are outlined in Table 5.1. All names are pseudonyms.

Table 5.1 Summary of the District-Level Educators

Participant	Sex	Race	Age Range	Role and Location	Prior Experience
Hazel	F	*	60s	PK-6 science curriculum specialist; Los Angeles	25 years in education; 10 years as an elementary classroom teacher
Bailey	F	*	*	K-5 science curriculum specialist; Seattle	15 years in education; 4 years teaching in 4th grade bilingual classroom; 3 years coaching
Paulo	M	White	40s	K-5 science coach; Florida	17 years teaching: 4th grade classroom teacher for 7 years; 2 years teaching 5th grade science; 8th year in a coaching position
Frankie	F	*	30s	Director of STEM programs; Los Angeles	6-8 years of teaching experience; taught marine biology in informal education

*Did not provide

Hazel, who has been in education for 25 years as an elementary school teacher and teacher on special assignment (i.e., an experienced teacher who takes on a specialized role outside of the classroom), is now an elementary science curriculum specialist for a large school district in California, which includes 36 elementary schools across seven cities. Her role as a curriculum specialist for pre-kindergarten through sixth grade requires her to write science lessons, model teaching lessons in the classroom, and design and lead professional learning experiences for classroom teachers related to science. She is responsible for providing professional development to over 900 elementary teachers in the district on the science curriculum. Hazel has her undergraduate degree in biology and cognitive psychology, as well as a Master's in special education.

Bailey is also an elementary science curriculum specialist who works with grades kindergarten through fifth grade in Seattle. Bailey has worked in education for 15 years, including four years teaching fourth grade in a bilingual classroom and two years as a district-level elementary science coach for five schools in the district. Bailey took a break from coaching and being in the classroom to pursue her Ph.D. in science education. After graduating, she is now an elementary science coach for a K-5 STEM school. For this role, her work involves creating and rewriting the science curriculum, facilitating professional learning experiences for science teachers, and planning and leading coaching cycles for elementary teachers in science content and pedagogy.

Paulo has worked in education for 17 years, as a fourth-grade classroom teacher, fifth-grade science teacher, and science coach. While Paulo does not have a formal background in science teacher education, he came to his current role as a science coach through a passion for the subject. Paulo has worked with kindergarten through fifth grade both students and teachers as a science coach in a public school in Florida for the past eight years. When working with teachers, Paulo supports classroom teachers by helping to create science lessons and find the necessary materials for meaningful hands-on learning experiences.

Frankie has a unique role as director of a STEM program for low-income elementary students of color in Los Angeles. Frankie has a background in STEM education and ocean education, and before this role, Frankie has taught marine biology in a variety of informal educational roles. She has also taught at the high school level. The STEM program she currently directs partners with 85 elementary school teachers in the Los Angeles area to provide the teachers with free NGSS-aligned science curricula that the teachers implement in their classrooms. The program also includes an afterschool STEM program that teaches children about different careers in STEM and a medical STEM program. Frankie's work as the director of this program involves writing curriculum, preparing kits of materials to accompany lessons, sending staff into classrooms to help implement the curriculum, evaluating their programs, and writing grants. Frankie holds a doctorate of education degree, for which she focused on teacher education.

Data Sources

The data in this study was collected from three sources: initial surveys, individual interviews, and focus group interviews.

Surveys. Participants first completed an online 15-question survey via Qualtrics, a web-based survey tool. The purpose of this survey was to gather demographic information about each participant and information about the context each participant was working in at the beginning of the pandemic (March 2020) and the following 2020-2021 academic year. Using both open-ended and multiple select question types, the survey was also designed to gain an initial understanding of the challenges these educators faced in their particular roles in science education as leaders during the pandemic and what kinds of support they needed. The survey questions are listed in Appendix D.

Individual and Focus Group Interviews. Each participant first participated in an individual interview with the researcher and then one focus group interview with the researcher and 2-3 other elementary science teachers or educators. Both types of interviews were held over Zoom, a video conferencing platform. The audio of the interviews was transcribed automatically through Zoom. I edited and corrected the transcripts from Zoom using the audio recordings. The purpose of the individual interviews was to gain a detailed, in-depth understanding of the participants' experiences and challenges as elementary science leaders during the pandemic. The purpose of the focus group interviews was to gain an even more nuanced understanding of the experiences and challenges of the participants during the pandemic, to allow participants to compare and contrast their experiences and provide support to one another, and to note any changes to their experiences over time. The individual interviews lasted 45-60 minutes and the focus group interviews lasted 60-90 minutes.

Data Analysis

To analyze the data in this study, I followed a constructivist, grounded theory approach (Charmaz, 2014), allowing themes and ideas to emerge from the data through multiple rounds of coding. My initial coding process involved generating initial codes from the interview transcripts. From there, I grouped the initial codes into broader, conceptual focused codes (Charmaz, 2014). Next, I used a distributed leadership framework to guide the grouping of focused codes into themes related to the participants' experiences and challenges as elementary science leaders during the COVID-19 pandemic. To group the focused codes into themes using a

DL framework, I looked for major themes related to leadership practice from the initial codes (e.g., actions as leaders and challenges inhibiting the ability to lead), as well as groups of initial codes that did not fit into these themes.

Role of the Researcher. My role as the researcher in this study was to quickly build bonds and a sense of trust with the participants during the interviews so that they felt comfortable being transparent with me in sharing their experiences. Doing so was facilitated by my role as an elementary science teacher myself who is experiencing similar challenges to the elementary science teachers that the participants worked with. The job responsibilities of the participants involved working with elementary teachers and coaching them on the science curriculum and therefore, the struggles associated with teaching science during the pandemic are a shared experience for myself and the participants. The educators in this study could relate to my experiences and I could relate to their work with elementary science teachers, thus generating a sense of trust and shared understandings.

Findings and Results

Theme 1: Impacts of the COVID-19 Pandemic on District-Level Educators

The findings show that the COVID-19 pandemic has impacted the work of district-level elementary science educators and coaches as leaders in elementary science in two main areas: (a) how they are managing their time working, and (b) how they are supporting other teachers with science instruction through professional development and in classrooms.

Managing Time in New Ways

The data from the four district-level elementary science educators and coaches related to the theme of managing time and using their time in new and different ways due to the COVID-19 pandemic. In this theme, participants discussed feeling a sense of privilege as they had the ability to work remotely, the challenges of not being in the classroom, the eagerness to work directly with students and teachers again, and the impacts of the reduced prioritization of science instructional time during the pandemic.

One of the main impacts of the pandemic on many workers globally was the requirement to work remotely. Many teachers, however, returned to the classroom in the Fall of 2021, as best practices for teaching and learning encouraged in-person learning and social interaction for students. While many teachers returned to their classrooms and learned how to teach safely in a socially-distanced world, many district-level educators had the ability (and expectation) to continue working remotely during the 2021-2022 academic year. For example, Frankie described how in addition to feeling grateful for having a job during the pandemic, her being able to work remotely felt like a privilege that classroom teachers who were working in person did not have, as teachers working in person are at a greater risk of getting sick or being exposed to the virus. Frankie said:

> We are fully able to do most of our work remotely. Um, my staff and I all have jobs. Um, so I think I'm in a very privileged space. Um, and I know that many of our partner teachers really don't feel that much support. So, cause I personally, I mean, this sounds probably terrible given the light of the pandemic, but I love this. Like I, I love working from home. I, um, like I live 50 miles away from campus, and not having a three-hour commute every day saves me… time.

The ability to work from home is not only a privilege in terms of health risks, but Frankie felt she became more productive because of the time she saved by not commuting daily. Frankie also recognized the privilege of the amount of support she received at her job, compared to that of her partner teachers who are working in schools. Similarly, Bailey described how she had a feeling of guilt in the Spring of 2020 when she was suddenly faced with a great deal of free time when she could no longer visit in-person classes as part of her coaching work. She described how:

> I felt guilty because I'm not in the classroom, right? So I was like, what? You're paying me a full salary. I am sitting at home. Okay. Like we're not having class, so it's not like I can go in and coach, so what am I doing?

Bailey utilized this extra time during her workday to create more resources and activities for remote science instruction to support remote science teaching in the spring of 2020.

Similarly, Hazel felt like the pandemic created a new division of her work time, in which the aspects of her job as a curriculum specialist she is spending time on have shifted. Instead of spending time in various schools in her district working with teachers and principals to improve science instruction, she now provides more technological support for teachers. Much of Hazel's work during the beginning of the pandemic and the immediate switch to distance learning in the spring of 2020 required her to move all of the science curricular materials to Canvas, an online learning management system. Therefore, she described how teachers came to her for support with this platform:

> My job has changed to a lot more ed tech support, right. Where somebody is like, "ah, this isn't working," you know, and I'll say, "make me a teacher in your classroom." And I go in, and it's usually something really that you would probably find trivial, like where the person has published the module, but not the assignment. And they'll be like, my students can't see it. The links don't work, but the links always work.

Hazel described how her time as a science curriculum specialist typically spent in schools working with teachers in person was reallocated to supporting teachers with technology. She was helping them navigate the learning management system for which she created science instructional modules. Likewise, Paulo's role as a science coach during the pandemic started to unofficially include technology support, as classroom teachers could not manage to help a class full of students to join Zoom. Paulo would jump in and support teachers by helping students join the Zoom lesson.

Participants also had their roles as coaches and curriculum specialists shift due to the demands of the materials needed for hands-on science learning. While this was not a new responsibility for participants, this part of their jobs became more laborious and more time-consuming. Frankie, who typically has the support of other staff members and graduate students, had the responsibility of making 1200 kits of lesson materials by herself at the onset of the pandemic. Hazel, who runs the warehouse of science supplies, would normally have volunteers in-person to help prepare materials and distribute them to teachers. Because of the pandemic, Hazel had to ask for support from family members and friends by dropping off supplies to count, prepare, and package the materials to give to teachers. Paulo similarly described how the responsibilities of the materials management aspects of his job as a science coach have increased due to the pandemic. He is the point person for science materials, which before the pandemic involved being the central person in the building who was responsible for the room of science supplies. This aspect of his job typically involved organizing and cataloging the supplies, as well as locating the supplies needed for a given lesson and providing them to the teacher. However, this role became much more demanding during the pandemic, as lesson materials used in person could no longer be shared between students. Paulo re-organized supplies during the pandemic and had to find COVID-friendly materials to use for in-person science lessons.

While in some ways working remotely as an educator can feel like a privilege and can increase productivity, there were inherently many challenges that the participants faced by not being able to work in person. Before the pandemic, coaches and curriculum writers had the freedom to easily see their work in action. They could observe classroom teachers teaching a science lesson, pop into a classroom in the middle of a lesson, or bump into a teacher in the hallway and remind them of something related to their science lessons. Without these face-to-face interactions when working remotely, participants were faced with new challenges of how to navigate supporting the teachers they work with. During the 2020-2021 academic year, Bailey supported teachers who were working either in-person or online, and while she could more easily visit the classrooms of teachers who were teaching science in person, she found it harder to support teachers who taught science remotely on Zoom:

> It's different like with my in-person, I can look in the window, and if they're doing science, and they're not at capacity for our spacing capacities in a room, I can go in, but on Zoom, it's like there's no window on Zoom, so I feel like if I chime in in your waiting room, like most of the time they greet me and they're like oh my God, I'm so sorry, I'm not doing science today.

As a coach, the ability to pop into a classroom is not the same as trying to observe science instruction over Zoom spontaneously. In addition, the informal interactions, or "water cooler chats," were missing for educators who were not able to work in schools, which created a void not just for teachers to socialize, but for important or quick, conversations about teaching and learning between educators. Bailey described how this impacted her work as an instructional coach:

> It's been hard to replace, but also made it so visible, is how valuable hallway chats are. How, how much work happens at the copier. Like how much, how much thinking about student learning just happens in the, like the nooks and crannies and in-between time, that [we] haven't found a replacement on Zoom. I mean, I feel like [with] some teachers, like, I'm definitely like, here's my cell number. Here's my cell number, text me whenever. And like some teachers have taken me up on that and were like, quick question and we just hop on Zoom real quick, but that's still not the same.

Bailey felt that as a coach, her ability to support classroom teachers with science instruction was greatly limited by the online teaching format compared with being in school.

Similarly, from a professional perspective, Hazel felt her philosophy toward coaching has had to shift to adapt to leading professional development in a virtual setting. She shared an example of when coaching teachers through a lesson on assembling an electric circuit using wires, a bulb, and batteries remotely, compared to in-person:

> And there's so much lack of knowledge. And that's when I feel that angst, like, "Oh, if I could just be in that classroom," so I have to make a fib up, like, "Well, sometimes the scholars haven't taken away enough insulation," you know? But in person, I would see that like teachers would go, "These batteries don't work." And then I would just circulate and the wire strippers would be there. And I could say like, "Well, if you see a group where they've lit the bulb," and then they would be like, "Oh, a-ha." And they'd strip the wires. And now I can't do any of that kind of stuff, you know?

As an example, when building an electric circuit, in person Hazel might suggest that teachers look over at a group that has successfully lit their lightbulb to help solve an issue. However, in a virtual setting, Hazel has to directly state what the problem might be, such as stripping off more of the insulation on the wires. Virtually, Hazel feels she has become the "sage on the stage" and simply models how to teach lessons, compared to doing in-person teacher trainings in which she would co-plan and co-teach with teachers and be able to physically circulate the room while giving feedback to teachers. Hazel also described how her "show, not tell" style of coaching where she would typically lead teachers to the solution to a problem in-person does not translate to virtual coaching or professional development. Virtual coaching settings do not allow Hazel to facilitate the same types of learning experiences for teachers.

While these educators may have been able to adapt their work of curriculum writing and supporting teachers somewhat successfully from afar, participants felt a strong desire to be back in the classroom working directly with students and teachers. From an emotional perspective, Hazel described how she has a passion for teaching and missed the time she would spend modeling lessons for teachers. Bailey shared a similar eagerness to be back in the classroom, working with teachers. Bailey described:

> My biggest joy comes from working with kids, or seeing how my work with the teacher and the teacher's work with the kids, and the kids have that moment of like, "Oh my

> gosh. Or like I figured this out," or, just being able to communicate like, "Oh, like that's, that's what I mean," like, those moments and I don't have access to those anymore. So that's been really hard.

While science instructional time has historically been not prioritized in place of teaching literacy and mathematics in elementary schools, science instructional time has been even further marginalized because of COVID-19, as classroom teachers are facing many demands and adjusting their practice to be safe but also educational in a pandemic world. As a result, that means for Bailey, she was not able to do normal science instructional coaching cycles with classroom teachers. Bailey described how her typical coaching cycle before the pandemic would involve a schedule of regular meetings with the teachers in professional learning communities and frequent opportunities for teachers to try out what they are learning with the PLC in the classroom over the course of eight to 12 weeks. Bailey was also able to easily put some pressure on classroom teachers to teach a sequence of science lessons by asking the teacher if she can come into the classroom for five days in a row to test out the lessons. However, she described how this coaching routine has been disrupted by the COVID-19 pandemic:

> But I just feel like everyone, I feel like we're all a little like treading water in this space of like, what, have I done in a coaching cycle this year? Like normally that's a regular part of my practice, with multiple teachers at a time, you know, like I kind of have in recent weeks, but like it took a lot to get.

With half of the teaching happening in-person and half virtually, the normal structure that Bailey could rely on for her science instructional coaching to become meaningful for teachers could not exist, as teachers were facing many demands with instruction, technology, and more.

As leaders in science education, district-level educators who work as elementary science coaches or curriculum specialists had to reimagine their work during the COVID-19 pandemic. These teachers had to reconsider not only what does support for elementary teachers with science teaching and learning look like, but also what types of supports do teachers working directly with children need the most during this time. Participants learned how to lead from afar by supporting teachers with virtual science instruction and creating new science curricular materials. Participants also took on new responsibilities, such as supporting students and teachers with technology and preparing large amounts of classroom materials. While doing this work and readjusting their roles, these educators are managing their feelings of being disconnected from the classroom, students, and teachers.

Shifting Priorities

The data from district-level elementary science educators and coaches showed that the COVID-19 pandemic impacted the types of support these educators provide for teachers through leading professional development, coaching, and creating science curricula. In this theme, participants discussed how their support for classroom teachers looks different during the pandemic because of the types of professional development that get prioritized for classroom teachers and the overall reduced prioritization of science learning during the pandemic.

As teachers were required to learn new ways of doing their job during the pandemic, teacher learning during the pandemic has focused first and foremost on the strategies and skills teachers need to successfully teach remotely and teach in-person in a socially distanced classroom. Therefore, coaches and other educators who traditionally support teachers with science instruction had to shift how they are involved with teacher learning. For Hazel, this means conducting teacher training on using different types of technological tools in science instruction, like Flipgrid or Jamboard, in place of training teachers on how to teach the science curriculum. For Paulo, this means becoming the go-to person for technology support. He described how:

> I tried to serve, you know, unofficially in that role early in the year when teachers were having trouble. I would, you know, because the teachers got 20 kids to talk to. They can't

> help Johnny figure out how to turn his camera on. You know, and someone has to sit down and spend the time to do that. And early in the year, I was watching teachers. They have a 50-minute planning block, you know, they're spending 25 minutes just helping the kids get to online PE, you know, cause the kids didn't know how to end the meeting and start a meeting, kind of a thing.

At his school, there was no one person who was responsible for providing on-the-spot support for students who were having technical issues joining a lesson remotely, and so Paulo stepped into that role to take the burden off the classroom teachers. While not officially working as technological support, Paulo has assumed the role of supporting teachers and students with technical issues.

Traditionally, elementary school teachers have greater pressure to have their students become strong readers, writers, and mathematicians, compared to helping students become strong scientists. This is reflected in that instructional time that is dedicated to teaching science in elementary schools is declining (Blank, 2013). This greater urgency to teach literacy and mathematics over science was enhanced during the pandemic, as educators and parents are generally concerned about potential gaps in students' learning because of the time spent away from the classroom. Paulo described how being responsible for students' science learning during the pandemic, compared with reading, writing, and mathematics, was not an extremely stressful experience:

> The stress has not been as, as heavy for me, because to be honest, when things got serious, nobody was worried about science. They weren't, you know, my K, one, and two weren't in a panic because they couldn't figure out how to teach science, you know? So it wasn't, it wasn't as dire a situation. And, um, I guess just being honest, it wasn't just, wasn't that stressful, um, for, for me from a, from a science point of view.

Compared with the pressures of teaching students to read, write, and do mathematics, the teachers Paulo worked with were not worried about their students' science learning. Paulo felt as though there will be plenty of time in the future for students to make up any science learning they missed because of the pandemic.

While some educators were concerned about gaps in students' knowledge due to missed learning experiences as a result of the pandemic, Bailey shared a similar sentiment to Paulo in the lack of concern about the amount of science content that is covered during pandemic learning. At Bailey's school with her support as a science coach, a good deal of the typical science content that is taught in a normal year was still taught during the 2020-2021 academic year. She described how when thinking about whether or not science is being taught during the pandemic:

> I'm like, kind of the ones that always jumped to people's minds, are like, is it happening? Is science happening at all? Like, is that a thing or are we just saying, ah, we'll catch up later, just do math and language arts. So I'm, I'm happy to say that I am 95% sure that 80% of the unit happened, like, right. Like I knew it was happening because of what teachers would bring to our PLCs, even if I wasn't able to get around to all 25 classes every two weeks, whatever. Um, so it's like, I feel like getting kids access to some degree to content.

Fortunately, Bailey as a science coach was still able to provide the necessary supports to classroom teachers in the form of lesson plans and coaching to continue a close to normal amount of science instruction during the pandemic. Conversely, Hazel, who works with 85 different elementary schools in a district, did not have the same success. The teachers at her schools asked her for support by coming into their schools and leading the science lessons for them:

> Just the other day, the science lead teacher at one of the lowest-performing schools said, well, could you just come and do like a once-a-week lesson? But I said, you know, and I'm not like a traveling field trip, right. This is a bigger issue here. Um, and I would rather meet with like the fifth-grade team and, and show them how.

For the schools Hazel works with, the science curriculum she created was not being taught because of the resistance of the teachers to teach science.

While science is often not prioritized in elementary school classrooms but prioritized in others, the pandemic has illuminated this discrepancy between schools. During the pandemic, some teachers and schools continue to prioritize science and push for making time and space for science instruction in a pandemic world, while others do not. As leaders in science education, participants were committed to making science happen in some form and rewrote curriculum, redesigned professional development, and reimagined science coaching to fit the constraints of a pandemic world. However, some schools continued to welcome this support for science instruction, while others, like some in Hazel's district, did not prioritize science instruction and did not use the science curriculum that was created for them.

Theme 2: Overcoming the Challenges of the COVID-19 Pandemic as Leaders

The ways in which district-level elementary science educators and coaches are overcoming the challenges they face during the COVID-19 pandemic included two themes: (a) adapting science curriculum to meet the needs of teaching in a pandemic world, and (b) growing professionally to learn how to overcome new challenges.

Adapting Curriculum

The data from district-level elementary science educators and coaches related to the theme of overcoming the challenges of the COVID-19 pandemic included adapting and modifying science curricula to fits the new needs of teachers and students during the pandemic. In this theme, participants discussed how the pandemic required them to create new digital lesson plans for the teachers they work with, prepare lesson supplies or kits of materials to be sent home to children learning remotely, and be creative in preparing new types of science learning activities that work within the constraints of pandemic learning.

While all teachers had to adapt their curricula to remote and/or socially distanced learning as a result of the pandemic, elementary science educators faced a unique challenge of adapting science lessons in particular, which are typically hands-on, collaborative, and materials-based, to being meaningful in a remote learning setting. For science curriculum writers and coaches, this meant adapting existing lessons or creating new lessons entirely that use materials students have available at their homes, that can be followed asynchronously, and/or that a child can navigate to using an online platform. When many of the schools in her district went remote, Hazel as the curriculum specialist was tasked with moving the science curriculum to new science learning modules on a specific learning management system, Canvas. Canvas was a new technological tool adapted to meet the needs of remote learning and this shift came with both its benefits and its challenges for Hazel. On one hand, the teachers Hazel worked with described how every child was able to submit a video response to their assignment on Canvas, which was different from in-person learning because there was not enough time during a lesson to have all 32 students in a class share out their responses. On the other hand, Hazel faced many challenges in preparing the teachers she works with to use the Canvas modules she created with science lessons. Teachers needed a good amount of training on Canvas, as well as other technological educational tools, that Hazel was responsible for organizing and leading. For students who opted to spend half the day at school and half the day at home, the science modules on Canvas were designed by Hazel for students to work on independently at home. When teachers were provided with digital content to post on Canvas, some teachers simply chose to not publish the science modules. Hazel described how teachers do not publish the modules with the science content:

> So again, if they would publish the modules, they could do them at home. We design them to be done, you know, with families or even independently, like I would have been, I'm a first-generation student. So I was very aware of the sort of latchkey kid, that would have been me. Um, so, but if the teacher doesn't publish it, what can we do?

Within Hazel's district, some principals required their teachers to teach science, while others did not, which created inequities in Hazel's perception. Oftentimes it was up to the teacher whether or not they taught science, which was a source of frustration for Hazel as she created virtual lessons that students who were interested in science could participate in, but teachers who simply would not post the lesson were a barrier to these students have any science learning experiences.

Paulo similarly adapted his science curriculum to be taught remotely and to be taught in a socially-distanced classroom with students not collaborating or sharing any materials. He described how while some science units lend themselves well to this format of learning, some science units do not:

> To be honest, I feel like we just have to admit that sometimes there isn't a way and we just have to do the best we can and not beat yourself up because it's, you somehow failed at finding a way to translate this hands-on lab in, into a virtual. It's just not possible. And until we can get things back to normal, we just have to go to plan B, and sometimes plan B is not as good.

While working his hardest at adapting the curriculum, Paulo also accepted that sometimes there was not a good solution in place of students being able to share materials and collaborate, and he accepted that this adaption might not be perfect or as good as the ideal hands-on, collaborative science learning environment that we aim for.

An enormous way in which district-level educators and curriculum specialists had to adapt their science curriculum was considering the supplies needed for each lesson and sending the materials to students learning from home. Hazel compared the amount of assistance she had preparing bags of materials for teachers to collect before the pandemic to not being able to work together in person due to COVID-19 restrictions:

> I have adult transition students who are like 18 to 22, um, I used to, they would be in person. Right. And they'd make like, count things, make things for me. That's all

> changed… And, but now that all has to be one bag per student. So I need many more bags. I have less help.

Before the pandemic, Hazel would have the help of many people to help put bags of materials together. Because of the pandemic, Hazel needed to create more bags of materials as students could no longer share materials, with less help. Since she was working from home, she even asked her partner to help put together kits of materials. Similarly, the program Frankie directs supplies kits of science lesson materials to 85 classrooms for 20 weeks. While she typically would have assistance assembling these kits, to ensure her safety during the pandemic, she assembled 1200 kits of lesson materials, working long days by herself in her office. Moreover, she emphasized the importance of sending these kits to her students, as many of her students come from low-income families who would not have access to or be able to afford these materials otherwise. To Frankie, the work of ensuring that all of her students have access to the necessary materials to be able to learn science at home was an equity issue that she was committed to addressing.

Educators also had to adapt their science curriculum by including new types of activities for both in-school and out-of-school learning. Educators were forced to be creative when coming up with new ways to learn science, and participants described how while these new learning environments were established out of necessity, they might want to keep these types of activities in place after the pandemic ends. When Bailey's school suddenly shifted to remote learning in the spring of 2020, Bailey spent a good deal of her time as a science curriculum specialist creating digital lessons for students to complete at home. She designed these new remote lessons to be week-long, asynchronous projects that could easily be tailored and adapted for each elementary grade:

> But that was kind of the spring, were these like week-long projects and we did it K through five. So I basically said, let's pull the DCI through and say, if we're going to be growing plants, what does this look like from a Lima bean, from whatever dried beans you got in your house, whatever thing you think might be a seed, what do you think, what do you need to do to activate your seed? Okay. Like, let's see what happens. Right. Um, and why does that work?

For each project, the main concept the students were learning about was the same, but the assignment was adapted for different grades so that children in different grades could learn specific details at a level that is age-appropriate for them. Not only did Bailey create science assignments that students can work on throughout the week that are differentiated for each grade level and that siblings within a family might collaborate on, but she also created assignments that used materials flexibly, so students could utilize whatever material was available to them in their homes, such as any type of bean the family has.

As a science curriculum specialist, Hazel described how one shift in her job responsibilities was in place of an in-person family science night, Hazel was asked to plan a virtual STEAM night that families can participate in remotely:

> I used to do a lot of family science nights in person. That was a big thing. Family engagement really helps with the equity piece. And so we're going to do our first virtual STEAM night on December 3rd with one of our lower-performing schools, with a principal who really does care about science. And I think it'll be fun. And I'm looking forward to that.

While there are restrictions to what types of activities families can participate in virtually, there are some benefits of holding family events virtually. For example, parents do not have to get childcare to watch over another child if they are attending a virtual STEAM night with one child. For the virtual family STEAM night, Hazel packaged materials, including family night journals, to send to families who were participating. She also included a community partner, who led their own activity, using breakout rooms on Zoom. Therefore, Hazel described how offering a virtual

STEAM night for families might be something she wants to continue doing after the pandemic, as it may be more inclusive and allow more families to participate.

During the COVID-19 pandemic, district-level science educators had the huge responsibility of moving the curriculum to new online platforms and preparing materials for many students to be able to learn science. The process of adapting science curricula for remote learning and socially-distanced classrooms came with struggles for these educators, as teachers sometimes do not even use or publish the science lessons they are given, and the amount of work involved in having to prepare lots of materials for students alone. Nonetheless, the adaptation of science curricula came with some positives, as educators created new types of activities out of necessity which they hope to continue post-pandemic, and felt committed to ensuring participation in meaningful, hands-on science learning by providing students who may not otherwise have access the necessary science learning materials.

Growing Professionally

The data from district-level elementary science educators and coaches related to the theme of overcoming the challenges of the COVID-19 pandemic showed the ways these educators grew professionally. In this theme, participants discussed how they grew professionally as a result of the pandemic through connecting with other educators virtually in different parts of the country, learning new technological educational tools, and reaffirming their conviction to hands-on science learning and reducing inequities in students' science education.

One of the ways in which participants experienced professional growth as a result of the pandemic was by reaching out and connecting with educators virtually who live all over the country. Participants described how they would use social media, like Twitter, to meet other educators in similar roles, as well as Zooming together to tackle some of the unique challenges that science educators are facing during the pandemic. For Bailey, this connection was a support for her when figuring out how to successfully coach teachers in science in an online environment. She described how she met other science coaches through Twitter, some of who were coaching teachers remotely before the pandemic, and they talked about how to do the work of coaching virtually and discussed examples of what coaching looks like in online learning environments. While Twitter is not a new social media platform, the use of Twitter to problem-solve and connect with educators doing similar work in science was new to Bailey. This new way of connecting with other educators was both a support and a silver lining, or an unexpected positive outcome, of the pandemic. Bailey described this unexpected benefit:

> I've really been using Twitter a lot more than I thought I would ever use it. Right. And, um, connecting with other science educators. And so I kind of started this group where I was like, Hey, I want to know how to do initial models with Jamboard over Zoom. Does anyone want to come play with me? And so we did like eight Sundays in a row and we just threw out different lessons. And the first few I just did, like as a rehearsal, like you would do in like teacher school, you know like, let me just treat you as fifth graders for a second, then like we can talk about it. And so in 90 minutes, uh, we, we covered a couple of different topics.

While many participants learned how to use new technological educational tools out of the necessity of needing new platforms to teach students remotely, participants also viewed the learning of these new platforms as a positive takeaway. Educators found tools that they never would have sought out without the pandemic that they felt enhanced learning and that they hope to continue using, even during in-person learning post-pandemic. In terms of her professional growth, Hazel described how she has always been interested in learning new technology, and how she is happy that she has learned how to use Canvas. She now describes herself as a Canvas expert.

As a result of the pandemic, many participants grew in their conviction to teach hands-on science and to reducing inequities in students' science learning. The pandemic made hands-on science teaching challenging and often impossible due to restrictions on sharing materials and maintaining a social distance for safety reasons, as well as it illuminated inequities related to students' science learning, such as students' access to materials for learning at home and the level of parental support and involvement in student learning at home. In general, Hazel saw the difference across schools within her district in that lower-performing schools avoid spending time on teaching hands-on science learning in place of teaching reading, writing, and mathematics. She described how she feels those schools fail to see opportunities to integrate literacy into science instruction:

> Lots of equity concerns, because I feel like, in general, our highest performing schools are the ones that are doing science in-person. Our least performing schools are, there'll be like, oh, we, we have to just do foundational skills. So they don't see the connection between the language that happens when you do science.

While Hazel saw many opportunities during science instruction for learning language, the philosophy at lower-performing schools in her district was to prioritize reading and writing over science, despite these opportunities to learn literacy skills in science. In addition to her growth in technological skills, Hazel also described her growth as an educator in her conviction to not giving up on trying to continue making meaningful, hands-on science learning experiences:

> I still don't want to give up hands-on science for kids. I'm not there. I don't want it to all be, uh, simulations and PhET simulations all the time. I'm not, I'm not there yet. So in that way, I've grown in my conviction. Right. That hands-on science truly, um, gets at language. Right. Because I could send you some of these videos that kids have done and you would just be like amazed, you know, like where they'll be like, okay, I just want to show you this. Like the water is going through the dirt, you know, and they're just talking and talking and talking.

Similarly, Frankie described her growth in being a reflective educator and trying to eliminate making assumptions about what students may or may not have access to:

> I think we've really had to be very particular about, or even further investigating our issues of equity and access when it comes to, um, like inferring that kids might have supplies or inferring that all kids are going to have a printer of like, oh, you can just print

> this worksheet. That'll be fine. No, I'm really taking a deep look at what students may or may not have.

Frankie described her growth in being conscious of issues of equity and access to learning supplies, and her growth in thinking about how to create change in these inequities.

Paulo noted that he sees inequities in the amount of support that students get while learning at home:

> Where we're seeing equity issues is support at home. Um, we have some kids that are, they're not left home alone, but they're basically left to school alone. And if there's a technology issue, they gotta figure it out themselves. There's, there are language issues. And it's, it's really difficult to teach kids in a different language. It's really hard to teach them virtually in a different language because trying to tell them to click that button and not that button is very hard to do. So, the inequity I definitely see is the kids at home. Um, I manage our school's social media and I see all these wonderful posts from families with their, with the moms and the dads, helping the kids with their activities and their lessons. And a lot of my kids don't, don't get that support at home.

Paulo described how the level playing field of a classroom is eliminated during remote learning. There were inequities in how much support students get at home when attending school online and those students who are not native English speakers had an even harder time trying to navigate new and difficult technology that they needed to learn.

As educators who typically want to push themselves towards professional growth, the pandemic provided the participants of this study with surprising opportunities for growing professionally as science curriculum specialists and coaches. In place of being able to attend in-person professional development sessions and speaking with other educators face-to-face, participants sought out new ways to collaborate and learn from others from all over the country through virtual platforms, like social media. Additionally, science educators were forced to be creative to find ways to make meaningful science learning happen when collaborative, hands-on science learning could not happen, and thus participants learned about new educational technological tools that they may even continue using post-pandemic. Finally, the participants in this study grew in their conviction to teaching hands-on science learning. The pandemic has reduced opportunities to create hands-on science learning experiences for students, so participants described their commitment to making these experiences again when it is safe to do so, or to creating similar, yet safe, partially hands-on science learning experiences. Participants were also further committed to reducing the inequities in science learning that were illuminated because of the pandemic, such as having access to learning materials at home and support from parents who are home during the school day.

Discussions and Implications

Before the COVID-19 pandemic, the participants in this study as district-level educators, science coaches, and science curriculum specialists, acted as leaders in elementary science education in different ways. Their traditional work as leaders in elementary science education before the pandemic involved leadership tasks such as writing and refining elementary science curricula, mentoring and coaching teachers on science instruction, and creating and leading professional development related to science teaching and learning.

Disruptions to Elementary Science Leadership

As with many aspects of education, school leadership and science instructional leadership were disrupted by the restrictions and constraints of the COVID-19 pandemic. From a distributed leadership perspective, leading is a shared practice among many actors and depends on the social processes between members of the school community (Spillane et al., 2001b). With schools operating remotely or in person but requiring a safe social distance, this model of leadership was disrupted by the pandemic. Additionally, best practices for instructional leaders, including being located within the school and collaborating with teachers frequently and over time (Mangin & Stoelinga, 2010), were no longer possible during the pandemic.

As coaches and instructional leaders, the participants in this study were impacted by how they manage their time on micro, day-to-day leadership tasks (Spillane et al., 2001b), such as rewriting science curriculum so it can be taught remotely and preparing materials for students to learn science at home. On top of this, participants were faced with the challenge that in some schools, the subject of science was further marginalized by teachers and administrators during the pandemic, and the priority for instruction was placed on literacy and mathematics. The social context from a distributed leadership perspective (Spillane et al., 2001b) plays a central role in leadership, but in addition to leadership tasks looking different during the pandemic, social context also looks different in a remote or socially-distanced world. Collaboration between teachers, instructional coaches, and administrators cannot happen in the traditional sense in-person, through interactions such as formally and informally observing one another teach, bumping into each other in the hallway and having "water cooler chats," or meeting together to co-plan or reflect on a lesson, due to safety requirements to maintain a social distance from other people. The collaboration and social aspects of leadership must happen remotely, which has limitations.

Reimagining Elementary Science Leadership

Although leading during a pandemic comes with many challenges, the COVID-19 pandemic is also an opportunity to reimagine school leadership. Participants in this study described the different ways in which they reimagined their roles as leaders in science education and how they reimagined their leadership tasks. Many of the micro leadership tasks that leaders enact daily, which contribute to larger macro-tasks (Spillane et al., 2001b), had to be reimagined by the participants. For example, the participants acted as leaders in reimagining the macro-task of what science learning can look like when students are home and working with their siblings, instead of their peers, or reimagining how families can be engaged in a STEAM night through micro-tasks of curriculum writing and planning special events. In terms of the macro-task of teacher learning, participants supported the teachers they worked with by creating virtual professional development and teacher trainings, focused on what teachers needed the most during the pandemic. Participants were leaders in their own professional growth in that they became experts in new technological tools and learned about new virtual resources for teaching science to children at home, which they shared with teachers. While collaboration was not happening in person, participants connected with other educators virtually, who may have lived farther away, but who served as knowledgeable resources for problem-solving issues that arose during the pandemic and for collaboration. Despite all of the challenges encountered and the creativity required to reimagine what their work looks like during the pandemic, the participants in this study strengthened their conviction to meaningful, hands-on science learning for all of their students, in the face of inequities that became more apparent among students. For participants, the *how* of how they are leading others within their school communities in science education looked different because of the COVID-19 pandemic, but the *why* of why these educators were committed to doing the work of being leaders in science education did not change.

Conclusions

As leaders in science education, the work of district-level elementary science educators, science curriculum specialists, and instructional coaches is essential to enacting change in science education and supporting elementary teachers' science learning. From a distributed leadership perspective, the micro-tasks these leaders are enacting throughout the pandemic, such as their daily work of writing science curricula for online learning and developing PD in new formats, are contributing to change in science education and helping teachers adjust their science teaching practice to be able to teach science through the challenging and unprecedented time of the COVID-19 pandemic. These leadership tasks include rewriting the science curriculum so that it is safe but still hands-on and collaborative; redesigning professional development and coaching to support the current needs of teachers; and pushing for the prioritization of science instruction within their schools or districts.

While the educators in this study were able to reimagine science education leadership and continue to enact leadership tasks in science education throughout the pandemic, it is important to provide more support for educators doing this work. These educators grew professionally out of necessity and thus learned how to create new science lesson plans for students learning remotely, learned how to use new technological educational tools, created extensive amounts of lesson supplies and kits of materials for students to learn science from home, and sought out virtual connections with educators doing similar work in different parts of the country. However, rather than putting the onus on educators to grow and adapt, there should be more supports in place to support these educators and their growth during the pandemic, such as providing professional development on science curriculum writing or help from the administration creating kits of lesson materials. In doing so, these leaders will be better equipped to serve as leaders in science education and enact change through coaching and supporting elementary teachers and their science instruction.

Chapter VI: Discussion, Implications, and Conclusions

In this chapter, I summarize the significant findings of this study and the theoretical frameworks that guide them. I also provide a synthesis of findings across both chapters of findings, providing a broader view of the implications of this study and possible directions for future research. The overarching research question that guided this study was: *What are the various challenges that elementary science teachers and leaders face during the COVID-19 pandemic, and how are they overcoming the challenges they face?* The broader research question was divided into four research sub-questions:

1. How do first-year and early career elementary science teachers continue to learn to teach during the COVID-19 pandemic?
2. How are first-year and early career elementary teachers coping with the stress they face while teaching during the COVID-19 pandemic?
3. How are district-level elementary science educators and coaches impacted by the COVID-19 pandemic?
4. How are district-level elementary science educators and coaches overcoming the challenges they face to serve as elementary science leaders during the COVID-19 pandemic?

Summary of Major Findings

Chapter IV explores the challenges that first-year and early career elementary science teachers are facing during the COVID-19 pandemic and how they are coping with the stress of the pandemic as education professionals. Using the transactional model of stress and coping (Lazarus & Folkman, 1984), the participants in this study coped with the stress of the pandemic in a variety of ways in order to see the pandemic as less of a threat to them as elementary science educators, and more of a challenge that they can work within the constraints and function better as science teachers during this time of crisis. The findings showed that both first-year and early career elementary science teachers relied on problem-solving and social support as coping strategies for the stress they experienced as professionals during the pandemic. For example, these teachers problem solved by readjusting their curricular plans to fit within new school schedules and incorporating elements of prior teaching experiences to supplement their teaching experiences in the classroom. They also relied on social support in that they collaborated with other teachers in their schools, who may not have been science teachers, for professional support and advice. These teachers demonstrated personal attributes that helped them be able to cope with the stress of the pandemic. They all demonstrated flexibility, which allowed them to comfortably prioritize which units to teach when they had reduced instructional time and adjust lesson plans to be taught safely within a socially distanced classroom. Moreover, as outside support, all of the participants worked in independent schools which provided them with certain outside supports, like adjustments to their teaching schedules to feel safer, and budgets to buy more lesson supplies to be able to send kits of materials home with students. With these coping strategies, personal attributes, and support from their schools, the first-year and early career teachers were able to cope with the stress of the pandemic, adjust to new changes, and work well as first-year and early career elementary science teachers during a time of crisis.

Chapter V discusses the experiences and challenges faced by district-level elementary science curriculum specialists and instructional coaches, following a distributed leadership framework (Spillane et al., 2001b). As leaders in elementary science education, these educators do not work directly in the classroom, they typically share leadership with classroom teachers and administrators, and they work as leaders through instructional coaching, leading professional development, and curriculum writing. For these leaders in science education, the traditional ways in which they acted as leaders were disrupted in many different ways because of the COVID-19 pandemic. These ways included schools and their administration prioritizing mathematics and literacy learning over science learning, not physically being in the classrooms with the teachers they were working with, and not being able to collaborate with other educators in person. These educators also spent a great deal of time rewriting their science curriculum to be either taught while students are learning from home or safely in person in a classroom. Despite these traditional ways in which these educators acted as leaders in science education being disrupted, the COVID-19 pandemic also provided opportunities for these leaders to grow professionally and for educational leadership to be reimagined in new ways. These educators creatively rewrote science curricula to incorporate new elements, making them more family-oriented while students are learning from home, and they found new ways of collaborating virtually with educators across the country. Additionally, they refocused the types of professional development and coaching experiences they were providing to science educators to be more directly supportive of teachers' needs during this time, such as to support technology use in science. By overcoming the challenges that these leaders faced professionally during the COVID-19 pandemic, district-level science educators found many opportunities to reimagine what distributed leadership in science education looks like, while reaffirming their conviction to create meaningful, hands-on science learning experiences and to reducing inequities in students' science learning.

Synthesis of Findings Across Research Questions

The COVID-19 pandemic has disrupted the educational world in many ways, from teachers and students abruptly transitioning to online learning in the middle of March 2020, to teachers learning how to facilitate meaningful, online learning experiences for young children, to readjusting to in-person learning in the Fall of 2020 while maintaining a social distance. All of the adjustments are new and sudden for educators, so it is important to understand how educators in a variety of roles experience changes due to the pandemic, are negatively and positively impacted by the pandemic, and how they are overcoming the challenges they face during the pandemic. In particular, science teaching and learning present a unique set of challenges to educators during the pandemic, compared with teaching literacy and mathematics. Based on current best practices, science learning experiences should be hands-on, use a variety of materials, and be collaborative, allowing students to make sense of their learning through tangible experiences and communicating with their peers. However, both remote learning and in-person learning during the COVID-19 pandemic prohibit these types of science learning experiences to be facilitated easily, as students need the necessary lesson materials at home and students in-person cannot share materials or work together. Through this study, I explore the experiences of three groups of science educators during the COVID-19 pandemic: first-year elementary science teachers, early career elementary science teachers, and district-level elementary science leaders, who work as curriculum specialists and instructional coaches.

For science educators in these three types of roles, a variety of factors impact their success as educators during the pandemic. These educators are impacted by their prior teaching experiences, either in their current roles or experiences in different roles. Prior teaching experiences impact these educators in that teachers draw on their prior experiences to support their work during the pandemic. Teachers in a new role without direct prior experience in that role can lean on their teaching experiences in other contexts, such as previously working as informal educators and teacher educators, as a means of support for how to navigate their job during the pandemic. Prior experiences provide support for both teachers and leaders in that they feel prepared with philosophies and approaches to teaching elementary science that translate into how they adjusted curriculum and pedagogical strategies. For instance, while group work was no longer physically possible for in-person learning, science teachers and leaders maintain their stance that science learning should be collaborative by finding workarounds, such as by asking students to collect data individually and then analyzing class data that all students contributed to. The prior experiences of educators keep them grounded in their approaches to science learning, which they are striving to maintain even when faced with challenges due to the COVID-19 pandemic.

The pandemic also drastically impacts how educators communicate and collaborate with one another. While schools are typically communities in which teachers, coaches, and administrators can informally communicate and share ideas through hallways conversations and water cooler chats, the typical forms of communication and collaboration for educators are disrupted by the nature of distance learning and maintaining a social distance when in-person. Therefore, both teachers and district-level leaders can rely on networks of social support in new ways for support during the pandemic. While traditional models of student teaching and direct mentoring and coaching are not possible during the pandemic, both teachers and coaches are finding new ways to give and provide support to teachers. Teachers are relying more on their co-teachers and homeroom teachers, and coaches provide support to teachers from afar in the form of technological support and professional development that teachers need most during the pandemic. Social support is particularly important for first-year teachers, as they seek out support from other teachers and rely on others to help navigate their first year as elementary science teachers and find nontraditional ways to learn and grow in their roles.

One of the ways in which the district-level science leaders can navigate and find success as leaders in science education during the pandemic is due to their autonomy and ability to seek out their own professional development. These district-level curriculum specialists and instructional coaches find their own opportunities to learn independently outside of formal professional development sponsored by their schools and districts, thus taking ownership of their own independent learning (Jones & Dexter, 2014). These leaders are able to learn through exploring new technological tools and online platforms on their own and through problem-solving online with other educators they connect with virtually. These district-level leaders are not only seeking out the professional learning experiences they need to find solutions to problems they face during the pandemic, but they also have significant prior teaching experience and other experiences in science education, and therefore significant pedagogical content knowledge (PCK) that they can rely on when faced with challenges. By seeking out their own learning and relying on their prior experiences and knowledge, the district-level science leaders can continue their leadership work in science education within the constraints of the pandemic, and thus are not overwhelmed by the challenges they face. While newer teachers and educators may feel more overwhelmed by the challenges and stress of the pandemic, district-level leaders who have more experience, PCK, and expertise in science education can adapt more easily to changes and seek out the support and learning they need to be successful in their roles.

In addition to social support and prior experiences, teachers, coaches, and curriculum specialists are having success as educators during the COVID-19 pandemic due to personal attributes and their outlook on the situation. The educators who are able to adjust to new teaching schedules, new roles, new lessons, and new tasks for their roles have the flexibility to change as the pandemic presents new challenges and hurdles, rather than sticking to what has been done in the past. These educators are flexible in their ability to face new demands, and they even see opportunities for professional growth and learning through this time of crisis. Moreover, these teachers are maintaining their commitment to quality science teaching and learning and do not give up when faced with challenging circumstances. These educators are taking the opportunity to reimagine their roles in terms of the instruction provided to students, the coaching provided to teachers, the format and content of professional development, and the writing of new science curricula. These educators prioritize what could work during the COVID-19 pandemic. This reimagination also requires educators to be creative when finding solutions that work within the constraints of the pandemic. The educators who are flexible and creative are finding success in their work in science education.

The first-year and early career elementary science teachers and the district-level science leaders all apply different strategies to cope with and succeed in their roles during the COVID-19 pandemic. The level of stress that the participants experienced during the pandemic is a level that the teachers and leaders can easily tackle through coping strategies and their personal attributes. For these educators, collaboration and social support in a variety of forms help them connect with others experiencing the same challenges, including other teachers in their schools and meeting other educators online from across the country. These educators are flexible and can also readjust their lesson plans, professional development, and schedules, and find meaning in the new ways of enacting their roles. These educators are thus successful in that they are able to prioritize what science learning experiences are most important for students during the pandemic, readjust lesson plans to be safe but still hands-on and engaging, support teachers in the ways that they needed it most during a time of crisis, and learn new teaching roles as elementary science educators.

The success of the participants in this study is professional success in the sense that they are able to adjust to new jobs or new requirements of their old jobs, and they can adapt to changes in their jobs while maintaining their commitment to meaningful elementary science learning. However, while the participants can overcome the stress of being science educators during the pandemic through coping strategies and personal attributes, these teachers and leaders most likely are experiencing some degree of stress on a personal level because of the impacts of the pandemic. While stress in their personal lives may be separate from professional stress that educators experience in their school contexts, the experience of feeling stress on an individual level is not differentiated between personal and professional stress, and professional stress is most likely magnified if someone is experiencing personal stress as well. The participants did not share many details of personal stress due to the pandemic, which indicates low levels of personal stress and most likely supports their ability to cope with their professional stress as educators.

The findings of this study extend beyond the success of these teachers and leaders during the COVID-19 pandemic into what science education might look like in a post-pandemic world. Elements of the resources and coping strategies used by science teachers and leaders during the pandemic can be retained and incorporated into post-pandemic teaching practices. For both the participants and myself as an educator, the flexibility to adapt to new situations and new challenges utilized during the pandemic can be an attribute on which educators can draw to be adaptable to changes in their school communities. Moreover, the participants drew on resources such as social support and past teaching experiences in innovative ways to support them during a challenging time. The teachers and leaders problem solved in creative ways, such as using breakout rooms on Zoom to facilitate student collaboration during remote learning and designing new types of meaningful and engaging science assignments for students learning at home. This flexibility, creativity, and reflexivity are resources from the pandemic that can be incorporated into post-pandemic pedagogy as well, as a means to support teachers and educators through a variety of challenges they might face. In addition, the importance of elementary science learning is highlighted during the pandemic as science instruction is often pushed to asynchronous instruction and science instructional coaching is not prioritized. For the participants and myself, we can continue to advocate for making space for meaningful elementary science learning experiences, both during the pandemic and in a post-pandemic world.

Use of Theoretical Frameworks

This study is guided by multiple theoretical frameworks: the transactional model of stress and coping (Lazarus & Folkman, 1984); the buffering effect of social support (Cohen & McKay, 1984); and distributed leadership (Spillane et al., 2001b). The transactional model of stress and coping and the buffering effect of social support are useful frameworks for making sense of how elementary science teachers manage the stress of the pandemic. The transactional model of stress and coping in particular provides a framework for understanding different coping strategies (both emotion-focused and problem-focused), and how these strategies may benefit or inhibit one another. Furthermore, the buffering effect of social support is insightful in understanding not only the importance of social support during times of stress, but *how* social support can function as a means of coping for the participants.

A distributed leadership framework helps understand the actions and leadership practices of many leaders in science education. By viewing leadership from the perspective of a practice shared among many actors, I can gain insight into how the leadership tasks of the participants change as a result of the pandemic and how the participants reimagine their leadership work during this time of crisis. Moreover, this perspective provides a framework for understanding the impacts on elementary science teaching and learning, as multiple leaders share the leadership tasks to enact change in science education. Despite the ways in which distributed leadership is useful to understanding leadership in science education, one of the drawbacks of this framework is that it does not sufficiently consider how power is distributed within an organization, such as within a school (Bolden, 2011). In the context of elementary science, power dynamics influence science as a content area, as it is typically marginalized in elementary schools compared to other subjects that are taught (Mensah, 2010; River Maulucci, 2010). The leaders in elementary science in this study are limited in the ways that they can distribute science leadership during the pandemic, such as needing to provide teachers with technological support in place of science instructional support and typical cycles of science coaching not being prioritized in their schools, thus demonstrating the further marginalization of elementary science during the pandemic.

Limitations of This Study

Inherent in all studies are some limitations of the research, which I address in this section. One limitation of this study is the educators who chose to participate in this study. As most teachers are under extreme stress and demands from their administration during these times, those teachers who elected to participate in my study were those who had the time and emotional and mental energy to devote to participate voluntarily. The participants are educators who received the recruitment flyer via the NSTA listserv and who chose to participate in this study by completing the participant intake survey. The voices included in my study are those of educators who had the flexibility and capacity to share their experiences and devote time to participate in completing the survey and participating in both individual interviews and focus group interviews. Therefore, I assume that the voices and experiences of those educators who were not able to afford time and energy to participate because of their teaching contexts perhaps feeling too overwhelmed, busy, and/or overworked to devote their time to participate in a research study were not included in my study. Moreover, the majority of the participants in this study work in private or independent schools, and not many of the educators who chose to participate work in public schools. To get a better sense of the challenges and experiences of working in public schools during a pandemic, it would be essential to include more elementary science educators who work in public schools as participants.

Furthermore, as a researcher, a doctoral student, and an elementary science specialist myself, I hold certain biases and assumptions related to elementary science teaching and learning. One assumption I have is that best practices for teaching elementary science teaching are well-understood by all participants and that all participants hold similar views to mine about what quality elementary science instruction should look like. Therefore, I assume that the teachers and educators in this study are working toward creating similar types of science learning experiences for elementary students during the pandemic. I documented my biases and assumptions through memo writing as I read and analyzed the data.

One of the challenges of conducting this study is limitations due to the constraints of the pandemic. By not being able to directly observe the participants in their teaching contexts, I am not able to observe aspects of leadership firsthand. From a distributed leadership perspective (Spillane et al., 2001b), I am only able to understand the leadership contexts and the interactions between leaders and followers through the participants' descriptions, rather than observing these aspects of leadership myself. Another limitation of using the framework of the transactional model of stress and coping (Lazarus & Folkman, 1984) during the pandemic to understand the experiences of first-year and early career teachers is that the data is focused on the coping strategies used, rather than the process from the two cognitive appraisals of the stressor to the experience of stress and coping strategies used. The participants shared their experiences at the point of using coping strategies in their roles as educators, rather than collecting direct data from the beginning of the pandemic to deeply understand the appraisal processes and stress experienced at that point.

As I reflected on the experiences of my participants, I share many similar views to those of the educators in this study about elementary science teaching during a pandemic. Similar to many of the teachers in this study, I am facing many challenges when teaching elementary science remotely and in person in a socially distanced classroom during the pandemic, such as students not having materials when learning from home and difficulty facilitating student collaboration. However, I too am relying on social support, problem-solving, and embracing the positives of professional growth to manage the stress of teaching during the pandemic. One way to connect with other elementary science educators as a means of social support is through meeting and talking with the participants in the study. During the interviews of this study, I was able to meet incredible and inspiring elementary science educators who were experiencing challenges similar to mine, and I was able to feel connected and supported as we discussed solutions to the challenges we face.

Implications for Practice

This study provides a variety of implications for practice and policy in elementary science education. While the COVID-19 pandemic is not yet over, there are opportunities to learn from this crisis to better prepare educators for another pandemic or another type of crisis that may disrupt education in sudden and unexpected ways. While these teachers and educators in this study can more easily cope with the stress and challenges they face, other teachers and educators in different contexts may face larger challenges and higher levels of stress. This study has implications for what types of supports elementary teachers and other educators need in this crisis and other crises, so that teachers can be better prepared with the necessary support systems, mindsets, and flexibility to continue to teach well during a time of crisis.

Additionally, the context of this study is based in the COVID-19 pandemic, but the larger context of this study is elementary science education. While science teaching is traditionally marginalized in elementary schools, this marginalization was exacerbated by the pandemic. In order for science to continue to be taught at the elementary level in times of crises and beyond, elementary science teachers, leaders in elementary science education, and elementary science teacher educators need to be prepared with the necessary resources, strategies, and support.

Recommendations for Elementary Science Teaching

For elementary science teachers who are working directly with children, it is essential that teachers who are working in the classroom are prepared with a variety of coping mechanisms to handle the stress faced while teaching during a time of crisis. The buffering effect of social support hypothesizes that the right forms of social support can reduce stress on health and well-being (Cohen & McKay, 1984). Therefore, elementary science teachers should be prepared with multiple ways in which to connect with other educators who can provide social support. Teachers should seek out opportunities to connect with others, either virtually or in person, who are doing the same work as elementary science teachers, as sometimes there is only one elementary science specialist per school. Teachers should also work on building these relationships not just in times of crisis so that the relationships already exist and the supports are in place when there is a crisis and a need to buffer stress with social support. Administrators should also help facilitate these relationships within their schools by providing more opportunities for teachers to build relationships beyond the necessary collaboration needed for work.

Elementary science teachers and specialists, as well as elementary science instructional coaches and leaders, should also be prepared with pedagogical strategies for meaningful online science teaching. As remote learning may be a staple in education moving forward, elementary science teachers need to learn best practices for teaching young children science when teachers and students cannot physically be together. These strategies might include how to engage students with different scientific phenomena online, how to facilitate student collaboration online, and how to best handle materials and lesson supplies for remote teaching. Elementary science teachers could learn these strategies by seeking out elementary science professional development.

Another implication of this study on elementary science teaching is the use of the NGSS by elementary science teachers. The elementary science teachers in this study worked at independent schools, and thus had autonomy over their science curricula and created their own curriculum (Kane, 1991). While science teachers at independent elementary schools may not be bound to teaching to the current standards of science education, they are still familiar with the NGSS and may use them to guide their curriculum planning. This use of the NGSS to guide elementary science curriculum planning could be further strengthened through professional learning for teachers as a means to prepare elementary teachers for a time of crisis. By gaining a deeper understanding of the NGSS, three-dimensional science learning, and how to design lesson plans that are NGSS-aligned through professional development, elementary science teachers will be better prepared to write and adapt lesson plans that create meaningful, high-quality science learning experiences for remote teaching and teaching in socially distanced classrooms.

Recommendations for Teacher Education and Professional Learning

As we enter a new era of science teaching and learning, it is necessary that teacher education programs change with the new demands of remote teaching and teaching in socially distanced classrooms. Teacher education must formally prepare their graduates with the skills needed to enter a classroom and potentially face another crisis. Science teacher education programs should now incorporate into their coursework strategies on online science pedagogical skills and how to design science lesson plans for remote learning for future teachers. In addition, teacher education programs should explicitly teach social-emotional learning to prepare teachers with to develop a toolbox of strategies to handle their emotions during challenging times.

For ongoing teacher learning, faculty in teacher education programs can create professional development for science teachers on how to adjust or rewrite science curricula for online learning experiences, as well as teaching them pedagogical strategies for online teaching. Faculty can learn these pedagogical strategies through examining emergent research on remote instruction. These skills cannot be taught quickly, but teachers need to know how to shift or create their own curriculum for an online learning environment so that they can still create meaningful science learning experiences if they have to abruptly shift to remote learning again.

The first-year and early career teachers in this study were flexible and had positive outlooks on the stressful situation of teaching science during the pandemic due to their personality traits and the coping strategies they used. Balossi and Hernandez (2016) described how having a growth mindset is one characteristic that independent schools use to define the high-quality teachers they seek to hire. However, all teachers, regardless of working in a public, private, or independent school, could benefit from having a growth mindset (Dweck, 2007) to be more adaptable to new and volatile teaching situations. Professional development sessions could also offer teacher learning on adopting a growth mindset so that less flexible teachers can shift their perspectives to be more open to change and more easily able to shift and grow their teaching practice if need be. Teachers should also be provided with opportunities to learn from other teachers, as science teachers across the country are all facing similar challenges due to the pandemic, but some teachers cannot easily learn from what other teachers are testing out and finding success with, and instead are isolated and have to tackle their challenges all alone.

While teacher educators and faculty in teacher education are navigating their own challenges during the pandemic, it is necessary to think about what is manageable for these educators during this time of crisis to support teachers and elementary science education. While we cannot expect teacher educators and faculty in teacher education to take on a great deal of new and challenging work, what might be manageable during this time is for faculty in teacher education to incorporate small changes to their existing teacher preparation courses, such as including mini-lessons on social-emotional learning throughout their courses. Teacher educators can also make small adjustments to existing professional development through teaching pedagogical skills for remote teaching simultaneously with other teaching skills and through incorporating more opportunities for teachers to learn from other teachers by connecting them through social media platforms.

Recommendations for Science Education Leadership

A major implication for science education leaders (i.e., district-level science curriculum writers and science instructional coaches) is to work towards helping support the prioritization of science education for young learners, even during a time of crisis. During the COVID-19 pandemic, schools and administrators (as reported by the participants in this study) prioritized literacy and mathematics education for elementary children, as those are seen as essential subjects to children's learning and development. The effects of this were that science teaching was sidelined and taught either asynchronously during remote learning or reduced in instructional time when schools were back in-person. Now, more than ever, all learners must continue to learn science, even during a time of crisis. Leaders in science education can help emphasize the importance of science teaching by talking with administrators about the need for science teaching and increasing science instructional time. More importantly, science coaches and curriculum specialists can support teachers by teaching them how to integrate science into other subjects. If school administrators cannot add more science instructional time to the school day during a crisis, classroom teachers can learn how to integrate science into other core academic subjects and develop their pedagogical practice for making cross-curricular connections and teaching science through other subjects.

District-level leaders in science education must also support teachers with quality science lesson plans and curricula that can easily be taught remotely or in a socially distanced classroom. Science curriculum writers must generate these curricula with the constraints of remote learning and socially distanced classrooms so that teachers are prepared to teach meaningful science lessons, even if there is another crisis with little or no advanced warning. Coaches can teach teachers specific pedagogical strategies for online science teaching that align with current best practices in science education, such as how to promote student collaboration in an online learning environment. Through these recommendations, science teachers and leaders can align on supporting ongoing, quality science teaching and learning for young learners, even during a time of crisis.

Future Research

This study provides multiple opportunities for future research on elementary science education during the pandemic. As the COVID-19 pandemic is new and has created novel challenges and constraints to education, we are just touching the surface of what can be learned from this time of crisis that can inform how to best to support educators during a time of crisis as well as prepare educators for future times of crisis. While we hope that there are no additional crises in the immediate future, it is best to learn from the crisis we are currently experiencing to better prepare educators for the possibility of another crisis that disrupts education and learn how science education may still be taught well.

One possible direction of future research is to dive deeper into the experiences of science educators in public schools. While private and independent schools offer teachers and educators a greater level of flexibility in terms of curriculum, smaller (and thus safer) class sizes, and schedule adjustments, it is important to gain a deeper understanding of the challenges that elementary school teachers in public schools are facing related to science instruction. How do the pressures and constraints of working in public schools impact how educators can adapt science instruction? Which structures within public school contexts support or constrain elementary science teaching during the pandemic?

Another area of future research is to examine the experiences of elementary science teachers and specialists who have more than eight years of experience teaching. As the teachers in the study were first-year and early career elementary science teachers, it would be insightful to understand the experiences and challenges of teachers during the pandemic who have more classroom experience because they are at different stages of their growth as science educators.

There is also a need for more and more detailed research on how different supports and coping strategies used by science educators, such as social support, function to help science educators over time. As the pandemic is ongoing and still somewhat uncertain, it is necessary to look at the coping strategies and supports needed for elementary science educators as their needs change over time. How effective are specific coping strategies over time? What does sustained social support for teachers over time look like? As the pandemic continues, how do the challenges and needs of elementary science educators shift? Through analyzing the challenges, needs, and coping strategies of elementary science educators over time and the experiences of science educators in public schools, we can gain a better understanding of how to support all elementary teachers and thus elementary science learning so that elementary students can continue to have meaningful science learning experiences, despite learning during times of crisis.

Policy Brief

Problem Statement:

The COVID-19 pandemic has presented unprecedented challenges for teachers and other educators because of the ways it has disrupted education. The shutdown due to the pandemic forced schools to close and teachers immediately moved to remote forms of instruction from their homes. When schools reopened, the safety constraints of socially distanced classrooms put a strain on all teachers, but elementary science teachers were particularly challenged, as they could not allow student collaboration or the sharing of materials.

Methods:

This study examined the experiences and challenges of three groups of educators in elementary science education: first-year elementary science teachers, early career elementary science teachers, and district-level leaders in science education. Following a qualitative approach, a survey, individual interviews, and focus group interviews were used to collect data and understand on a deeper level the experiences and challenges of these educators, as well as their ways of overcoming challenges, coping with stress as educational professionals, and embracing moments of professional growth and learning during the pandemic.

Key Findings:

In this study, first-year and early career elementary science teachers found ways to overcome the challenges they faced teaching science during the pandemic by relying on collaboration and support, drawing on prior teaching experiences, and embracing the positives, such as learning new technological tools for teaching and finding more time to be reflective educators. The findings also indicate that leadership in elementary science education was disrupted by the pandemic, but that leaders reimagined what leadership in science education could look like by rethinking what science instruction and curricula look like and what supports teachers need most during these times.

Implications and Recommendations:

The findings of this study provide foundations for a post-pandemic pedagogy for elementary science educators. During this time of crisis and moving forward, elementary science teachers must be able to be flexible, creative, and reflective in order to succeed. They must also learn the necessary pedagogical skills for online teaching and teaching in socially distanced classrooms, develop a stronger understanding and use of the NGSS, and establish networks of social support with other teachers as a form of coping with stressful times.

Faculty in teacher education and teacher educators can make small adjustments to their inservice professional development and current coursework to prepare future teachers, such as incorporating best practices for online teaching, teacher social-emotional learning, and developing a growth mindset.

The pandemic has highlighted and augmented the marginalization of elementary science education. Leadership in science education must continue to provide teachers with high-quality and easily accessible science curricula and lesson materials. Elementary science instructional time should be prioritized and leaders can help elementary teachers find more opportunities to integrate science into other subjects they teach.

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Appendix A: Recruitment Flyer

Teachers College, Columbia University
IRB Protocol #19-273

RECRUITING VOLUNTEERS FOR A STUDY ON

ELEMENTARY SCIENCE TEACHERS & SCIENCE SPECIALISTS

QUALIFICATIONS:

Currently working as an elementary science teacher, elementary science specialist, or elementary science curriculum specialist.

You do NOT qualify for this study if you are an elementary classroom teacher and you teach all subjects, including science.

COMMITMENTS:

If you think you may qualify, please complete this survey.

After completing the survey, you may be asked to participate in a follow-up phone interview and/or a focus group interview.

This study aims to explore the challenges that elementary science specialists face while teaching in-person and remotely during the pandemic.

QUESTIONS? CONTACT:

Allison Bookbinder, PhD Candidate
Teachers College, Columbia University
akb2190@tc.columbia.edu

Appendix B: Informed Consent Form

INTRODUCTION: You are invited to participate in this research study called "Teacher Leadership and Science Instructional Practice: A Holistic Approach." You may qualify to take part in this research study because you currently teach elementary science as an elementary science specialist or an elementary science teacher. Approximately 20 people will participate in this study and it will take 60 - 90 minutes of your time to complete over the course of three months.

WHY IS THIS STUDY BEING DONE? This study is being done to explore the challenges that elementary teachers who teach science face during the COVID-19 pandemic, while teaching in-person and/or remotely.

WHAT WILL I BE ASKED TO DO IF I AGREE TO TAKE PART IN THIS STUDY? If you decide to participate, the primary researcher will ask you to complete a survey, individually interview you, ask you to participate in a focus group with your peers, and ask you to provide two science lesson plans.

You will be asked to complete a brief survey online through Qualtrics. The survey will ask about your background and about your experiences teaching science since the pandemic began. It will take about five minutes to complete.

During the individual interview, you will be asked to discuss your experiences teaching science, both remotely and in-person, and science leadership within your school. This interview will be audio-recorded. After the audio recording is written down (transcribed), the audio recording will be deleted. If you do not wish to be audio-recorded, you will still be able to participate. The researcher will just take hand-notes. The interview will take approximately forty-five minutes. You will be given a pseudonym or false name in order to keep your identity confidential.

You will then be asked to participate in a virtual focus group, run by the primary researcher, where you and teachers like yourself will discuss your experiences teaching science since the pandemic began. This will be audio-recorded and the audio recording will be deleted after it is analyzed. Everyone will be asked not to discuss what is being spoken about outside of the focus group, but it is impossible to guarantee complete confidentiality. This focus group session will take about one hour.

You will also be asked to provide two lesson plans that you used while teaching science remotely or in-person.

All of these procedures will be done remotely at a time that is convenient to you. The individual interview and the focus group will be conducted over Zoom at a break time, after school, or on a weekend as to not interfere with your classroom teaching and preparation time.

WHAT POSSIBLE RISKS OR DISCOMFORTS CAN I EXPECT FROM TAKING PART IN THIS STUDY? This is a minimal risk study, which means the harms or discomforts that you may experience are not greater than you would ordinarily encounter in daily life while taking routine physical or psychological examinations or tests. However, there are some risks to consider. You might feel uncomfortable discussing leadership of the school you are currently working. You do not have to answer any questions or share anything you do not want to talk about. You can stop participating in the study at any time without penalty. You might feel concerned that things you say might get back to your supervisor. Your information will be kept confidential. The interview and focus group will take place in a private location that is safe and at a time that is convenient to you as to not interfere with your work responsibilities.

The primary researcher is taking precautions to keep your information confidential and prevent anyone from discovering or guessing your identity, such as using a pseudonym instead of your name and keeping all information on a password protected computer and locked in a file drawer.

WHAT POSSIBLE BENEFITS CAN I EXPECT FROM TAKING PART IN THIS STUDY? There is no direct benefit to you for participating in this study. Participation may provide you with extra support from the primary researcher in your science teaching and participation may benefit the field of teacher education to better understand how elementary teachers improve their science teaching practice.

WILL I BE PAID FOR BEING IN THIS STUDY? You will not be paid for participating in this study. There are no costs to you for taking part in this study.

WHEN IS THE STUDY OVER? CAN I LEAVE THE STUDY BEFORE IT ENDS? The study is over when you have completed the individual interview, the focus group interview, and the survey and you have provided two science lesson plans. However, you can leave the study at any time even if you have not finished.

PROTECTION OF YOUR CONFIDENTIALITY: The primary researcher will keep all written materials locked in a desk drawer in a locked office. Any electronic or digital information (including audio recordings) will be stored on a computer that is password protected. What is on the audio recording will be written down and the audio recording will then be destroyed. The master list identifying the subject is kept locked and separate from the list of codes. All written and digital data will be destroyed after three years.

For quality assurance, the study team and/or members of the Teachers College Institutional Review Board (IRB) may review the data collected from you as part of this study. Otherwise, all information obtained from your participation in this study will be held strictly confidential and will be disclosed only with your permission or as required by U.S. or State law.

HOW WILL THE RESULTS BE USED? The results of this study will be published in the dissertation study of the primary researcher. Your identity will be removed from any data you provide before being used for educational purposes. Your name or any identifying information about you will not be published. This study is being conducted as part of the dissertation of the primary researcher.

CONSENT FOR AUDIO RECORDING: Audio recording is part of this research study. You can choose whether to give permission to be recorded. If you decide that you don't wish to be recorded, **you will still be able to participate.**

_ I give my consent to be audio recorded

_ I do not give my consent to be audio recorded

WHO MAY VIEW MY PARTICIPATION IN THIS STUDY

_ I consent to allow written and audio-recorded materials viewed at an educational setting or at a conference outside of Teachers College, Columbia University

_ I do not consent to allow written and audio-recorded materials viewed at an educational setting or at a conference outside of Teachers College, Columbia University

OPTIONAL CONSENT FOR FUTURE CONTACT: The primary researcher may wish to contact you in the future. Please indicate below whether or not you give permission for future contact.

_ Yes, the researcher may contact me in the future.

_ No, the researcher may not contact me in the future.

WHO CAN ANSWER MY QUESTIONS ABOUT THIS STUDY?

If you have any questions about taking part in this research study, you should contact the primary researcher, Allison Bookbinder, at 203-524-3487 or at akb2190@tc.columbia.edu. You can also contact the faculty advisor, Dr. Mensah at 212-678-3816.

If you have questions or concerns about your rights as a research subject, you should contact the Institutional Review Board (IRB) (the human research ethics committee) at 212-678-4105 or email IRB@tc.edu or you can write to the IRB at Teachers College, Columbia University, 525 W. 120th Street, New York, NY 10027, Box 151. The IRB is the committee that oversees human research protection for Teachers College, Columbia University.

Appendix C: Participants' Rights Form

PARTICIPANT'S RIGHTS

· I have read the Informed Consent Form and have been offered the opportunity to discuss the form with the researcher.

· I have had ample opportunity to ask questions about the purposes, procedures, risks and benefits regarding this research study.

· I understand that my participation is voluntary. I may refuse to participate or withdraw participation at any time without penalty to future employment.

· The researcher may withdraw me from the research at their professional discretion.

· If, during the course of the study, significant new information that has been developed becomes available which may relate to my willingness to continue my participation, the researcher will provide this information to me.

· Any information derived from the research study that personally identifies me will not be voluntarily released or disclosed without my separate consent, except as specifically required by law.

· Identifiers may be removed from the data. De-identified data may be used for future research studies, or distributed to another researcher for future research without additional informed consent from you (the research participant or the research participant's representative).

· I should receive a copy of the Informed Consent Form document.

By checking the "I agree" box and typing your name below, you are electronically signing this consent form to participate in this study. You affirm that an electronic signature has the same effect as a written signature. You also confirm you are 18 years or older. To agree: Check the "I agree" box and click NEXT to participate in the study.

_ I agree

_ I do not agree

Appendix D: Survey: Initial Questionnaire

As educators are facing increasing demands and new challenges during the COVID-19 pandemic, staying connected is more critical than ever. Your responses and our conversations will allow me as a researcher to support you in science teaching and learning.

1. Are you currently teaching for the 2020-2021 academic year?
    a. Yes, I am teaching full-time
    b. Yes, I am teaching part-time
    c. No, I am not teaching this year
    d. Not sure yet
    e. Other: ____

2. Did you teach during the last academic year (2019-2020)?
    a. Yes, full-time
    b. Yes, part-time
    c. I completed my student teaching last year.
    d. No
    e. I taught for a portion of the 2019-2020 year.
    f. Other: ____

3. For how many months did you teach during the 2019-2020 school year?

    ____

4. How would you describe your current teaching role?
    a. elementary science teacher
    b. elementary science specialist
    c. science curriculum specialist
    d. other: ____

5. What grades do you teach science? Select all that apply.
    a. Kindergarten
    b. 1st grade
    c. 2nd grade
    d. 3rd grade
    e. 4th grade
    f. 5th grade
    g. Other: ____

6. How long have you been teaching full-time?
    a. This is my first year teaching.
    b. This is my second year teaching.
    c. I've been teaching for 3-5 years.
    d. I've been teaching for 6-8 years.
    e. I've been teaching for 9-10 years.
    f. I've been teaching for 10+ years.
    g. I have not taught full-time.

7. Have you held any other full-time teaching roles, other than your current role? If yes, please list your previous teaching positions.
    a. Yes: ____
    b. No

8. Are you currently teaching science in-person or remotely during this academic year?
    a. Fully in-person currently
    b. Hybrid of in-person and distance teaching
    c. Fully remote currently
    d. Other: ____

9. During the 2019-2020 school year, did you do any remote science teaching?
    a. Yes
    b. No, I only taught in-person last year.
    c. No, I was not teaching last year.

10. As a science educator, what challenges have you faced so far during this academic year? Select all that apply.
    a. Finding resources for remote learning lessons
    b. Learning new technology
    c. Connecting with distance learning students
    d. Limited ability to collaborate with other teachers
    e. Adapting in-person instruction for socially-distanced classrooms
    f. Other

11. What other challenges have you faced so far this academic year?

____

12. As a science educator, what has been your biggest challenge so far this year?

____

13. I feel more prepared to teach science this academic year compared to the last academic year.
    a. Strongly agree
    b. Agree
    c. Neither agree nor disagree
    d. Somewhat disagree
    e. Disagree
    f. Strongly disagree
    g. Not applicable

14. I have been provided the right tools and resources to be effective while teaching remotely.
    a. Strongly agree
    b. Agree
    c. Neither agree nor disagree
    d. Somewhat disagree
    e. Disagree
    f. Strongly disagree
    g. Not applicable

15. What kinds of support and resources would help you feel more prepared to teach science this year?

____

Appendix E: Interview Protocol A: Individual Interview

Time of interview:

Date:

Interviewer:

Interviewee:

Questions:
Professional Background:

- Describe your current teaching role this year.
- Is your school in-person, remote, or hybrid right now?
- How long have you been teaching? What grades have you taught?

2019-2020 School Year:

- Tell me about your experiences teaching science last year as you moved to remote teaching mid-year.
- What was the biggest challenge you faced last year as a science educator?
- Describe the science teaching you did remotely last year.
    - synchronous & asynchronous teaching, co-planning, assessments
    - How do you find resources for remote science teaching?

2020-2021 School Year:

- Describe what your science teaching practice looks like this year. How is it different from last year?
- How has science education at your school been impacted as COVID-19 continues to be a major issue throughout the new school year?
- You mentioned some challenges you've faced during the transition to remote learning. Tell me a bit more about those challenges.
    - What kinds of support do you need?
- Do you have any equity concerns related to your students' science learning? Why? How has your students' learning of science been impacted by COVID-19?
- What are your professional goals for teaching science in the future, either remotely or in-person?
- What changes would you like to see made in the future in your profession based on your experiences with COVID-19?

Emotions as an Educator:

- How has remote teaching helped you grow as a science educator?
- What types of feelings have you experienced as a science teacher through this situation? How have you been coping through all of this?
- Is there anything else you'd like to share about your experiences with science teaching during this pandemic?

Appendix F: Interview Protocol B: Focus Group Interview

Time of interview:

Date:

Interviewer:

Interviewees:

Questions:

1. Provide an update as to how your professional life continues to be impacted by COVID-19 this school year.

2. Explain one way in which COVID-19 has negatively impacted your professional experience.

3. Explain one way in which COVID-19 has positively impacted your professional experience.

4. How do you believe science education has been impacted as COVID-19 continues to be a major issue throughout the school year?

5. How do you believe your students' learning has been impacted by COVID-19 over time?

6. About a year into the COVID-19 pandemic, what has been the biggest challenge? How have you overcome these? What additional supports do you still need?

7. From your various responses, it seems like materials management has had a significant influence on science teaching this year. Do you agree/disagree and why?

8. Multiple participants mentioned the difficulties around adapting lessons for in-person and virtual students. Do you agree/disagree and why?

9. What is the main thing you would want others to know about your professional experience(s) through COVID-19?

10. Is there anything else you would like to share about your experiences?

Appendix G: Summary of Codes

INITIAL CODES	FOCUSED CODES	THEMES
Concerns about students' science learning Equity concerns Last-minute changes Limitation of remote learning Limitations of socially distanced classroom Materials Science not prioritized Technology	Challenges	Teachers and educators are faced with a wide range of challenges, some specific to science and some that all educators face, and these teachers also must navigate feeling a wide range of negative emotions.
Stressed Anxious Exhausted Concern for students' well-being Feeling privileged Hopeful Isolated Nervous Overwhelmed Sad	Negative emotions	
Asynchronous instruction Changes out of teachers' control Curricular adaptations Participation in remote learning Reduced instructional time	Changes due to pandemic (Spring)	While the pandemic is stressful and emotional, this time provides opportunities for reflect on teaching practice and re-imagine how education has been done. Educators who are flexible can more easily adapt to new job responsibilities and embrace the positives of growing professionally.
Curricular adaptations Participation in remote learning Reduced instructional time	Changes due to pandemic (Fall 2020-2021)	
Connecting with other educators Learning new technology More time in the day New schedule or teaching structure Reflecting on teaching practice	Positive takeaways	
Creating or adapting curriculum Coaching	Actions	
NGSS Sense-making Differentiated units for siblings	Science instruction	
Collaboration Increased budget	Supports needed	Collaboration is a necessary coping strategy and is needed be a successful science educator during this time.
Confiding in other people/educators Dedicating more time to work Drawing on other teaching experiences Hobbies Ignoring own emotions	Coping strategies	
College or grad school Prior teaching experience Description of current role	Background experiences	