Teachers' Conceptions and Enactment of Disciplinary Literacy in Elementary Science Instruction: A Comparative Case Study

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TEACHERS’ CONCEPTIONS AND ENACTMENT OF DISCIPLINARY LITERACY IN ELEMENTARY SCIENCE INSTRUCTION:
A COMPARATIVE CASE STUDY

by

Melissa P. Mendenhall

A dissertation submitted in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

in

Teacher Education and Leadership

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2023
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by

Melissa P. Mendenhall, Doctor of Philosophy
Utah State University, 2023

This comparative case study explores elementary teachers’ conceptions and enactment of disciplinary literacy in elementary science instruction and the interaction between the two. Specifically, the purpose of this research was to describe how four fifth-grade teachers view these issues. Participants for this research were invited to participate by responding to an online survey and were selected using a criterion sampling technique. Data sources include interviews, teacher artifacts, and observation. Qualitative data were analyzed using immersion coding to produce basic codes, theory-driven coding as overall themes to illuminate patterns in basic codes, and global themes as sense making tools to describe each case, case comparisons, and all cases together. The final written report includes narratives describing individual and comparison cases as well as the overall themes, global themes, and graphics displaying relationships between codes and themes for all cases. Findings suggest these educators’ view literacy as reading, writing, speaking and listening; text as written words; and science text as written words that contain science
content. Additionally, teachers’ conceptions of disciplinary literacy were heavily focused on content area literacy ideas. In practice, disciplinary literacy in science instruction again presented as content area literacy. However, during enactment, each teacher’s unique conception of what is entailed in overall effective instruction interacted with content area literacy ideas to personalize instruction. This suggests that teacher preparation programs and in-service teacher development opportunities should explicitly help educators to understand what disciplinary literacy is, how it is different from content area literacy, what it looks like in instructional resources, and how to implement it during science instruction.

(215 pages)

Keywords: disciplinary literacy, elementary, middle school, science education
This case study explores elementary teachers’ conceptions and enactment of disciplinary literacy in elementary science instruction and the interaction between the two. Specifically, the purpose of this research was to describe how four fifth-grade teachers view literacy appropriate to science. Participants for this research were invited to participate by responding to an online survey and were selected based on criteria. Data sources include interviews, teacher artifacts, and observation. Qualitative data were coded, the codes compared to ideas in the field (overall themes), and global themes were generated as sense making tools to describe trends found in each case, case comparisons, and all cases together. The final written report includes narratives describing individual and comparison cases as well as the overall themes, global themes, and graphics displaying relationships between codes and themes for all cases. Findings suggest these educators’ view literacy as reading, writing, speaking and listening; text as written words; and science text as written words that contain science content. Additionally, teachers’ conceptions of disciplinary literacy were heavily focused on general literacy ideas of speaking, listening, reading, and writing to comprehend information. In practice, disciplinary literacy in science instruction again presented as general literacy acquisition. However, during enactment, each teacher’s unique conception of what is entailed in overall effective instruction interacted with general literacy ideas to personalize
instruction. This suggests that teacher preparation programs and in-service teacher development opportunities should explicitly help educators to understand what disciplinary literacy is, how it is different from general literacy, what it looks like in instructional resources, and how to implement it during science instruction.
DEDICATION

This dissertation is dedicated to my grandchildren. I want them to know that education is important and can have a very positive impact on their lives if held in the proper perspective. Also, I want them to know that they can do hard things. You are the future. I have great faith in you!
I want to thank Dr. Kimberly Lott for supporting me along this journey. As my dissertation chair, she has always been positive, kind, and has worked with me through any questions. I have appreciated her feedback on my many drafts. Her suggestions have been helpful and wise. Also, I want to thank my committee: Dr. Steven Camicia, Dr. Colby Tofel-Grehl, Dr. Leigh K. Smith, and Dr. Suzie Jones. They all responded quickly to anything I needed through this process such as providing internships, adding independent study courses, responding to emails, answering phone calls to provide wise council, and just being a friend and peer. Additionally, they provided astute feedback to help me improve both my proposal and dissertation.

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Finally, I want to thank my dear friend Jean. She was always present with a text or call of encouragement. She was my constant cheerleader and problem solver. I am so fortunate to have her friendship.

Melissa Mendenhall
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Chapter I Introduction

Disciplinary literacy is “an emphasis on the knowledge and abilities possessed by those who create, communicate, and use knowledge within the disciplines” (Shanahan & Shanahan, 2012, p. 8). In other words, disciplinary literacy is the ability to communicate effectively within a discipline utilizing the appropriate knowledge, practices, and norms of the discipline. For example, scientists have a distinct way of using the knowledge, practices, and norms of the discipline to communicate with each other as they engage in their work. The same is true for professional ballet dancers, who also share specific knowledge, practices, and norms of the discipline that affect how they communicate with each other. While both scientists and professional ballet dancers communicate appropriately and effectively within their respective disciplines, they do not communicate in the same way because each discipline has unique knowledge, practices, and norms that members of the discipline utilize within their respective communities (Gee, 2002; Shanahan & Shanahan, 2008). Thus, utilizing the unique knowledge, practices, and norms of a discipline provides the ability for individuals to enter the discourse of a community and engage with the community in appropriate and effective ways. This ability is the essence of disciplinary literacy.

Developing disciplinary literacy is important for K-12 students because doing so opens pathways for these students to access further education (e.g., college) and careers in the disciplines they choose (Fang & Coatoam, 2013; Fang, 2014; Moje, 2015; NRC, 2012; National Research Council [NRC], 2012; National Governors Association Center for Best Practices & Council of Chief State School Officers [NGA & CCSSO], 2010; Shanahan & Shanahan, 2014). In fact, developing disciplinary literacy during K-12
education is so critical that the Common Core State Standards for English Language Arts (CC-ELA) and Mathematics (CC-M), as well as the Next Generation Science Standards (NGSS), include concepts regarding disciplinary literacy (NGA & CCSSO, 2010; NGSS Lead States, 2013). An example of this found in the NGSS (NGSS Lead States, 2013) is standard 3-LS4-3, which states that students should be able to “construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all” (3-LS4-3). This standard expects students to know the science concept of adaptation, the scientific practice of argumentation, and how scientists construct arguments from evidence as a way of being in the discipline. By using the knowledge, practice, and way of being interrelatedly, students can effectively express meaning, thus, communicating appropriately with others in the science community about this science concept. Consequently, as they work toward proficiency in this standard, they are developing disciplinary literacy.

A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas (The Framework) asserts that effective teaching and learning in science instruction includes disciplinary literacy notions (NRC, 2012). For instance, students should “engage in opportunities to experience how science is actually done”, meaning that during classroom instruction, students should participate in the enterprise of science in similar ways as scientists do in the field (NRC, 2012, p. 1). This includes engaging in authentic scientific activities, such as asking questions, carrying out investigations, developing models, constructing explanations, and engaging in argument from evidence (NRC, 2012). Through participating in these types of authentic tasks, students develop the ability to communicate appropriately within the science discipline. Thus, research in
science education promotes the notion of working as scientists do through utilizing science practices to ultimately communicate in appropriate ways for the discipline of science.

Although research regarding effective teaching and learning in science education, which includes disciplinary literacy, is clearly known and available, research regarding teacher conceptions and enactment of disciplinary literacy in elementary and middle school education is limited. However, the limited evidence available supports the position that developing disciplinary literacy in students promotes deeper understanding within the different disciplines such as science, mathematics, social studies, and other content areas (Ardasheva et al., 2019; Buelow et al., 2018; Doerr & Temple, 2016; Lemley et al., 2019; Monte-Sano & Harris, 2012) and that teachers need support to develop usable resources for disciplinary literacy instruction (Koomen et al., 2016). Additionally, some research suggests that teachers often confuse developing disciplinary literacy during instruction and developing content area literacy skills (e.g., summarizing, note taking, or using graphic organizers to comprehend information from text) (Fang & Coatoam, 2013; Shanahan & Shanahan, 2012; Wilder & Herro, 2016).

While these studies explored conceptions and enactment (i.e., teacher use of disciplinary literacy during instruction and teacher development of student disciplinary literacy) of disciplinary literacy in instruction in general, specific descriptions of teacher conceptions and enactment during instruction are limited and notions for elementary science instruction are extremely limited. Additionally, the linkage between practitioner conceptions of disciplinary literacy and enactment has not been pursued.
To address these gaps in the literature, the purpose of this study was to explore elementary teacher conceptions and enactment of disciplinary literacy during science instruction and the interactions between them to answer the following main research questions:

1. What are fifth-grade teachers’ conceptions of disciplinary literacy in elementary science instruction?
2. How do these teachers enact disciplinary literacy during elementary science instruction?
3. In what ways do these teachers’ conceptions and enactments interact with one another?

**Theoretical/Conceptual Framework**

Because the purpose of this research was to deeply explore a phenomenon, qualitative research is an appropriate theoretical framework from which to accomplish this objective (Creswell & Poth, 2018; Denzin & Lincoln, 2011; Marshall & Rossman, 2016). Specifically, comparative case study was utilized as a way to explore the phenomenon in more detail (Creswell & Poth, 2018; Marshall & Rossman, 2016; Thomas, 2011; Yin, 2012). Additionally, to make sense of the phenomenon under exploration, teachers’ conceptions and enactment of disciplinary literacy in elementary science instruction, two conceptual learning theories were employed. First, constructivism (Nussbaum, 1999; Mayer, 1996), which suggests that learners actively construct their own knowledge, is a lens through which the researcher made sense of what was occurring in the phenomenon. This occurred as the researcher interviewed the participants, analyzed submitted lesson plan artifacts, and observed classroom instruction.
Additionally, the researcher utilized sociocultural theory, which suggests that learning occurs within social and cultural contexts (John-Steiner & Mahn, 1996; Wertsch, 1980; Wertsch & Tulviste, 1992) as an additional sensemaking tool. This occurred when the researcher was immersed in the phenomenon within a specific context, the classroom, during observations. Further details about this study’s theoretical and conceptual framework are more fully described at the end of Chapter 2.

**Summary of Methodology**

This study explored the previously delineated research questions through case studies of four fifth-grade elementary teachers in a comparative case study design (Creswell & Poth, 2018; Marshall & Rossman, 2016; Thomas, 2011; Yin, 2012). The summaries of these cases each delineate the conceptions and enactment of participants in regard to disciplinary literacy in science as well as any interactions between the two. Each case study was created through collecting interview transcripts, lesson plan artifacts, and observations with the individual participants; after which, each set of artifacts was analyzed using both immersion style coding (Marshall & Rossman, 2011; Miles & Huberman, 1994) and theory-driven codes (Marshall & Rossman, 2016) as a way to derive overall meaning (Saldana, 2016) depicted as Global Themes (Leary & Walker, 2018) for each participant and across all participants. Details about this study’s methodology are described more fully in Chapter 3 including the exact data collection and analyzing processes utilized as well as the ethics guiding the researcher and implemented into the research process.

**Significance of the Study**
Marshall and Rossman (2016) stated that “convincing the reader that the study is likely to be significant and should be conducted entails” (p. 78) showing that the study builds the knowledge base of the topic discourse and is of practical value to the Discourse (Gee, 2004) community. This study specifically addressed a gap in the literature related to knowledge about teachers’ conceptions and enactment of disciplinary literacy in elementary science education and any interactions between the two. By conducting this comparative case study, not only may knowledge about these notions be gleaned but implications for what this means for preservice and in-service teacher professional learning experiences are discussed in light of the findings in Chapter 5. This information contributes to the existing literature surrounding the conversation of this topic, which may affect how future elementary teachers are prepared and how current elementary teachers are supported as they shift to the new disciplinary literacy expectations promoted in recent research about effective science instruction (NRC, 2012). Thus, this research adds to the knowledge base and may be of practical use by providing foundational information about what is currently occurring in elementary classrooms similar to those of the participants in this study.

Limitations

A possible limitation of this study is self-reporting within the interview. This includes the threat of participants misconstruing interview questions (Gall et al., 2003). To reduce this threat, the data was triangulated with lesson plan artifacts and observations as a way to promote a more accurate understanding of participant conceptions (Creswell & Miller, 2000; Lincoln & Guba, 1985; Marshall & Rossman, 2016; Maxwell, 2012).
Another possible limitation is researcher misunderstanding of participants’ responses during the interview, intentions of their lesson plans, or purposes of strategies utilized during instruction. To lessen this issue, the researcher participated in peer debriefing and interrater reliability procedures (Creswell & Miller, 2000; Marshall & Rossman, 2011) with her chair as well as member checks (Creswell & Miller, 2000; Maxwell, 2012) with each of the participants.

Additionally, a limitation of the study overall that cannot be remediated within the parameters of this research is generalizability (Creswell, 2012). This is an issue because of the limited number of participants (i.e., four; Creswell, 2012), and the specific demographics of both the participants and the district in which the participants work (Creswell, 2012).

**Definition of Terms**

Within this research, the following terms are discussed: disciplinary literacy, content area literacy, constructivism, and sociocultural learning theory. To support understanding of the study, these terms are defined within this section for reader reference:

1. Disciplinary literacy is the ability to appropriately and effectively communicate in a discipline through using the knowledge, norms, and practices of that discipline. Specifically, disciplinary literacy entails the following components: (a) the authentic ways communication occurs (e.g., texts, patterns of discourse) within the discipline, (b) the conceptual content knowledge of the discipline, (c) the nature or norms of the discipline (e.g.,
dispositions, values), and (d) the practices utilized within the discipline (e.g., skills, ways of working).

2. Content area literacy focuses on supporting comprehension in a subject through applying generic literacy strategies (e.g., summarizing, note taking, using graphic organizers to comprehend information from text).

3. Constructivism is a learning theory that posits learners actively construction knowledge.

4. Sociocultural learning theory posits that learning takes place in a social and cultural context.
Chapter II Review of Literature

The purpose of this study was to explore elementary teacher conceptions and enactment of disciplinary literacy in science and the connections between them. In order to make sense of these conceptions and their enactment, an understanding of (a) disciplinary literacy, (b) disciplinary literacy in science and science instruction, and (c) how teachers understand and enact disciplinary literacy during instruction is necessary.

Thus, this chapter contains sections delineating current literature about disciplinary literacy, disciplinary literacy in science, and disciplinary literacy instruction in general, as well as disciplinary literacy instruction specific to science. The chapter then addresses available studies related to teachers’ conceptions and enactment of disciplinary literacy during instruction and proposes a gap in the existing literature. The concluding section of this chapter provides an explanation of the theoretical/conceptual framework through which the research of this study was conceived and viewed.

Disciplinary Literacy

The term literacy is often used as if the definition is so commonplace that there is no need for explanation. However, in reality, there seems to be as many definitions for literacy as there are different groups of people defining it (Irwin, 1991; Organization for Economic Co-operation and Development, 2010; United Nations Educational, Scientific, and Cultural Organization, 2006). Some academics claim literacy is the ability to read and write in a person’s first language (Hodges, 1999; United Nations Educational, Scientific, and Cultural Organization, 2006). Others expand that definition to include the ability to speak and listen (i.e., communicate; International Literacy Association [ILA], 2015; Keefe & Copeland, 2011; Position Statement of the International Reading
Association [IRA], 2012). All of these definitions denote the ability to both receive and express meaning in specific situations (Hodge, 1999; ILA, 2015; Keefe & Copeland, 2011; Position Statement of the IRA, 2012). Therefore, for the purpose of this study, literacy is defined as the ability of a person to receive and express information in ways that are meaningful for a given context.

Disciplinary literacy is the ability of people to receive and express meaning appropriately and effectively in the context of a specific discipline. For example, scientists who work in the field use specific language, texts, and patterns of communicating that differ from historians working in their own field. While both may speak the same national language (e.g., English, French, German), they do not speak the same disciplinary language.

Disciplinary literacy is complex and includes multiple components. Gee (2004) stresses the importance of becoming an “insider” of a discipline. In order to be an insider, a person must understand the patterns of communication utilized within the discipline. Within science, this may include engaging in argument from evidence, constructing explanations of phenomena using appropriate science mechanisms and processes, or developing models to promote shared meaning (NRC, 2012). Thus, one component of disciplinary literacy is the ability to participate in the authentic ways communication occurs (e.g., texts, patterns of discourse) within the discipline.

Communicating effectively and appropriately within a discipline also relies on conceptual knowledge of the discipline and an understanding of how knowledge is created and used within the discipline. Particularly, a person must know the content knowledge and ways of being within the discipline in order to communicate as an insider.
Thus, a scientist must have specific knowledge and an understanding of how to generate new knowledge in the discipline in order to appropriately communicate as an insider (Gee, 2004; Moje, 2008; NRC, 2012; Shanahan & Shanahan, 2008, 2012). Therefore, two other critical components of disciplinary literacy are a *conceptual content knowledge of the discipline* and a knowledge of *the nature or norms of the discipline* (e.g., *dispositions, values*).

Fang and Coatoam (2013) suggest that within disciplinary literacy, “literacy skills/strategies and disciplinary content are inextricably intertwined and that without literate practices, the social and cognitive practices that make disciplines and their advancement possible cannot be engaged” (p. 628). This means that knowing the communication patterns, content knowledge, and ways of being in a discipline all work together so a person can perform the appropriate practices or skills insiders utilize as they carry out their work in the discipline. This idea of specialized practices within a discipline is also echoed by Shanahan and Shanahan (2008) who conclude that experts in a discipline read in specialized ways because they engage in practices specific to their discipline. In science, this includes practices such as asking questions, engaging in argument, developing and using models, and analyzing and interpreting data (NRC, 2012). Thus, the act of carrying out authentic practices in a discipline is intertwined with communication, content knowledge, and a way of being. Therefore, another critical component of disciplinary literacy involves the unique *practices utilized within the discipline* (e.g., *skills, ways of working*) that support both receiving and expressing meaning in the discipline.
Through identifying these components of disciplinary literacy, a detailed definition emerges that encompasses the notion of expressing and receiving meaning in a discipline. Disciplinary literacy is the ability to appropriately and effectively communicate in a discipline through using the knowledge, norms, and practices of that discipline. Specifically, disciplinary literacy entails the following components: (a) the authentic ways communication occurs (e.g., texts, patterns of discourse) within the discipline, (b) the conceptual content knowledge of the discipline, (c) the nature or norms of the discipline (e.g., dispositions, values), and (d) the practices utilized within the discipline (e.g., skills, ways of working).

**Disciplinary Literacy in Science**

In the sections that follow, the four previously identified components of disciplinary literacy (i.e., authentic communication within the discipline, conceptual content knowledge of the discipline, nature or norms of the discipline, and practices utilized within the discipline) are explained in detail in relation to the discipline of science.

**Science Disciplinary Communication**

Within a specific discipline, “what allows these individuals to share and refine their disciplinary ways of knowing is the system of semiotic resources they develop to represent this disciplinary knowledge” (Airey & Linder, 2009, p. 2). For example, scientists use modalities of text that include words, graphs, charts, figures, diagrams, formulas, tables, symbols, maps, and images (Airey & Linder, 2009; Coleman & Goldston, 2011; Deresz & Mattewson, 1982; Hand et al., 2003; Hand et al., 2010; Lemke, 1998; Norris & Phillips, 2003; NRC, 2012; Wellington & Osborne, 2001; Yore,
Bisanz et al., 2010). These semiotic resources or modes represent different types of text in the discipline and include visual, written, and other semiotic representations. For example, Serafini (2012) explains that text may look like “written text, visual images, graphic elements, hyperlinks, videoclips, audio clips, and other modes of representation” depending on how “meaning is made, interpreted, communicated and shared through…different representations” by members of the discipline (Wyatt-Smith & Kimber, 2009, p. 72). In science instruction, these modes may take on the appearance of written words, diagrams, images, graphs, charts, and other symbols (NRC, 2012) that are utilized by scientists in the field (Kress, 2010; Lemke, 1998, 2004).

Scientists also use a variety of genres as they communicate, such as field notes, emails, journal articles, newspapers, magazines, textbooks, blogs, and websites (Hand et al., 2003; Hand et al., 2010; NRC, 2012; Moje, 2015; Yore, Bisanz et al., 2010). According to Hand et al. (2003) “oral and written communication and the processes of speaking, listening, writing, and reading are highly valued within the scientific community; scientists who communicate well are successful in gaining support from members of their own communities, funding agencies, and the wider society” (p. 693). They accomplish this communication through genres that shape the way scientists think both for personal (e.g., fieldnotes, memoirs) reasons and public (e.g., journal articles, blogs, magazines, new releases, websites) reasons. Scientists also communicate in ways that support science instruction including textbooks, lab books, and trade books (i.e., informational texts on a specific topic; Hand et al., 2003).

Additionally, communication within the discipline of science occurs through certain patterns of discourse. As Gee (2004) denotes, “everyday language is not how the
Discourses of the sciences operate” (p. 27). Within the field, scientists communicate with other members of the discipline by engaging in argument, constructing explanations, representing meaning through models, and asking researchable questions (NRC, 2012). Hand et al. (2003) describes these patterns as ways that “structure oral interactions, focus discussions, construct arguments (claims, evidence and warrants), develop explanations, and promote conceptual understanding” in the discipline of science (p. 704). Thus, to participate in the discipline of science, discourse patterns that are different from everyday communication discourse patterns are required.

**Science Disciplinary Content Knowledge**

Intertwined with developing authentic communication within a discipline is the disciplinary literacy component of conceptual content knowledge of the discipline because being literate within the discipline requires the ability to communicate appropriately about scientific concepts (Norris & Phillips, 2003). Norris and Phillip (2003) describe this as the derived sense of scientific literacy, which entails “being knowledgeable, learned, and educated in science” (p. 224). They also delineate aspects of this derived sense such as (a) knowing substantive content knowledge, (b) understanding what does or does not constitute science, (c) applying science knowledge in context, (d) participating in social science issues, and (e) evaluating the risks and benefits associated with science (Norris & Phillips, 2003).

Thus, to communicate effectively in a discipline, meaning occurs through both the ways the communication takes place (i.e., through appropriate modalities, genres, and discourse patterns of text) and the information contained within the communication (i.e., the content knowledge). An understanding of the conceptual disciplinary ideas of science
is then a key component of disciplinary literacy as it allows meaningful communication to occur between people within a discipline.

**Disciplinary Nature of Science**

The dispositions and values of science, epistemology, are also a critical component of disciplinary literacy. To fully understand the discipline of science, one needs to understand what the community believes in and values (Aflalo, 2014; Pekbay & Yilmaz, 2015).

According to Gee (2004), humans set up different communities revolving around specific “affinities”, meaning “people have an affinity for the content of [a] domain and share endeavors in regard to that content” (p. 2). Therefore, they share “norms, values, and knowledge about what constitutes degrees of mastery in the domain and what sorts of people are more or less, ‘insiders’ or ‘outsiders’” (p. 2). In other words, in addition to being able to authentically communicate in a discipline using appropriate subject matter knowledge, being an insider entails understanding a community’s dispositions and values. In science, McComas and colleagues (1998; see also American Association for the Advancement of Science [AAAS], 1993; Abd-El-Khalick et al., 1998; Bell, 2007; Kim & Irving, 2009; McComas, 2002, 2007; Pekbay & Yilmaz, 2015) refer to these elements as the *nature of science* (*NoS*). Elements of this *NoS* include the notion that science is: (a) tentative, (b) creative, (c) objective and subjective, (d) based on empirical evidence, observation, and inference, (e) embedded in a cultural and social context, and (f) utilizes scientific laws and theories. For example, a common myth regarding science is that it is “procedural more than creative” (McComas, 2002, p. 18). However, within science, scientists analyze and reason with collected data to discover patterns and create
inferences. There is not a prescribed procedure for deriving an exact conclusion. The inference is the result of scientists using inductive thought to create a possible explanation (McComas, 2002).

In summary, for disciplinary literacy in science to be present, an understanding of the dispositions and values of the discipline are necessary. These include elements that are labeled NoS. They promote a way of being within the discipline that members of the science community relate to and utilize as they work in the field.

**Science Disciplinary Practices**

Understanding how communication occurs as well as the content knowledge and norms of the field of science allow scientists to carry out practices (e.g., skills, ways of working) that are authentic to the field. The National Research Council (NRC; 2012) names eight of these practices, which are called the Science and Engineering Practices (SEPs). While not fully inclusive, these SEPs focus on “how scientists operate” (McComas et. al., 1998, p. 84) as they conduct their work. These eight identified practices include: asking questions; developing and using models; planning and carrying out investigations; analyzing and interpreting data; using mathematics and computational thinking; constructing explanations; engaging in argument from evidence; and obtaining, evaluating, and communicating information. Using these practices effectively implies that scientists are authentically communicating and using content knowledge in appropriate ways. In other words, effective use of these practices displays the application of disciplinary literacy. As Shanahan and Shanahan (2012) explain, disciplinary literacy emphasizes “the specialized knowledge and abilities possessed by those who create,
communicate, and use knowledge within each of the disciplines” (p. 7). The ability to effectively use authentic science practices is disciplinary literacy in action.

Because these four components (i.e., authentic use of communication within a discipline, conceptual content knowledge of the discipline, nature or norms of the discipline, practices utilized within the discipline) are critical indicators of disciplinary literacy within the discipline of science, identifying them within teacher descriptions or enactment (i.e., teacher use of disciplinary literacy during instruction and teacher development of student disciplinary literacy) provide understanding of teacher conceptions and enactment of this instructional practice.

**Disciplinary Literacy Instruction**

Both disciplinary literacy and instruction are important to consider because “students need the opportunity to apprentice into the ways of producing and communicating knowledge valued in the disciplines” (Moje, 2015, p. 259). In other words, students need explicit instruction in and tasks that support the development of disciplinary literacy (Fang, 2014; Fang & Coatoam, 2013; C. Shanahan & T. Shanahan, 2014; T. Shanahan & C. Shanahan, 2012) as they generally do not learn these concepts without support (Stahl et al., 1996). Knowing what disciplinary literacy looks like in a specific discipline (e.g., science) is, therefore, critical to envisioning how it looks during classroom instruction.

Instruction for disciplinary literacy focuses on developing skills that support appropriate and effective communication in a specific discipline through using the knowledge, norms, and practices of that discipline. In contrast, content area literacy instruction focuses on supporting comprehension in a subject through applying generic
literacy strategies (Bean et al., 2011; Fang & Coatoam, 2013; Shanahan & Shanahan, 2012). Specifically, Fang and Coatoam (2013) explain “content area literacy focuses on developing students’ ability to effectively use reading and writing as generic tools for learning from content area texts...It promotes explicit teaching of generic strategies...that are to be applied universally across content areas” (p. 627). These include strategies such as summarizing text, note taking, concept mapping, and utilizing graphic organizers (Shanahan & Shanahan, 2012).

In contrast, when developing disciplinary literacy it is critical to focus on ways literacy is utilized within a specific discipline to support students’ ability to become “insiders”, members of the discipline community (Gee, 2004). Content area literacy, on the other hand, supports general comprehension. It does not focus on developing the abilities of students to appropriately communicate within a specific discipline. It supports overall strategies that promote comprehension.

**Disciplinary Literacy in Science Instruction**

The Framework (NRC, 2012), which synthesizes prior research about how students learn science (AAAS, 1993; National Center for Education Statistics, 2009; NRC, 1996; NRC, 2006; NRC, 2007; NRC, 2009), outlines how teachers can implement three of the four delineated components of the definition of disciplinary literacy, including communicating in authentic ways, gaining conceptual content knowledge, and using practices appropriate to the discipline of science. These components are enacted through implementing what The Framework (NRC, 2012) terms the three dimensions of science instruction: Science and Engineering Practices (SEPs), Crosscutting Concepts (CCCs), and Disciplinary Core Ideas (DCIs).
Specifically, within these three dimensions, the SEPs describe the common ways that scientists work in the field (i.e., asking questions; developing and using models; planning and carrying out investigations; analyzing and interpreting data; constructing explanation; using mathematics and computational thinking; engaging in argument from evidence; and obtaining, evaluating, and communicating information; NRC, 2012). The SEPs serve as an entry point for students to “develop their capability to engage in scientific inquiry…developing students’ knowledge of how science and engineering achieve their ends” (p. 41). For instance, scientists plan and carry out investigations and analyze and interpret data as they engage in inquiry (NRC, 2012). Therefore, students develop the component of using practices appropriate to the discipline as the SEPs are utilized within science instruction.

Additionally, scientists communicate through using the SEPs. For example, the SEPs specifically call for teachers to develop students’ abilities to construct explanations of what they observe, develop and use models to explain and predict what is occurring in systems, and engage authentically in argument as a way to communicate conclusions from their investigations (NRC, 2012). In order to authentically carry out these practices, students also “develop vocabulary, grammar, spelling, punctuation, patterns of argumentation, and technical writing utilized in the science” (Hand et al., 2003, p. 700). Thus, supporting students to authentically engage in the SEPs also facilitates students developing the disciplinary literacy component of communicating authentically in science.

The CCCs, help students make sense of how the different disciplines of science relate to each other and the discipline of science in general (NRC, 2012). They also help
students make sense of the discipline by providing ways that scientists think as they work in the field (NRC, 2012). These CCCs include patterns; cause and effect; scale, proportion and quantity; systems and system models; energy and matter; structure and function; and stability and change (NRC, 2012). As students use these different ideas to frame their thinking, the CCCs “help students develop a cumulative, coherent, and usable understanding of science” (p. 83) both within a specific science discipline, such as life science, and across all disciplines of science (e.g., life science, physical science, Earth and space science). This supports students in gaining conceptual content knowledge of the discipline, another component of disciplinary literacy.

The DCIs are the science conceptual knowledge that students should know and be able to apply in novel situations as they explain the world around them. The Framework (NRC, 2012) identifies foundational science concepts that “prepare students with sufficient core knowledge so that they can later acquire additional information on their own” (p. 31). The selected concepts meet at least two of four criteria that narrow the focus of all possible science concepts to those that provide this preparatory foundation: 1) Importance across many science disciplines or foundational to one, 2) Key to understanding more complex concepts, 3) Relevant to personal or societal science concerns, and 4) Teachable over grade levels with increasing complexity (NRC, 2012). By focusing instruction on developing understanding of science concepts identified as foundational by the provided criteria, teachers again support students gaining the conceptual content knowledge component of disciplinary literacy that is critical to the discipline of science.
By implementing these three dimensions (i.e., SEPs, CCCs, and DCIs) into science instruction, teachers support students learning to authentically communicate within the discipline, know and apply the conceptual content knowledge of the discipline, and participate in the practices utilized within the discipline. However, the fourth component of science disciplinary literacy, the norms (values and dispositions) of science, which were previously described as the NoS, is not explicit in The Framework (NRC, 2012). There is not an organized, concrete place within The Framework (NRC, 2012) that delineates these norms of science. In fact, McComas and Nouri (2016) contend that “it is easy to note the lack of prominence of NoS [in The Framework], although NoS topics appear throughout if one looks specifically for them” (p. 558). As a result, it has been argued that instruction targeting this component needs to be added to the use of the three dimensions delineated in The Framework (NRC, 2012) in order for all four components of disciplinary literacy to be developed. This can occur by building into instruction the NoS tenets previously identified. For instance, an example of one tenet, scientists are creative, can be developed as teachers scaffold students to develop an inferred conclusion from analyzing and reasoning about data (AAAS, 1993). Another example of developing a NoS tenet, science is objective, can occur as students peer review each other’s work and provide feedback (AAAS, 1993).

Ultimately, if students are “expected to use specialized literacy skills, strategies, and practices to engage in disciplinary learning and socialization” (Fang & Coatoam, 2013, p. 628) in the discipline of science, classroom instruction needs to include all four disciplinary literacy components. As noted previously, The Framework (NRC, 2012) can provide support for how to enact three of the four components of disciplinary literacy:
authentic communication within the discipline, conceptual content knowledge of the
discipline, and practices utilized within the discipline. However, teachers need to
augment this three-dimensional instruction with explicit instruction regarding NoS tenets
in order to address the fourth component: norms of the discipline.

**How Teachers Understand and Enact Disciplinary Literacy: Current Research**

In the sections that follow, current research on teacher conceptions and enactment
of disciplinary literacy are explored through the lens of the components of disciplinary
literacy. Gaps in the current research are then identified.

***Teacher Conceptions of Disciplinary Literacy***

Of the three qualitative studies found in the extant literature that explored teacher
conceptions of disciplinary literacy in elementary or middle school contexts, the first
study discovered that preservice and first-year teachers either do not know how or do not
take the time to engage with mathematics texts in ways that promote deep comprehension
during higher education mathematics courses (Harkness & Brass, 2017). This infers that
these teachers do not understand the role disciplinary literacy plays in both gaining
conceptual knowledge and being able to receive understanding through an authentic way
that mathematicians communicate. The researchers concluded that preservice teachers
“must comprehend natural language, academic language, and mathematical language in
order to make meaning of [mathematics] texts” (Harkness & Brass, 2017, p. 8). For this
to occur, Harkness and Brass (2017) determined that preservice courses should include
disciplinary literacy instruction as a course objective. By so doing, preservice teachers
can gain an understanding of the importance of disciplinary literacy instruction and what
it entails for two identified components of disciplinary literacy: conceptual knowledge of the discipline and authentic ways communication occurs within a discipline.

Lemley et al. (2019) found that exploring ways disciplinary literacy practices are used and valued within disciplines increased existing teachers' knowledge or conceptions of disciplinary literacy. In this study, participants read research articles about literacy in a specific discipline, interviewed experts in the discipline, and studied mentor texts from the discipline as a way to “identify and articulate literacy practices associated with the discipline” (Lemley et al. 2019, p. 20). This emphasis on gaining conceptual understanding of what disciplinary literacy within a given discipline entails implies the importance of teachers knowing and understanding all of the components of disciplinary literacy. However, Lemley et al. (2019) also noted that teachers needed more time studying the discipline to fully understand disciplinary literacy components as the study’s short time period allowed teachers only a surface look at disciplinary literacy practices. Thus, the participating teachers’ conceptions of disciplinary literacy contained only beginning understandings of what the disciplinary literacy components entail.

And finally, the third study concluded that teachers can adapt primary science texts to be developmentally appropriate for different reading levels in ways that maintain authentic communication found within the discipline of science (Koomen et al., 2016). In particular, participants learned how experts in science authentically communicate using discourse patterns appropriate to science. Through learning what this entails, teachers could then adapt primary text to be appropriate for students of younger ages. Thus, the participating teachers gained knowledge or conceptions about how to write and then read text using the discourse patterns of the discipline. However, Koomen et al. (2016) also
concluded that while teachers did gain surface conceptions of how authentic communication occurs through disciplinary texts, they needed considerable support to actually create these texts. Similar to the previous study, this implies that these teachers only have a beginning or surface conception of disciplinary literacy. Both sets of researchers concluded that teachers need more disciplinary literacy knowledge to fully understand what is entailed in authentic communication within the discipline (Koomen et al., 2016; Lemley et al., 2019).

Overall, these studies suggest that teacher conceptions of disciplinary literacy for all four components are lacking. The research depicts that some teachers have a shallow knowledge of the four components of disciplinary literacy (Koomen et al., 2016; Lemley et al., 2019). In other words, they understand the “gist” of disciplinary literacy. However, in all of the studies, the researchers concluded that teachers need more knowledge to fully comprehend what the components of disciplinary literacy entail (Harkness & Brass, 2017; Koomen et al., 2016; Lemley et al., 2019). Also of note, while teachers may have some understanding of one or more of the components of disciplinary literacy, the studies do not address exactly what teachers’ conceptions do or do not contain for each component. These studies address disciplinary literacy in a more general sense and not in specific teacher conceptions.

**Teacher Enactment of Disciplinary Literacy**

Research regarding teacher enactment of disciplinary literacy in elementary or middle school is also limited. What is described within the studies that are available is confusion between disciplinary literacy and content area literacy. For example, Wilder and Herro (2016) found enactment of disciplinary literacy thwarted as a literacy coach
and science teacher attempted to work together to implement disciplinary literacy during instruction. The literacy coach’s lack of content knowledge and understanding of the authentic ways scientists work and norms of the discipline posed barriers to implementing disciplinary literacy during instruction. Similarly, Monte-Sano and Harris (2012) observed that history teachers in their study utilized either disciplinary literacy approaches (e.g., utilizing discourse patterns of the discipline, focusing on conceptual content knowledge, implementing norms and practices of the discipline) to support student writing in history or content area literacy skills (e.g., asking different types of factual and inferential questions, learning notetaking skills, organizing writing using transitions), but not both. This either/or pattern of instruction and the outcomes in students after instruction led these researchers to conclude that both approaches have benefits because one focuses on how communication occurs within a discipline in authentic ways and the other supports basic literacy skills needed to write effectively.

Interestingly and importantly, Norris and Phillips (2003) argue that both instructional approaches together constitute scientific literacy. They describe the *fundamental sense* of scientific literacy as the ability to read and write and the *derived sense* as the ability to utilize content knowledge, practices, and norms of the discipline in authentic ways. Furthermore, they postulate that while both senses can be discussed separately, in reality they are inextricably intertwined and cannot be separated (Norris and Phillips, 2003). Thus, when basic literacy skills are viewed within a discipline, they become a part of disciplinary literacy because they are subsumed within disciplinary literacy components.
This notion that disciplinary literacy subsumes general literacy (e.g., how to spell, write, read) may be the reason why other studies only mention the importance of disciplinary literacy and not general literacy as disciplinary literacy goes beyond just generic reading and writing to include how to authentically and effectively communicate within a discipline. For example, other studies noted that developing disciplinary literacy (a) allowed teachers to meet students’ individual literacy needs in addition to supporting increased content knowledge, (b) focused on both how to enact disciplinary ways of being as well as content knowledge acquisition, and (c) was an integral part of instruction in a discipline (Ardasheva et al., 2019; Buelow, Frambough-Kritzer, & Au, 2018; Doerr and Temple, 2016). This implies that through disciplinary literacy instruction students gain the skills to be literate within a discipline, and these skills include the general ability to read and write.

While the previous studies about teacher enactment of disciplinary literacy focus on the use of disciplinary literacy as an overall broad term, other studies have focused on the enactment of the components of disciplinary literacy. Interestingly, the component *authentic ways communication occurs within the discipline* is addressed in four of the five studies about teacher enactment (Ardasheva et al., 2019; Buelow et al., 2018; Doerr and Temple, 2016; Monte-Sano & Harris, 2012). Within these studies, authentic modes (e.g., symbols, graphs, charts) and genres (e.g., cartoons, articles, journals) of the discipline were both used and created during instruction to promote student understanding of the discipline (Ardasheva et al., 2019; Buelow et al., 2018; Doerr and Temple, 2016; Monte-Sano & Harris, 2012). Additionally, instruction developing
authentic patterns of discourse for the discipline community is evident in two of the studies (Doerr & Temple, 2016; Monte-Sano & Harris, 2012).

Another two components, *the conceptual content knowledge of the discipline* and *the practices utilized within the discipline* (e.g., skills, ways of working), are found in teacher enactment of disciplinary literacy within two of the studies (Ardasheva et al., 2019; Buelow et al., 2018). For instance, Buelow et al. (2018) noted that during visual arts instruction, knowledge about different brush stroke techniques used in creating watercolor paintings was developed and then the brush strokes were utilized to create authentic text of the discipline. Meanwhile, Ardasheva et al., (2019) observed students during small group instruction “begin to connect personally to the discipline” (p. 103) as they gained content knowledge and used practices authentic to the discipline.

However, for *the nature or norms of the discipline* (e.g., dispositions, values) component, none of the enactment studies described evidence of teachers developing this aspect of disciplinary literacy during instruction. This component was conspicuously missing in teacher enactment of disciplinary literacy.

**Interaction Between Teacher Conceptions and Enactment of Disciplinary Literacy**

Currently, research does not appear to explicitly address the interaction between teacher conceptions and their enactment of disciplinary literacy. However, scholars suggest that there is a connection (Battista, 2004; Bullough & Baughman, 1997; Jones & Leagon, 2014; Pajares, 1992; Smith, 2002). For example, Smith (2002) concluded that “the way teachers interpret and implement curricula is influenced significantly by their knowledge and beliefs” (p. 33) or conceptions. In other words, teachers’ conceptions affect enactment of a practice because teachers’ conceptions impact “(a) teacher
planning, (b) teachers’ interactive thoughts and decisions, and (c) teachers’ theories and beliefs” (Smith, 2002, p. 42). Therefore, understanding teacher conceptions provides an insight into what instruction is enacted during classroom instruction.

Overall, in analyzing conclusions from existing research addressing both teacher conceptions and enactment of disciplinary literacy in elementary and middle school, interesting trends arise. First, teachers display a lack of understanding about what disciplinary literacy is, its importance, and the components entailed in disciplinary literacy (Harkness & Brass, 2017; Koomen et al., 2016; Lemley et al., 2019; Monte-Sano and Harris, 2012). Second, teachers can implement disciplinary literacy components into classroom instruction with appropriate support (Koomen et al., 2016; Lemley et al., 2019). Third, researchers tend to agree that disciplinary literacy is important for elementary and middle school classroom instruction (Ardasheva et al., 2019; Buelow et al., 2018; Doerr & Temple, 2016; Lemley et al., 2019; Monte-Sano & Harris, 2012). Fourth, research does not specifically address if there are any interactions between teacher conceptions and enactment during instruction. Fifth, there is little research available about disciplinary literacy conceptions and enactment in elementary and middle school. And, finally, there is relatively no research about disciplinary literacy conceptions and enactment in elementary science instruction. Thus, there is a gap in current research. Therefore, the purpose of this study was to explore elementary teacher conceptions and enactment of disciplinary literacy and the connections between them to address the following research questions:

1. What are fifth-grade teachers’ conceptions of disciplinary literacy in elementary science instruction?
2. How do these teachers enact disciplinary literacy during elementary science instruction?

3. In what ways do these teachers’ conceptions and enactments interact with one another?

**Theoretical/Conceptual Framework**

Within this research study, the theoretical perspectives of constructivism and sociocultural theory were utilized as a way to construct knowledge about the phenomenon, teachers’ conceptions and enactment of disciplinary literacy in elementary science instruction. By being in the natural setting of the phenomenon, talking with the participants in their context, collecting authentic artifacts from the setting, and generating meaning through qualitative analysis, understanding was constructed regarding teacher conceptions and enactment of disciplinary literacy in elementary science education both on an individual case and a multiple case basis. Because of the significance each of these theories plays in making meaning of the phenomenon of this research, a short discussion follows for each theory and how it fits into qualitative research and this study.

**Constructivism**

This theory postulates that learning involves people “actively construct[ing] their own understanding” (Nussbaum, 1999, p. 20). The perspective within this theory is that people learn through knowledge construction (Mayer, 1996).

When learning is viewed as knowledge construction, the learner “actively selects, organizes, and integrates incoming experience with existing knowledge” (Mayer, 1996, p. 156) with the desired outcome of sensemaking (Nussbaum, 1999). This involves the process of obtaining information and helping the learner find ways to organize the
information and “form multiple connections between items of information” (Nussbaum, 1999, p. 16). Therefore, the theory of constructivism forwards the idea that learning is an active cognitive process (Mayer, 1996; Nussbaum, 1999).

Because learning involves actively constructing knowledge, it fits naturally with qualitative research when exploring a phenomenon. For example, in qualitative research in general and in this particular study, the researcher takes on the role of learner and seeks to make sense of information. This information is typically gathered in many forms “such as interview, observations, and documents… [The researcher] review[s] all of the data and make[s] sense of it, organizing it into categories or themes that cut across all of the data sources” (Creswell & Poth, 2018, p. 43). Therefore, the researcher actively engages in gathering data and constructing knowledge from it by looking for patterns in the data as a way of organizing and making sense of the information (Creswell & Poth, 2018).

**Sociocultural Theory**

This theory also plays a role in making meaning of a phenomenon. John-Steiner and Mahn (1996) posit that sociocultural approaches to learning are “based on the concept that [learning] take[s] place in cultural contexts” (p. 191), in real context at the time the phenomenon is occurring. This means that learning takes “place in socially and culturally shaped contexts” (p. 194). Learning occurs as sense is made of social and cultural situations (Wertsch, 1980; Wertsch & Tulviste, 1992) because learning is a “collective participatory process of active knowledge construction emphasizing context, interaction, and situatedness” (Salomon & Perkins, 1998).
Therefore, sociocultural theory plays a critical role in qualitative research. Many of the characteristics of qualitative research identified by Creswell and Poth (2018) support this claim. For example, they suggest that qualitative research takes place in the natural setting where researchers “collect data in the field at the site where participants experience the issue…under study…[through] gather[ing] up-close information by talking directly to people and seeing them behave within their context” (p. 43). Additionally, qualitative research is context-dependent because “meaning [is] shaped by the unique circumstances in which [the phenomenon] occur[s]” (Maxwell, 2013, p. 30). By going to where the phenomenon occurs, the researcher focuses on the participants in their natural context. Thus, through a sociocultural lens during qualitative research the researcher can explore the meaning of a phenomenon in the actual context by socially interacting with the participants as a way to make sense of the phenomenon. In this study, social interaction with participants occurred during interviews. Additionally, the researcher observed participants teaching science in their context. Both of these interactions provided insights for the researcher to make sense of the phenomenon of investigation: teacher conceptions and enactment of disciplinary literacy during elementary science instruction.

Furthermore, while many scholars argue that knowledge is individually constructed (Mayer, 1996; Nussbaum, 1999) and others claim that knowledge is socially constructed (John-Steiner & Mahn, 1996; Wertsch, 1980; Wertsch & Tulviste, 1992). Salomon and Perkins (1998) posit that there is a “spiral reciprocity” (p. 19) between the two in which “each process can be understood in its own right, [and] understanding the interplay yields a richer and conceptually more satisfying picture” (p. 2). Thus, each
learning theory, constructivism and sociocultural theory, provides insights into the phenomenon. Utilizing them both provides a deeper exploration of the issue from multiple perspectives to form a more holistic understanding of the phenomenon (Larkin, 2012; Salomon & Perkins, 1998). During this study, the researcher constructed meaning through both coding of interviews, observations, and teacher artifacts, as well as actually talking to and observing the participants in their context.

**Research Design Genre: Case Study**

Within the framework of qualitative research, there are many genres from which to choose. Creswell and Poth (2018) specifically elaborate on five: narrative research, phenomenology, grounded theory, ethnography, and case study. Among these, case study provides an approach that allows the researcher to “explore a real-life, contemporary bounded system (a case) or multiple bounded systems (cases)...through detailed, in-depth data collection involving multiple sources of information...and report...case description[s] and case themes” (Creswell & Poth, 2018, pp. 96-97). Furthermore, Yin (2012) suggests that a case study is appropriate when the question explores what is happening and emphasizes “the study of a phenomenon within its real-world context” (p. 5). When both of these are the occurring in research, a case study “provide[s] rich descriptions ...[and] favors the collection of data in natural settings” (p. 5). Thus, using a case study to explore teachers’ conceptions of disciplinary literacy and how these conceptions are enacted during elementary science instruction appears to be an effective genre to utilize that aligns with both constructivism and sociocultural theory.

Additionally, case study is an appropriate qualitative research method for this study because this research genre focuses on “contextualized deep understanding...[and]
favor[s] intensity and depth, as well as exploring the interaction between case and context” (Marshall & Rossman, 2016, p. 19). These delineated outcomes of case study align with the main research questions of this study that focus on understanding in depth teacher conceptions and enactment of disciplinary literacy as well as any interactions between the two. Using case study as the research genre, therefore, supports the researcher in building knowledge of the phenomenon within its natural setting and gaining deeper understanding of what is occurring in order to address the main research questions.

**Typology of Case Study.** Within the case study genre, there are many options for types of case studies (Creswell & Poth, 2018). After investigating different types, one typology seems to make sense as a path to follow as it has a clear trajectory that allows the researcher to align participants, study purpose, study approach, and study process in an orderly manner that supports answering the research questions under exploration (see Figure 1).

**Figure 1**

*A Typology of Case Study (Thomas, 2011)*
Subject: Choice of Participants in General. In this typology for case study by Thomas (2011), within the subject, or who the participants are, he offers three choices: Local, participants are within the researchers’ day to day sphere such as “one’s own place of work” (p. 514); Key, participants are chosen because “of the inherent interest of the case” (p. 514); or Outlier, participants represent a divergence from the expected norm. Within this case study, as the purpose was to explore what is occurring in general with the phenomenon, the participants represent Thomas’ (2011) definition of Key participants.

Object: The Topic Focus of the Study. Thomas (2011) explains this component of the case study typology as “what is this a case of” (p. 515) or in other words, what is the topic. Within this study, the topic is disciplinary literacy instruction within elementary science education.

Purpose: The Why of the Study. Again, this typology provides guidelines. Four possible purposes include: Intrinsic, Instrumental, Evaluative, or Exploratory. Because the purpose has already been stated as exploratory, it fits within the typology guidelines.

Approach: The Underpinnings of Studying the Topic, Object of the Study. Thomas (2011) makes it clear that while there is an object or topic of the study and a purpose for exploring the object, there must also be a theoretical reason underpinning the study’s purpose. He specifically identifies four of these reasons in which there are “two kinds of theoretical case stud[ies] (theory seeking and theory testing)” (p. 516) as well as two kinds of “atheoretical [case studies] …picture drawing and storytelling…essentially (a) theoretical, or (b) illustrative” options (p. 516). Because the purpose of this study was to explore the conceptions and enactment of disciplinary literacy in elementary science
instruction or the “theory” of disciplinary literacy for these participating teachers, this study utilizes what Thomas (2011) classifies as a theory seeking or theory-building underlying assumption. This, again, aligns with the constructivism and sociocultural theoretical underpinnings that have previously been identified as this study seeks to build knowledge about what is occurring related to disciplinary literacy within the sociocultural context of specific teacher conceptions and classroom instruction.

**Process: How to Carry Out the Research.** Thomas (2011) describes this component as “an examination of the nature of the choices…about the parameters that delimit the subject of the study” (p. 516). These may include boundaries such as place, number of participants, events, etc. These notions are described in greater depth in the sections that follow. However, at this point, two basic boundaries are established. First, this study explores multiple cases as a way to make sense of the phenomenon. Therefore, it is a multiple case study. Second, the individual cases run parallel to each other, meaning each case is a separate entity and the study occurred simultaneously for all cases.

**Typology of This Case Study.** After considering all of the components in Thomas’ (2011) typology of case study, a clear path that articulates a thoughtful research process was established for this study. The choices of this pathway that were previously delineated can be graphically represented as seen in Figure 2.
Through following this process, the researcher was better able to address the research questions that explored the phenomenon of teacher conceptions and enactment of disciplinary literacy in elementary science instruction. This was accomplished through (a) exploring single cases of individual teachers and (b) comparing these cases to uncover a richer understanding of the phenomenon.
Chapter III Methods

The purpose of this research was to explore elementary teacher conceptions and enactment of disciplinary literacy and the connections between them to address the following main research questions:

1. What are fifth-grade teachers’ conceptions of disciplinary literacy in elementary science instruction?
2. How do these teachers enact disciplinary literacy during elementary science instruction?
3. In what ways do these teachers’ conceptions and enactments interact with one another?

According to Marshall and Rossman (2016), “historically, qualitative methodologists have described three major purposes for research: to explore, explain, or describe a phenomenon.” (p. 75). This aligns with the purpose of this study which was to explore elementary teacher conceptions and enactment of disciplinary literacy and the connections between them. Creswell and Poth (2018) provide a more in-depth definition of qualitative research by citing an excerpt from Denzin and Lincoln (2011):

Qualitative research is a situated activity that locates the observer in the world. Qualitative research consists of a set of interpretive, material practices that make the world visible. These practices transform the world. They turn the world into a series of representations, including field notes, interviews, conversations, photographs, recordings, and memos to the self. At this level, qualitative research involves an interpretive, naturalistic approach to the world. This means that qualitative researchers study things in their natural settings, attempting to make sense of, or interpret, phenomena in terms of the meanings people bring to them. (p. 3)
In order to accomplish this purpose, a comparative case study design was utilized. This chapter describes in detail how this research design (described in Chapter 2) was implemented. Specifically, the following main sections of this chapter include: context of the study, participants, data sources and collection, data analysis, and validity. Subsections with critical ethical information are included throughout each section. Also, included in this chapter is a description of the researcher perspective as a way to add clarity to the interpretation and parameters of the research.

**Context of the Study**

The main unit of analysis in “a ‘case’ is generally a bounded entity” (Yin, 2012, p. 6). In this research the bounded entity was the individual teacher situated in a specific context. For this study, Grade 5 was determined to be the grade from which teachers were selected to participate. This was decided because in the state where this research took place, elementary science is a tested subject in Grades 4-5, which encourages science instruction to occur. Between these two grades, Grade 5 was specifically selected as a matter of convenience because the researcher of this study taught fifth grade and is familiar with the developmental level of the students. This may increase understanding of choices participating teachers make due to the age considerations of the students, thus, helping the researcher to sort out developmental instructional decisions from conceptions related to the research topic, disciplinary literacy.

Within case studies, the design may include a single case or multiple cases. As a way to ensure the findings were more reliable and therefore more valid, a multiple case study design was employed to assure “the ensuing data can provide greater confidence in [the] findings…Thus, a common multiple-case design might call for two or more cases”
(Yin, 2012, pp. 7-8). In this particular instance, four teachers were selected for this multiple case study.

**Ethics: Study Context**

As a way to promote transparency and increase validity, ethical issues are addressed throughout the Methods’ chapter subsections. Since this is the study context section, ethics related to this topic are addressed now. Future ethical considerations are included as a sub-component of the related sections.

Creswell and Poth (2018) identify specific ethical issues that may arise related to study context. First, power issues may be present at the research sites if there are perceived power differences between the researcher and the administrators and teachers of the sites. This can be an issue in this study as the researcher holds a high position in the state office. As a way to counteract this issue, the researcher only introduced herself as a former classroom teacher who is working on a dissertation in the area of elementary science education. Second, gaining access to the site can become an ethical issue if not handled through the appropriate process. Therefore, the researcher utilized the gatekeepers within the selected district to gain information about the appropriate approval process and then followed that process, which included contacting district research personnel and the principals of the elementary schools located in the district. Additionally, a third issue noted by Creswell and Poth (2018), is becoming “familiar with research context and population [by] find[ing] out about cultural, religious, gender, and other differences that need to be respected” (p. 152). Because the researcher is the state science specialist and the school district is located in close proximity to the researcher,
she has intimate knowledge about the school district context and population, which helped her be respectful and build good rapport with each research site.

**Participants**

As has been mentioned previously, the participants were selected from one public school district. This district is located in a predominately urban area consisting of five cities where urban is defined by the United States Census Bureau (2015) as containing a population of 50,000 or higher comprising a “densely settled core of census tracts and/or census blocks…along with adjacent territory containing non-residential urban land uses” (Geography section, para. 2). Additionally, the selected school district is one of the larger districts in the state, with 41 elementary schools and a total of 175 full time fifth-grade teachers (X District Website, 2023). The student population is comprised of a majority of White students with a notable Hispanic/Latino subset. There is also a significant Economically Disadvantaged subset in the population (see Table 1).

**Table 1**

*Participating School District Demographics*

<table>
<thead>
<tr>
<th>District</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Student Population</td>
<td>57,829</td>
</tr>
<tr>
<td>Hispanic/Latino</td>
<td>18.7%</td>
</tr>
<tr>
<td>American Indian</td>
<td>0.4%</td>
</tr>
<tr>
<td>Asian</td>
<td>1.6%</td>
</tr>
<tr>
<td>African American/Black</td>
<td>1.1%</td>
</tr>
<tr>
<td>Pacific Islander</td>
<td>1.9%</td>
</tr>
<tr>
<td>Multiple Race</td>
<td>4.6%</td>
</tr>
<tr>
<td>White</td>
<td>71.8%</td>
</tr>
<tr>
<td>Economically Disadvantaged</td>
<td>18.4%</td>
</tr>
<tr>
<td>English Learner</td>
<td>7.7%</td>
</tr>
<tr>
<td>Student with Disability</td>
<td>12.6%</td>
</tr>
<tr>
<td>Homeless</td>
<td>3.3%</td>
</tr>
</tbody>
</table>

*Note.* Data collected from 2023FallEnrollmentGradeLevelDemographics (X State Education Website, 2023).
The process for selecting the specific participants initially utilized a convenience sampling technique because participants were selected from a public school district that is in close proximity to the researcher. These participants were recruited via school district email and expressed their interest to be involved in the research by clicking on a link and filling out a Qualtrics Survey (See Appendix A).

The four research participants from this volunteer group were selected using a criterion sampling technique to increase reliability and credibility of findings (Marshall & Rossman, 2016). By using this sampling technique, participants were matched on identified factors. These factors included: Teaches science, Year of Graduation, and Level of exposure to the new Utah Science with Engineering Education (SEEd) Standards (Utah State Board of Education [USBE], 2019), as indicated by participation in professional development opportunities (See Table 2).

**Table 2**

*Teacher Matched Factors*

<table>
<thead>
<tr>
<th>Participant</th>
<th>Charlotte</th>
<th>Sally</th>
<th>Jack</th>
<th>Jenna</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graduation Year</td>
<td>Prior to 2012</td>
<td>Prior to 2012</td>
<td>After 2012</td>
<td>After 2012</td>
</tr>
<tr>
<td>Level of Exposure to SEEd Standards</td>
<td>Minimal</td>
<td>Minimal</td>
<td>Minimal</td>
<td>Minimal</td>
</tr>
</tbody>
</table>

Other demographic information included in the survey provided the researcher with background information from which to write the case studies. The reason for this matching was to minimize differences between teachers on factors other than the one being explored. However, the factor, Graduation Year, was deliberately different. Due to the release of new research in science education, The Framework (NRC, 2012) (discussed previously), teachers who graduated prior to the release of this research may have had
different experiences in their science methods courses surrounding the topic of disciplinary literacy as compared to teachers who graduated after the release of this seminal research. Thus, they may have different conceptions of disciplinary literacy. To account for this possibility, two teachers were selected based on having graduated from a teacher preparation program prior to 2012 and two were selected based on having graduated after 2012. This created a situation discussed by Yin (2012) where “the multiple cases might include deliberately contrasting cases” (p. 8) making this comparison between the preparation participating teachers received in preservice programs a planned difference that may provide insights into teacher conceptions and enactment of disciplinary literacy.

**Ethics with Participants**

As with study context, Creswell and Poth (2018) also identify specific ethical issues that may arise related to participants. First, they describe issues related to power difference between participants and the researcher. This issue was handled as previously described; the researcher introduced herself as a former classroom teacher working on a dissertation.

Another issue to address was transparency with participants. For example, were participants “aware of why they [were] invited to participate with reference to the study purpose… [and were] they informed about the procedures and their rights” (Creswell & Poth, 2018, p. 152). To support full transparency with participants, they had the opportunity to read, ask questions about, and ultimately choose whether to sign an informed consent form (See Appendix B) that contains the following information as identified by Creswell and Poth (2018):
• The right to voluntarily withdraw from the study at any time,
• The purpose of the study and the procedures to be used in data collection,
• The protection of their confidentiality,
• The known risks associated with participation in the study, and
• The expected benefits of participation in the study (p. 155).

This information was provided to all teachers who received the recruitment email, including the four who were selected as participants prior to any data being collected.

**Data Sources and Collection Techniques**

As part of their book, *Designing Qualitative Research*, Marshall and Rossman (2016) include a chapter on basic data collection methods. Within this chapter, they describe that “qualitative researchers typically rely on four primary methods for gathering information: (1) participating in the setting, (2) observing directly, (3) interviewing in depth, and (4) analyzing documents…[Additionally,] most studies use a combination of [these] data collection methods” (p. 141). This study used three of the four identified information gathering methods: observation, interviews, and analyzing documents. The fourth type, participating in the setting, depends on the extent to which the researcher desires to be involved in the setting. As described by Creswell and Poth (2018), this extent of involvement occurs on a continuum from complete participant, participant as observer, nonparticipant or observer as participant, and complete observer. In order to record data in real time during the observation and influence the outcome of the observed instruction as minimally as possible, the researcher made the decision to be an observer, nonparticipant, in the setting.

**Interviews**
Creswell and Poth (2018) explain that “an interview is considered to be a social interaction based on conversation” (p. 163). This connotes that the interview is not totally structured and has a natural cadence of dialogue between the participant and researcher. This follows the theoretical perspective that learning occurs in social situations. Furthermore, these researchers state, “knowledge is constructed in the interaction between the interviewer and the interviewee” (Warren & Xavia Karen, 2015, p. 4). This supports the idea that knowledge is constructed through this interaction. To accomplish a conversational feel that allowed for knowledge to be constructed, this study employed a semi-structured interview that utilized an interview protocol. This technique allowed the researcher to “strike a balance, saying enough about [herself] to be alive and responsive but little enough to preserve the autonomy of the participant’s words and keep the focus of attention on his or her experience” (Marshall & Rossman, 2016, p. 148). By doing this, the researcher was “systematic and iterative” (p. 150) in gathering data from the participants.

**Participant Interview.** Selected participants received a recruitment email sent directly to the email address they provided when their willingness to participate in the study was granted. Arrangements were then be made for a date, time, and place for the interview at the convenience of the participants.

The researcher then met individually with the selected participants for a 45–60-minute interview (Creswell, 2012; Johnson & Christensen, 2000). During this time, an interview protocol (see Appendix C) and an interview guide (see Appendix D) were followed to help the researcher obtain data to answer the study’s research questions (Creswell, 2012; Gall et al., 2003).
Interview Protocol. According to Creswell (2012), an interview protocol helps to establish rapport and trust between the interviewer and interviewee so that effective data is collected. The following are necessary components:

1. Header to remind the interviewer of the important elements to record during the interview such as: Study purpose that includes why this information is important (Gall et al., 2003), consent form reminder, equipment check, and participant demographics.

2. Interview guide containing the questions, with spaces between questions to record notes and additional probes that elicit clarification or elaboration.

3. Closure remarks to remind the interviewer to thank participants, assure their confidentiality, allow them a time to ask questions, and clarify how data and study results will be used and distributed.

Interview Guide. Within the interview guide, the number, purpose, and sequence of questions were planned (Creswell, 2012; Gall et al., 2003) to address the three research questions:

1. What are fifth-grade teachers’ conceptions of disciplinary literacy in elementary science instruction?

2. How do these teachers enact disciplinary literacy during elementary science instruction?

3. In what ways do these teachers’ conceptions and enactments interact with one another?

Because the researcher completed a master’s thesis on the subject of disciplinary literacy in which she created and piloted a questionnaire about teachers’ conceptions of
disciplinary literacy, this survey was adapted to meet the purposes of this research (Mendenhall, 2018). The following subsections delineate how the Interview Guide questions provide information to help answer the research questions.

**Research Question #1.** The first two questions of the Interview Guide directly addressed research question #1 by asking open-ended prompts that uncover teacher conceptions of literacy and text in general. These two questions were then contrasted with questions 3 and 4 of the Interview Guide which asked about teacher conceptions of literacy and text used in science or disciplinary literacy in science. The term disciplinary literacy was not used with participants as it is likely not familiar to them. Therefore, the terms literacy in science and texts used in science seemed to be approachable for participants while still providing the researcher with information regarding teacher conceptions of disciplinary literacy.

**Research Questions #2 and #3.** The fifth interview question was also open-ended and addressed the notion of teacher perceived enactment of disciplinary literacy during science instruction. This helped the researcher compare what occurred during classroom observations and what was designed in teacher lesson plan artifacts with teacher conceptions of enactment.

These first five questions were followed by six instructional scenarios, again adapted from the researcher’s thesis questionnaire (Mendenhall, 2018) in the Interview Guide. These scenarios or “instances” as described by Southerland, Smith, and Cummins (2000) served as accompanying probes (Creswell, 2012) in order to delve more deeply into participant conceptions and perceived enactment of disciplinary literacy. According to Southerland et al. (2000), instructional scenarios can help identify conceptions that
teachers may not be able to describe but can identify in context. Additionally, Nott and Wellington (1998) suggest these types of scenarios “evoke responses from the teacher which provide an insight into the teachers’ view of science as well as matters to do with teaching and learning” (p. 582), which helps researchers to more accurately understand teachers’ conceptions.

The scenarios were designed to display a continuum of instructional practice from general literacy to disciplinary literacy. The prompt to these scenarios asked teachers to rate each scenario from 1–6, with 6 demonstrating the highest level of best practices in teaching students to be literate in the field of science and 1 demonstrating the lowest level of best practices in teaching students to be literate in the field of science. Teachers were asked to explain their ratings and provide evidence for where literacy appropriate for science instruction was found in each scenario. To view these instructional scenarios and get an explanation for how each scenario was designed to illuminate literacy on the continuum from general literacy to disciplinary literacy see Appendix D for instructional scenarios and Appendix E for criteria related to scenario construction.

**Recording Participant Interviews.** In addition to handwritten notes, a form of electronic recording device is recommended for archiving interviews (Creswell, 2012; Gall et al., 2003). For this study, the interview transcripts were recorded in Zoom as this was the platform asked for by all four participants. Permission to record the interview was requested of each participant at the beginning of the interview. Additionally, the interview was recorded using a personal recording device as a backup for transcriptions. All interview data was stored in a folder on a password protected computer in a locked desk drawer.
Documents to Analyze

As a way to cross-check information gathered from the interview and provide scaffolding for comparing participant-described conceptions of disciplinary literacy and enacted disciplinary literacy, documents in the form of three lesson plans were collected from each participant. Marshall and Rossman (2016) state that “researchers often supplement participant observation [and] interviewing…with gathering and analyzing documents…constructed specifically for the research at hand. As such, the analysis of documents is potentially quite rich in portraying the [conceptions] of participants in the setting” (p. 164).

One of the requested lesson plans aligned with the observation that followed the interview. The other requested lesson plans were selected by the participant to represent routine science instruction in the classroom. To increase the possibility that lesson plans were typical of routine class instruction, the researcher did not suggest any specific format for the lesson plans. However, participants were urged to submit enough detail that a substitute teacher could teach the science lesson for the class using these plans.

Lesson plans were submitted electronically via email through a file attachment. The researcher stored the documents in a folder on a password protected computer. After downloading the documents, the email was deleted and emptied from the email trash folder on the computer.

Observations

Marshall and Rossman (2016) explain that “observation is central to qualitative research” (p. 143). It allows the researcher to experience the reality of each participant
(Marshall & Rossman, 2016) regarding how planned instruction is actually implemented in the class. In this research, observations took place in the following manner:

1. The researcher observed teacher instruction at a date selected by the participant after the interview. This observation allowed the researcher to compare teacher conceptions from the interview and the submitted teacher lesson plan artifact with the actual enactment of disciplinary literacy during instruction,

2. The researcher asked the teacher for possible times to just drop in during science instruction as a way to compare data from planned and unplanned observations. The researcher completed two drop-in observations.

To glean the most from an observation, “systematic noting and recording of events” (p. 143) is critical. An observation protocol (see Appendix F) was utilized as a way of thoroughly and thoughtfully recording events and field notes. The observation protocol contains components identified by Marshall and Rossman (2016): header, descriptive notes, and reflective notes. The following paragraphs describe what each of these components entails.

**Header.** The header “record[s] essential information about the project” (Marshall & Rossman, 2016, p. 170), such as the interview date and time. It also contains a reminder of the study’s purpose to help focus the researcher on what to watch for as part of the observation.

**Descriptive Notes.** The remainder of the observation protocol is divided into three columns. The first column is for the researcher to note the point of the lesson plan currently being observed and the current time of day. The second column is where the descriptive notes are recorded. Within the descriptive notes, the researcher recorded in
detail what the participant was doing and saying that relates to the identified section of
the lesson. This provided data about how the participant enacts disciplinary literacy
during instruction.

**Reflective Notes.** The final column was available for reflective notes. This area of
the observation protocol was reserved for any insights the researcher had related to the
study purpose during the observation. Entries may include thoughts about future codes
for analyzing the data and connections to any of the three-dimensions previously
discussed from The Framework (NRC, 2012) document or NoS notions as previously
described along with any other insights that occurred in the moment.

**Ethics: Data Sources and Collection Techniques**

Creswell and Poth (2018) identify specific ethical issues that may arise related to
data sources and collection techniques. First, they delineate that “data collection might
disrupt the site” (p. 152). This can occur if the researcher intervenes or participates during
the observation. To decrease the disruption to both the participant and the students in the
classroom, the researcher was seated in the back of the room in a secluded area that was
not part of a traffic pattern of the class. A disruption to the class may also occur if the
interview that precedes the observation takes the teacher out of class time. To lessen this
issue, the researcher asked participants to set the interview at a time convenient to them
that was not during school hours when students were in attendance.

Second, there may be power inequities between the researcher and the participant.
The way to diminish this potential issue was described in prior sections. Additionally,
there is the issue of participants spending their time on this research project. To offset
participant time, a small and appropriate stipend of $150 was provided for each
participant. This was determined by allowing $25 for the interview, $25 for preparation for each lesson plan, $25 for time spent doing member checks to assure the accuracy of the data, and the final $25 for member checks of the accuracy of the researcher interpretations. As a result of the participants checking the data and interpretations, the ethical issue of accurately representing the participants intentions and protecting their dignity was addressed.

Finally, an important issue to consider is participant confidentiality. To increase and respect the privacy of participants, each study participant selected a pseudonym that was utilized in place of authentic names on all identifying data; the information from interviews, artifacts, and observations was stored on a password protected computer; and the computer was stored in a locked desk drawer for security.

Data Analysis

With data collected from interviews, observations, and teacher artifacts, there was a large quantity of collected information during this research. However, information on its own does not create understanding of a phenomenon (Creswell, 2012). To make sense of the data, it must be organized and interpreted (Creswell & Poth, 2018). This requires a systematic plan or “process of bringing order, structure, and interpretation to a mass of collected data” (Marshall & Rossman, 2016, p. 214). To accomplish this task, Marshall and Rossman (2016) suggest “typical analytic procedures fall into seven phases” (p. 217). The data in this study was analyzed using this seven-phase process, which is described in the following subsections: organizing the data, immersion in the data, coding the data, generating case summaries, offering interpretations, searching for alternative understandings, and writing the report. This data analysis section concludes with an
explanation of the researcher stance, which is important because researcher perceptions affect, to some degree, the interpretation of the data (Creswell & Poth, 2018).

Organizing the Data

Because this research generated many pieces of data, a Data Gathering Log (see Appendix G) was used to maintain the organization of the data as it was accumulated (Marshall & Rossman, 2016). This log contains columns with the following headers: Date, Place, Time, Who (i.e., what participant the data is for), and Activity (i.e., interview, observation, lesson plan). Additionally, all pieces of data were stored in a folder on a password protected computer in a locked desk drawer. Within this folder, separate folders were kept for each participant that contain all of the data associated with that participant.

Immersion in the Data

According to Marshall and Rossman (2016), “there is no substitute for intimate engagement with your data” (p. 217). As a way to become comfortable and familiar with the data, the researcher read each piece of data using an immersion style of coding (Marshall & Rossman, 2011; Miles & Huberman, 1994).

Coding the Data

The purpose of coding the data is to surface meaning from the data in a systematic way. The initial act of assigning meaning to a small chunk of data (e.g., word, phrase, sentence, thought) is the first step of the process. Saldana (2016) explains, “a code is a researcher-generated construct that symbolizes or ‘translates’ data and thus attributes interpreted meaning to each individual datum for later purposes of pattern detection,
categorization, assertion…development, theory building, and other analytic processes” (p. 4). Ultimately, coding data “generates the bones of your analysis…Integration will assemble those bones into a working skeleton” (Charmaz, 2014, p. 113).

The Coding Process. Within the first step of basic coding, “a code represent[ing] and captur[ing] a datum’s primary content and essence” (p. 4) was generated using immersion style coding where emergent codes surface within the data (Marshall & Rossman, 2011; Miles & Huberman, 1994), as seen in Figure 3.

Figure 3

The Coding Process

The second step in the coding process was to cluster the basic codes into patterns using a list of theory-driven codes “derived from the literature review” (Marshall & Rossman, 2016, p. 218). Saldana (2016) explains that “one of the coder’s primary goals is to find…repetitive patterns…in the data” (p. 6). This allowed the researcher to see how emergent codes aligned with theory-driven codes. In this study, the theory-driven coding categories became the “Organizing Themes” (Leary & Walker, 2018, p. 533), as depicted in Figure 3.

The third step in the coding process moves toward understanding the Organizing Themes (Saldana, 2016). The purpose of this step is “not to arrive at a reduced answer but to move toward consolidated meaning” (p. 10) because, as Saldana (2016) glibly
notes, “quantitative analysis calculates the mean. Qualitative analysis calculates meaning” (p. 10). This synthesis of the Basic Codes underlying the Organizing Themes to make sense of each participant’s conceptions and enactment of the Organizing Themes supported the researcher’s understanding of overarching “Global Themes” (Leary & Walker, 2018, p. 533) as depicted in Figure 3.

The final step was to organize all of the coding process into a Hierarchy Tree (see Figure 3). This is a visual representation of the meaning-making process of coding from the datum to the Global Themes (Leary & Walker, 2018; Saldana, 2016). A representation of this hierarchy tree is shown in Figure 4.

**Figure 4**

*Generic Hierarchy Tree*

![Generic Hierarchy Tree](image)

**Replication Logic.** Because this research is a comparative case study involving multiple cases, each case followed the coding process identified above. Then, the cases were compared and synthesized using what Yin (2012) describes as “replication logic” (p. 15). To accomplish this, the cases were compared according to participant graduation
date. Then, all four cases were synthesized together. This created Global Themes within each case and across all four cases.

**The Code Book.** To organize the data as it is coded, a code book (see Appendix H) was utilized in the following way:

1. Basic meaning chunks, Basic Codes, were identified, highlighted, and numbered within each participant’s lesson plans, interview, and observation.

2. Basic Codes were added to the Code Book along with a description of that code and code examples from the text (see Table 3). There is a section for each participant in the Code Book.

3. Organizing Themes were also included in the Code Book after each of the four individual participant Code Book sections. The theory-driven Organizing Themes were applied to the Basic Codes through a color-coding process within the original Code Books for each participant as delineated in step two of the coding process (see Table 3).

4. Organizing Themes were additionally depicted graphically for each participant with the theme as the header and the Basic Codes identified to align with a theme listed beneath it. These representations include a different graphic for Explanation of Instructional Scenarios from the interview, Interview/Enactment (i.e., open interview question #5 regarding where students will be using and developing literacy authentic to science during observations), Lesson Plans, and Enactment (i.e., data from the observations).

5. A separate section for Global Themes was added to the end of each participants’ section of the Code Book, and the Code Book in general across all four cases. In
these sections, Organizing Themes were analyzed to produce Global Themes as delineated in step three of the coding process.

Table 3

*Layout Example of the Code Book*

<table>
<thead>
<tr>
<th>Basic Code</th>
<th>Definition</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Themes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graphic Representation of Codes</td>
<td>Overall:</td>
<td>Explanation of Instructional Scenarios:</td>
</tr>
<tr>
<td>Related to Organizing Themes</td>
<td>Overall:</td>
<td>Interview/Enactment:</td>
</tr>
<tr>
<td></td>
<td>Explanation of Instructional Scenarios:</td>
<td>Lesson Plans:</td>
</tr>
<tr>
<td></td>
<td>Interview/Enactment:</td>
<td>Enactment:</td>
</tr>
<tr>
<td>Global Themes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Generating Case Summaries*

After the coding was completed, a summary was written for each case. These summaries contain a narrative about the Basic Codes, Overall Themes, and Global Themes findings of each case. Then, each participant was asked to complete a member check of the synthesized narratives from their data to confirm or provide feedback that addressed both accuracy of content and meaning (Leary & Walker, 2018).

*Offering Interpretations*

Once the data was organized, coded for meaning, and case summaries were checked by participants for accuracy, the researcher was ready to interpret the generated
analysis of data. Patton (2002) notes that “interpretation means attaching significance to what was found, making sense of the findings, offering explanations, drawing conclusions, extrapolating lessons, making inferences, considering meanings, and otherwise imposing order” (p. 480). This is where the researcher starts “telling the story” (Marshall & Rossman, 2016, p. 228) of the data. This involved telling the story in narrative form using information from each case, across participant graduation data, and across all cases.

**Searching for Alternative Understandings**

This section speaks to the ethics of data analysis. To be ethical, the research needs to implement checks along the way to make sure that interpretations are valid. To accomplish this, the researcher engaged in the following:

1. Peer debriefing as a way to check for alternative understandings by arranging with “knowledgeable and available colleagues to get reactions to the coding, case summaries” (Marshall & Rossman, 2016, p. 230), and hierarchy trees findings, and narratives. The knowledgeable colleague the researcher utilized was her dissertation chair.

2. Member checks to “ask the participants whether [the researcher] ‘got it right’” (Marshall & Rossman, 2016, p. 230). This specifically happened when the individual case study summaries were developed.

3. Audit trails through the use of a Data Gathering Log and a Code Book. This “provide[d] a transparent way to show how data were collected and managed…and trace[d] the logic leading to the representation and interpretation of findings (Marshall & Rossman, 2016, p. 230).
4. Intercoder reliability (Marshall & Rossman, 2016) in which the researcher “develops definitions for each code and asks ‘blind’ review coders to apply the definitions to data to check for consistency in meanings and application” (Marshall & Rossman, 2016, p. 230). This occurred for a sampling of the coded data. The researcher’s dissertation committee chair served as the reviewer.

**Writing the Report**

In writing the findings, the researcher must incorporate all of the various phases of data analysis in a way that “argues a balancing and weaving of these elements” (Marshall & Rossman, 2016, p. 231). By being transparent about the data analysis phases through providing the following:

1. For each case: Basic Codes, Overall Themes, Global Themes, and a Case Summary;
2. For each case comparison: a comparison case summary;
3. For the whole study (synthesis of all four cases): Overall Themes, Summary, and Hierarchy Tree.

Thus, the final report demonstrates “soundness, usefulness, and ethical conduct” (p. 230) as well as being engaging and interesting to the reader.

**Researcher Stance**

Every researcher has a perspective or lens through which the research data are perceived. This lens affects subjectivities and how the data is interpreted. Creswell and Poth (2018) explain:

Researchers recognize that their own background shapes their interpretation, and they “position themselves” in the research to
acknowledge how their interpretation flows from their own personal, cultural, and historical experiences. Thus, the researchers make an interpretation of what they find, an interpretation shaped by their own experiences and background. (p. 24)

It is therefore important to acknowledge the researcher’s background in order to be transparent about any biases or experiences that could affect the interpretation of data. This section, therefore, discloses the personal background that informs the researcher identity in regard to disciplinary literacy, the focus of this study so that the reader has access to the lens through which the qualitative data was analyzed (Marshall & Rossman, 2011).

To make this researcher lens public, it is important to disclose that my identity hinges around two distinct perspectives: learner and leader. During undergraduate studies, I discovered a desire to learn about many subjects. Elementary education seemed like the appropriate avenue to explore because the elementary education program included how to teach a variety of disciplines. After graduation and while teaching elementary students, I continued to be a student by completing an English as a Second Language Endorsement. The impetus behind gaining this knowledge was to help students with limited English proficiency become literate. A desire to help all students develop literacy skills followed as I then completed both a Reading and an Advanced Reading Endorsement. At this point, I realized that while I now had greater knowledge about how to develop and support literacy in elementary students, I had only basic foundational knowledge about the other disciplines that I was teaching in elementary school. Coming to this realization made me desire to learn more, which I did by completing the Master’s degree in Teacher Education at Brigham Young University. Through this program, I was able to specialize in integrated STEM education. This is where I discovered a passion for
disciplinary literacy. Before this time, I had never considered that different disciplines had specialized ways of communicating within the community. Currently, disciplinary literacy continues to be an area of extreme interest to me, specifically as it relates to science education, as I complete a Ph.D. in Education with a Science Education concentration.

My professional role in education at this time is the Elementary Science and STEM Specialist for the state in which I reside. Thus, my perspective is a leader. As a science education leader, I worry about building the capacity of Local Education Agency science specialists and all elementary educators of the state to provide equitable access to quality science education for K-6 students. Supporting educators in developing an accurate understanding of disciplinary literacy and enacting effective instruction that provides access for students to enter the Discourse (Gee, 2004) of science is my goal. Ultimately, my desire is for all students to leave K-12 education with a disciplinary literacy foundation in science that empowers them to critically consume and utilize science information to better their own lives and potentially enter science careers in the future, if that is what they choose.

Validity

Of great consideration in a study is validity or what Marshall and Rossman (2016) term as either “soundness” (p. 44), “credibility” (p. 46), or “trustworthiness” (p. 44). Regardless of the term used, the essence is that the readers can trust the research because they can “see for themselves the ways theory and researchers’ use of their interpretive skills have shaped the progression of the study… [to be] sound, trustworthy, and good”
Marshall and Rossman (2016) also make the argument that this notion of trustworthiness “cannot be separated from ethical concerns” (p. 44).

Other noted researchers add specific strategies to ensure this trustworthiness. Among these are Lincoln and Guba (1985). They suggest trustworthiness is met by triangulation of data, meaning “gathering data from multiple sources, through multiple methods” (Marshall & Rossman, 2016, p. 46). This study does meet the criteria for triangulation of data by collecting a variety of data through interviews, observations, and participant artifacts using protocols for both the interview and observation. Additionally, another strategy of trustworthiness, as noted by Lincoln and Guba (1985), is peer debriefing. This strategy was also implemented in this study as discussed in previous sections.

Creswell and Miller (2000) also suggest certain strategies to ensure trustworthiness. Among their strategies are the following that were previously discussed as pertaining to this study: triangulation, engaging in reflexivity, member checking, developing an audit trail, and peer debriefing. Another researcher, Maxwell (2012), also suggests: searching for alternative explanations, triangulation, and soliciting feedback. All of these strategies were implemented in this study.

In conclusion, throughout this study, the researcher sought to be transparent through articulating specific ways to support ethical behavior in working with participants, sites, data collection, and data analysis. The research behind and strategies utilized for supporting trustworthy or ethical behavior are located within each section of the research study as a way to demonstrate a vigilance and determination to be trustworthy, transparent, and ethical.
Chapter IV Findings

Understanding elementary teachers’ conceptions and enactment of literacy appropriate for the discipline of science, disciplinary literacy in science, as well as any interactions between these conceptions and enactment is the focus of this chapter, which explores these notions through a comparison case study method of four fifth-grade teachers. With this purpose in mind, the chapter starts with an explanation of what is contained within each of the four individual case studies (i.e., Basic Codes, Overall Themes, Global Themes). Then, the case summaries for two of the participating teachers are provided. These two cases, which include two teachers who graduated prior to new research in science education, The Framework (NRC, 2012) being released, are then compared for patterns in conceptions and enactment of disciplinary literacy in science. Following the comparison summary of the two case studies for teachers who graduated prior to 2012, the other two case studies are presented. These include the two teachers who graduated after 2012. Section four, then, is a comparison summary of the two teachers who graduated after 2012. The chapter concludes with section five, which compares cases across graduation date, prior to and after 2012, and section six that makes comparisons across all four cases (i.e., Overall Themes, Global Themes, summary, Hierarchy Tree) for teacher conceptions and enactment of disciplinary literacy as well as any interactions between the two.

Explanation of Case Study Contents

With the purpose of exploring disciplinary literacy in elementary education, the following case studies present findings from three different data sources (i.e., interview, lesson plan submissions, observations) for each of the four fifth-grade teachers as a way
to triangulate information and create a picture of what is currently occurring in this space. Specifically, each case summary contains sections that address the first five open-ended interview questions: (1) What do you think of as literacy?, (2) What do you consider to be text?, (3) What types of text do you think of as being used in science?, (4) What is entailed in being literate in the field of science?, and (5) In the upcoming observations, are there places where students are working on and using authentic literacy in science? Where?

The first four questions build background context for understanding teachers’ conceptions of literacy and text in general, and how these conceptions compared to their conceptions of disciplinary literacy and text appropriate for science. The fifth question builds context for teachers’ conceptions of enactment of disciplinary literacy during science instruction. Together, the findings from these first five questions address Research Question #1: What are fifth-grade teachers’ conceptions of disciplinary literacy in elementary science instruction?

The second section of each case study explores teacher conceptions of disciplinary literacy (Research Question #1) through six instructional scenarios (interview questions #6-11) in which varying levels of disciplinary literacy were embedded into the instruction. Two were developed to include low disciplinary literacy, two with some disciplinary literacy, and two with high levels of disciplinary literacy. For an explanation of the design and criteria of these scenarios, see Appendix E. For the interview scenario questions, teachers were asked to rate each scenario from 1-6, with 6 being the highest level of literacy appropriate for science. Additionally, they were asked to provide an explanation for their ratings. These scenarios were adapted from a study by
Mendenhall (2018). Table 4 provides a summary for each scenario that was presented to the teachers during the interview.

**Table 4**

*Summary of Disciplinary Literacy Instructional Scenarios by Number, Level of Disciplinary Literacy, and Description*

<table>
<thead>
<tr>
<th>Interview Question</th>
<th>Quality level of science literacy</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Low</td>
<td>Students were asked to read text about gravity and celestial objects, write a Haiku or Cinquain poem, and create an illustration in the Impressionist style.</td>
</tr>
<tr>
<td>7</td>
<td>High</td>
<td>Students began with a teacher generated question about the function of organelles within the whole structure of an organism. Students observed an online feed of organisms under an electron microscope, drew what they saw, paired with another student to compare their thinking to a textbook, and wrote their conclusions.</td>
</tr>
<tr>
<td>8</td>
<td>Some</td>
<td>Students were presented with lists of different celestial objects in the solar system organized according to diameter. They selected the list they thought was correct and researched online to determine if the objects were ordered correctly for size. Finally, students wrote an argument about the correctness of their list including a claim and evidence.</td>
</tr>
<tr>
<td>9</td>
<td>High</td>
<td>Students were presented with a question and researched the answer using multiple sources. Based on their research, students planned an experiment to test their hypothesis and wrote an argument based on evidence from the findings that included visual representations.</td>
</tr>
<tr>
<td>10</td>
<td>Some</td>
<td>Students observed microorganisms in pond water under a microscope, then drew, read text, and took notes about the organisms in a graphic organizer. Students then wrote a summary about microorganisms based on their notes.</td>
</tr>
<tr>
<td>11</td>
<td>Low</td>
<td>Students generated a KWL chart about Galileo’s invention of the telescope as they either listened to or participated in a readers’ theater presentation.</td>
</tr>
</tbody>
</table>

The third section of each case study explores findings from the Basic Codes and Overall Themes for all collected data (i.e., interview, lesson plan submissions, observations) and is broken down into the following subsections: Interview, Lesson
Plans, and Observation. After generating emergent codes from the data, these Basic Codes were categorized into six Organizing Themes that were derived from the literature according to the researcher’s best understanding of the participant’s intent. The Organizing Themes utilized in this study are:

1. Disciplinary Literacy (DL): Communication (i.e., Modalities, genres, and discourse patterns authentic to science)
2. DL: Practices (e.g., SEPs authentic to the discipline)
3. DL: Conceptual Content Knowledge (e.g., DCIs/CCCs authentic to the discipline)
4. DL: Nature or Norms of the Discipline (e.g., NoS)
5. Real-World Application (e.g., Authentic to real world contexts)
6. Content Area Literacy (e.g., Utilizes the general skills of reading, writing, speaking, and listening as well as general comprehension strategies as a way to acquire content knowledge)

The final section of each case study identifies Global Themes for the teacher. These represent a synthesis of the trends seen through the full transcripts, Basic Codes, and Overall Themes and provide understanding about elementary teachers’ conceptions and enactment of disciplinary literacy in science as well as any interactions between these conceptions and enactment, which was the purpose of this study.

Case Study: Sally

Sally, a white female, graduated prior to 2012. She taught second and third grade before taking time off to be with her children. She then returned to the teaching profession and for the past eight years has been in a fifth-grade classroom where she is
responsible for the instruction of all content areas (e.g., ELA, mathematics, science, social studies).

**First Five Open-Ended Interview Questions**

To her, literacy is “whole encompassing language” meaning reading, writing, speaking, and listening, and text is “anything that you would read” with written words of any length. When considering science text, this changed to what you can read that is informational and related to science. This includes: science curricula, articles, experiments, student textbooks, websites, and teacher pay teacher sites. To her, science text also includes readings from literacy sources that have science content.

Additionally, when asked what being literate in science means, she responded that it means “you can read, write, speak, listen, and make observations and evaluations based on logical thinking and data that is displayed.” She also included the ability to ask questions, solve problems, and find solutions into her conceptions of being literate in science. To Sally, science connects to real life, is all around you, and involves all of your senses. Because science is part of real life, “literacy in science connects and integrates with other core subjects: Math, ELA, and social studies.” When asked how she uses literacy appropriate to science during instruction, Sally explained that effective instruction involves students reading from informational texts, including science textbooks, and then using this information in ways such as making charts, completing graphic organizers, playing games, or applying the information to authentic applications in the world around them as a way to gain content knowledge.

**Scenario Ratings and Rationale**
Overall, Sally rated scenarios higher than their designed ratings for disciplinary literacy in science (see Table 5). Her explanations for ratings focused around two major themes: Content area literacy ideas and integration, where content area literacy promotes literacy used in general ways to comprehend or gain knowledge, and integration means putting more than one content area together during instruction. In scenario 6, her rating rationale included the conception that students were reading, writing, and listening as part of instruction, so they were using “three components…for literacy” where the unused component in this equation was speaking. This referred back to her description of literacy in general. She also pointed out that students in this scenario were integrating science with the arts. This seems important because she stated that “I’m happy if I cross-connect two subjects.” Scenario 7, emphasized the fourth component of her definition of literacy, talking, as critical to her high rating. She explained, “I’ve shifted my whole thinking of teaching that I’m just not the only one talking, that students need a chance to talk to teach each other…turn and talk to [their] neighbor.”

Table 5

\begin{table}
\centering
\begin{tabular}{|c|c|c|c|c|c|}
\hline
 & Scenario 6 & Scenario 7 & Scenario 8 & Scenario 9 & Scenario 10 & Scenario 11 \\
\hline
Designed Rating Sally & 1-2 & 5-6 & 3-4 & 5-6 & 3-4 & 1-2 \\
\hline
Sally & 5 & 6 & 4.5 & 6 & 5 & 4 \\
\hline
\end{tabular}
\caption{Sally’s Ratings of Science Scenarios}
\end{table}

Sally’s explanation of scenarios 10 and 11 also demonstrated the themes of content area literacy and integration. She rated scenario 10 a five out of six because students were reading, drawing examples, putting information into a graphic organizer,
and writing a summary. However, she explained that “I didn’t give it a six because there weren’t a lot of you know crosscutting things…you know, connections to…other subjects.” Additionally, scenario 11 was rated four out of six because “students have to read in a readers’ theater, which is great…and they have to read with rate and expression.” She also included in her rationale that the rest of the students were acting as an audience by listening and putting information into a graphic organizer, which was good. All of these reasons pointed to utilizing general content area literacy skills and acquiring content knowledge through content area literacy means. Even her integration explanation was grounded in content area literacy with art being paired with science to promote reading prosody.

Despite her overall focus on content area literacy conceptions during explanations, at times undertones of disciplinary literacy conceptions surfaced. In scenario 7, she added comments about students comparing models with peers and the science text to then make revisions as reasons for her high rating. This showed evidence of utilizing three of the four components of disciplinary literacy: authentic communication, nature or norms of the discipline, and practices of the discipline. Additionally, in scenario 9, she discussed the importance of students having an inquiry question, researching from multiple sources, designing investigations, compiling findings, creating tables and graphs, and writing claims based on credible sources. This demonstrated identification of the disciplinary literacy components authentic communication, nature or norms of the discipline, and practices of the discipline. Though disciplinary literacy components were identified, there was no distinction made between
them and general literacy usage. Instead, both were just viewed as literacy that was effective for science instruction.

Overall, her ratings were based on a conception of literacy in elementary science that aligned with content area literacy notions where students use general literacy skills to comprehend and gain content knowledge. Additionally, integration was an important element in her rating rationales. However, disciplinary literacy ideas from three components (i.e., authentic communication in the discipline, nature or norms of the discipline, practices utilized within the discipline) were noted in her explanations when they occurred within scenarios. It makes sense that conceptual content knowledge was not a focus of Sally’s explanations as an emphasis of content area literacy is comprehending information for acquiring content knowledge. This tends to look like finding the right answer, which then is more factual knowledge.

**Basic Codes and Overall Themes**

**Interview.** For Sally, Table 6 depicts the same trends in the codes of the science scenario ratings as the complete text summary. The coding depicted a heavy emphasis on content area literacy for the purpose of developing general literacy skills and acquiring content knowledge as facts, not conceptual content knowledge. In scenario 6, Sally stated that she rated this scenario a five out of six because “I don’t like it when students read independently, especially if it’s about information that I really need them to know and grasp.” This section was coded Content Area Literacy and placed in the Overall Theme of Content Area Literacy.
Table 6

*Sally Coding for Interview: Science Scenarios*

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Science Text</td>
<td>Science Discourse</td>
<td>SEPs</td>
<td>NoS Student-Centered Instruction</td>
<td>Authentic Application</td>
<td>Content Area Literacy</td>
</tr>
</tbody>
</table>

However, glimpses of the other three disciplinary literacy components along with real-world application did emerge occasionally, which was also noted in the summary of the interview. For example, in scenario 6, Sally mentioned that students were obtaining information from “a section in a science textbook”. This was coded Science Text and was categorized in the DL: Communication Organizing Theme.

Additionally, the integration theme shows up again subsumed in the Content Area Literacy category. It was organized under this theme because it appeared the intention behind integration was to put different content areas together during instruction as an effective teaching practice and not to deepen science understanding. For example, in scenario 11, she explained, “I think that’s great, that at least there were two different things going on here, and that [students] were accountable and listening as part of that literature literacy thing, too.” In the text, this was coded as Integration and then categorized under the Content Area Literacy Organizing Theme.

Furthermore, the coding of teacher conceptions of appropriate literacy for science enactment also depicted a reliance on content area literacy as seen in Table 7. The
components of authentic communication through science text and science discourse as well as authentic science practices did appear; however, the predominance of codes in the text were gray for content area literacy.

**Table 7**

*Sally Coding for Interview: Conceptions of Enactment*

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</thead>
<tbody>
<tr>
<td>Science Text</td>
<td>SEPs</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Science Discourse</td>
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</tbody>
</table>

**Lesson Plans.** After completing the first two rounds of coding for lesson plans submitted by Sally, the theme of content area literacy as foundational for science instruction was again brought to the forefront (see Table 8). Specifically, introducing and building vocabulary and content knowledge was emphasized within the submitted plans. However, disciplinary literacy components were embedded into instruction at times. When the disciplinary literacy components were utilized, the instruction also shifted from teacher-centered to student-centered. For example, in Lesson Plan #1, the teacher asked, “What is Matter?” to which “students try to come up with a definition of matter (anything that takes up space and has mass)” after which students created a graphic organizer to record information they learned during instruction. This was a teacher-centered instructional example in which the focus was more aligned with content area literacy notions such as vocabulary and knowledge acquisition and use of graphic organizers to record information. Following this example was a more student-centered instructional strategy where students determined “what conclusions… [they could] draw from the
properties of matter” they had just identified in pictures as a way to generate student
definitions for the three states of matter (i.e., solid, liquid, gas). Students worked in pairs
to accomplish this task. In this example, students were developing conceptual content
knowledge and communicating in ways authentic to the discipline, which are both
disciplinary literacy components.

Table 8

Sally Coding for Lesson Plans

<table>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Discourse</td>
<td>DCIs/CCC's Student-Centered Instruction</td>
<td>NoS</td>
<td>Authentic Application</td>
<td>Content Knowledge Vocabulary Content Area Literacy Teacher-Centered Instruction Cookbook Lab</td>
<td></td>
</tr>
</tbody>
</table>

Additionally, since tasks seemed to be tailored to a content area literacy perspective, planned instruction did not contain tasks that were authentic to science. It is noteworthy that all three of the other disciplinary literacy components appeared in instructional plans occasionally while the practices of science were conspicuously absent. This, again, forwarded the participant conception of literacy in science through a content area literacy lens.

Observation (Actual Enactment). While Sally’s lesson plans seemed to focus predominately on content area literacy, when categorizing Basic Codes into the Organizing Themes for teacher enactment, the colors were approximately half for content
area literacy and half for disciplinary literacy. When Sally enacted teacher-centered instruction that included content area literacy notions from her lesson plans, many of them turned into student-centered instruction that included disciplinary literacy components. For example, the planned teacher-centered instruction on vocabulary and content knowledge acquisition did not actually occur. Rather, the planned student-centered instruction that followed the teacher-centered instruction was elaborated upon in greater detail with the focus being on student sensemaking. See the following excerpt from Sally’s observation transcript:

Teacher: What are some properties of matter?

We will be looking at some pictures to see what these pictures have in common. Six pictures. Look for similarities, differences. (Glass of water, table, balloons, cans of pop, tree, car tire)

What do they have in common? What are the characteristics or properties they have in common?

Students: Talk to neighbor: Talk about how the pictures are connected and what properties they have similarly. Ask an open-ended question to your neighbor.

Teacher: Properties of matter help to describe them (how they feel, their size, their color, shape, etc.). Write the specific properties you saw in the pictures.

Students: List properties of matter you saw in the pictures.

Students: Talk with elbow partner about what you put in your list, put a star by similar things in your list

Teacher: Properties of matter are kind of similar across objects. We are going to categorize them into three properties. What could they be?

Within this except, there was evidence of authentic communication (e.g., student discourse, authentic texts), conceptual content knowledge (e.g., DCIs and CCCs), nature or norms of the discipline (e.g., NoS), and practices utilized in the discipline (e.g., SEPs). This occurred in about half of the instruction throughout the three observations and is displayed in Table 9.
Table 9

*Sally Coding for Observations*

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Student Discourse</td>
<td>SEPs Student-</td>
<td>DCIs/CCCs</td>
<td>NoS</td>
<td>Authentic Application</td>
<td>Teacher-Centered</td>
</tr>
<tr>
<td>Student-Centered</td>
<td>Centered Instruction</td>
<td></td>
<td></td>
<td></td>
<td>Instruction</td>
</tr>
<tr>
<td>Instruction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Content Area Literacy</td>
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<td></td>
<td></td>
<td></td>
<td>Vocabulary</td>
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<td></td>
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<td></td>
<td>Content Knowledge</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Cookbook Lab</td>
</tr>
</tbody>
</table>

**Global Themes**

Analysis of the full transcription text along with analysis of the Basic Codes and Overall Themes for the interview, lesson plans, and observations showed some definite trends for Sally related to teacher conceptions and enactment of literacy appropriate for science instruction that translated into Global Themes.

1. **Content Area Literacy**: Instruction focused on supporting comprehension in a subject through applying generic literacy strategies. For example, Sally consistently pointed out the general literacy components of reading, writing, speaking, and listening during the interview. Additionally, strategies to comprehend information were both identified during the interview and employed in planning and enactment of the lesson plans such as: utilizing graphic organizers and developing vocabulary.

2. **Integration**: Teaching with at least two different content areas during the same instruction. For example, in her explanation of scenario 11 during the interview, Sally noted that it was good to focus on reading rate and expression during a
reader’s theater that contained science content. Additionally, during the observations, Sally focused on general reading and writing strategies as a way to gain content knowledge in science. While this is content area literacy, it also demonstrated a focus on integration of ELA and science.

**Case Summary: Charlotte**

Charlotte, a white female, graduated prior to 2012. She taught first, second, and fourth grade before teaching in fifth grade for 19 years. In total, she has taught for 29 years and has always been responsible for instruction of all content areas (e.g., ELA, mathematics, science, social studies).

**First Five Open-Ended Interview Questions**

To her, literacy is communication that is accomplished through reading, writing, speaking, and listening. Text is “anything that [is] read” and is in a “word format” such as textbooks, articles, and information on the internet. This was similar to her conception of science text, which is informational text that contains science concepts. Additionally, when asked what being literate in science means, she responded that it means a person could “look at data and interpret [it] and be able to apply that knowledge in different areas.” A person could also “read graphs and interpret those [and] any form of data.”

When it comes to students using literacy appropriate to science, Charlotte stated effective instruction involves students talking and interacting, reading information and applying it, notetaking, writing in journals, as well as speaking and listening.

**Scenario Ratings and Rationale**
Overall, Charlotte rated scenarios higher than their designed ratings for disciplinary literacy in science (see Table 10). Her explanations for ratings focused around two major themes: Content area literacy ideas and real-world application, where content area literacy promotes literacy used in general ways to communicate, and to comprehend or gain knowledge; and real-world application means making the content relevant to the students’ lives.

Table 10

*Charlotte’s Ratings of Science Scenarios*

<table>
<thead>
<tr>
<th>Scenario</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Designed Rating</td>
<td>1-2</td>
<td>5-6</td>
<td>3-4</td>
<td>5-6</td>
<td>3-4</td>
<td>1-2</td>
</tr>
<tr>
<td>Charlotte</td>
<td>5.5</td>
<td>5.5</td>
<td>2.5</td>
<td>5.5</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

For the content area literacy theme, her rating explanations for all six scenarios included significant mention of the general literacy skills reading, writing, speaking, and listening, which she identified as communication, along with strategies for comprehending information. In scenario 7, Charlotte explained that students were “talking about it…they’re using writing, they’re using reading, they’re using speech…they’re using all the all [sic] four of those components of literacy.” Additionally, in scenario 10 she stated, “the speaking is gone. So yeah, just probably reading, writing,…filling in their graphic organizer,…writ[ing] a summary” so “definitely the communication part is done”.

Charlotte also put a strong emphasis on real-world application. In four of the six scenario rating explanations, she pointed out that real-world application was not
occurring during instruction. In scenario 6, Charlotte assigned a rating of 5.5, which was high compared to the designed rating. However, the one aspect that lowered her rating was that she questioned, “where would the real-world application be?” Another scenario that Charlotte rated higher than the designed rating was scenario 11. Again, a major reservation she had with the scenario was that it was “missing the application part...how am I gonna [sic] make science relevant for my students?” And again, with scenario 8, she questioned, “I just don’t know the real-life application. Why do we need to know which planet is bigger than the other?”

Similar to Sally, there were components of disciplinary literacy running through Charlotte’s explanations. When a scenario was designed with components of disciplinary literacy, she identified these in her explanations for why she rated the scenarios high along with continuing to point out content area literacy ideas. In scenario 7, she commented about students using models to describe the functions of organelles and how these “help the whole organisms to function.” These descriptions added in the disciplinary literacy components of utilizing practices in the discipline and developing conceptual content knowledge. She also acknowledged students discussing their models with others and revising them based on this discussion. This added both the disciplinary literacy components of authentic communication and the nature or norms of the discipline. Additionally, in scenario 9, another scenario that was designed with a high level of disciplinary literacy, Charlotte noted that students were “design[ing] an investigation based on what they’ve learned to test a claim” as well as “making a claim…using credible sources of science.” These comments show the use of the disciplinary literacy components of authentic communication, conceptual content
knowledge, and utilizing the practices of the discipline. It could also be argued that the nature or norms of the discipline were inherent here because science is empirically based. Thus, though disciplinary literacy components were identified, there was no distinction made between them and general literacy usage. Both were viewed as literacy that was effective for science instruction, which, again, was similar to Sally’s explanations.

Overall, Charlotte’s ratings were founded on a conception of literacy in elementary science that aligned with content area literacy notions. Students were using reading, writing, speaking, and listening, general literacy skills, to comprehend and gain content knowledge. Additionally, real-world application was a critical factor in her rating rationales. While all four disciplinary literacy ideas (i.e., authentic communication in the discipline, conceptual content knowledge of the discipline, nature or norms of the discipline, practices utilized within the discipline) were identified and noted in her explanations of the scenarios, they were not distinguished from developing general literacy skills.

**Basic Codes and Overall Themes**

**Interview.** Table 11 displays the same trends in the codes of the science scenario ratings as were noted in the complete text where the coding depicted a heavy emphasis on content area literacy for the purpose of developing general literacy skills that are involved in general communication and acquiring content knowledge. Additionally, the real-world application theme showed up in the coding. Two of the codes that were expected to fall under disciplinary literacy components (i.e., SEPs and NoS) were also located under the Organizing Theme: Content Area Literacy because the interview referenced these in just a general way: as good for learning. In scenario 9, Charlotte talked about the practice of
investigations, but just in a generic way by saying, “that seems like a really good experiment or lesson to me.” And in scenario 6, a possible practice of science and norm of the discipline could be construed from her explanation “[students were] expressing their knowledge in a creative way.” However, this was in reference to students creating Haiku poems, which is not an authentic way scientists communicate or are creative as they carry out their work in the field.

**Table 11**

*Charlotte Coding for Interview: Science Scenarios*

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<tbody>
<tr>
<td>Communication</td>
<td>SEPs</td>
<td>DCIs/CCCs</td>
<td>Nos</td>
<td>Real-World Application</td>
<td>Communication SEPs NoS Content Area Literacy</td>
</tr>
<tr>
<td>Science Text</td>
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</tr>
</tbody>
</table>

Furthermore, the coding of teacher conceptions of appropriate literacy for science enactment also showed a propensity toward reliance on content area literacy as a way to gain content knowledge, as seen in Table 12. The code, Communication, was aligned to both content area literacy and disciplinary literacy because it was talked about in both the general way where students were reading, writing, speaking, and listening as well as a more discipline-specific way, where students were having discussions about a science concept. The components of authentic communication through science text as well as authentic science practices and conceptual content knowledge did appear at times, although color-coding of all basic codes in this section of the text continued to show a predominance of gray for content area literacy conceptions.
Table 12

Charlotte Coding for Interview: Conceptions of Enactment

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<tbody>
<tr>
<td>Communication</td>
<td>SEPs</td>
<td>DCIs/CCCs</td>
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<td>Communication</td>
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<tr>
<td>Science Text</td>
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<td>Content Area Literacy</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Content Knowledge</td>
</tr>
</tbody>
</table>

**Lesson Plans.** After completing the first two rounds of coding, the lesson plans submitted by Charlotte showed an emphasis on content area literacy and real-world application. It appeared that the first lesson plan was mainly developed by Charlotte. This lesson contained many content area literacy tasks, such as asking questions about vocabulary and reading informational text to gain the right answer that was coded as Content Knowledge. The second lesson plan was adapted from an online resource that aligned to the Next Generation Science Standards (NGSS Lead States, 2013). This instructional plan started with a phenomenon, which was coded as Real-World Application and instruction focused on implementing the SEPs, DCIs, and CCCs which are the three-dimensions of science identified in The Framework (NRC, 2012), as noted in Table 13. Additionally, this lesson plan contained what was coded as a Cookbook Lab due to the prescriptive step-by-step procedures delineated in the lesson plan.
Table 13

*Charlotte Coding for Lesson Plans*

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</tr>
</thead>
<tbody>
<tr>
<td>SEPs</td>
<td>DCIs/CCCs 3D Instruction</td>
<td>NoS</td>
<td></td>
<td>Real-World Application</td>
<td>Content Knowledge Content Area Literacy Cookbook Lab</td>
</tr>
</tbody>
</table>

The final lesson plan artifact was a lesson created by the Genetic Science Learning Center. This is a department at the University of Utah that develops lessons based on real-world contexts. Thus, the code Real-World Application and DCIs/CCCs applied to this lesson. It was also coded as a Cookbook Lab because it was written with step-by-step procedures.

From her lesson plan selection, it appeared that Charlotte was familiar with three-dimensional instruction given as the lesson plans contained these components as well as real-world application of science concepts. Table 13 displays all of these aspects, where the main conception of literacy appropriate for science was content area literacy. Indeed, about a third of the basic codes were organized under one Organizing Theme: Content Area Literacy.

**Observation (Actual Enactment).** While the second and third lesson plans that Charlotte submitted were written mostly from a three-dimensional perspective (i.e., SEPs, DCIs, CCCs) that incorporated three of the four components of disciplinary literacy (see Table 13), observations of the enacted lessons depicted split strategies between content
area literacy strategies that focused on basic literacy skills and content knowledge acquisition and disciplinary literacy components (see Table 14).

Table 14

*Charlotte Coding for Observations*

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</tr>
</thead>
<tbody>
<tr>
<td>Science Text Communication</td>
<td>SEPs</td>
<td>DCIs/CCCs SEPs 3D Instruction Content Knowledge</td>
<td>DCIs/CCCs Real-World Application</td>
<td>Content Knowledge Content Area Literacy Vocabulary</td>
<td></td>
</tr>
</tbody>
</table>

For example, the following excerpt depicted a stretch of the first observation that was very content area literacy centric:

Teacher: I have been looking at your loops and wondering what you guys made here.

Students: Answer one at a time (food chain)

Teacher: So, the sun is part of the food chain? What is a food chain?

Students: Answer one at a time

Teacher: I heard order, predator, humans are at the top, sun, plants, animals.

Teacher: When you get your packet, put your names on it.

Teacher: Let’s see in our packets if we come across some of the words you just said. Let’s read the definition of a food web: To understand how plants and animals interact, scientists make food webs. To show the relationships, we make food webs.

Teacher: Continues reading an article about food webs (choral reading)

Teacher: What did we learn?

Students: Answer one at a time

Teacher: Where does energy start? (sun). The energy comes from the sun. Where does it transfer? (Into the plants). The energy goes from the sun to the plants. The energy stops right there?

Students: Answer one at a time
Teacher: So, it goes from the sun to the plants to the herbivores. What are some herbivores?

Students: Answer one at a time

Teacher: So, the energy stopped at the herbivores?

This excerpt depicted a focus on vocabulary acquisition, content knowledge as facts acquisition, and reading for comprehension. It is possible that an argument could be made that there was some conceptual content knowledge also being gleaned through this scenario. However, it seemed the focus was on comprehension of the correct answers.

Contrast this with an excerpt from the second observation:

Posted Objective: Obtain, evaluate, and communicate information that animals obtain energy and matter from the food they eat.

Teacher: Your section in your science journal is about ecosystems. How does the objective have to do with ecosystems?

Students: Answer one at a time.

Teacher: What is an ecosystem?

Students: Answer one at a time.

Teacher: What do you find in habitats? (animals)

Teacher: If animals are there, there must also be food because animals need food.

Picture of a student eating spaghetti.

Teacher: We talked about that humans are animals. Do we need to eat food?

Slide: Think about what you last ate.

Work as a group to come up with a list of food items.

Teacher: Everyone gets a strip of paper. Write your name on it. Then, make a loop. Second strip of paper, write one thing that you ate for lunch today. Join loops into a chain.

Teacher: Think about what plant or animal, specifically, your food came from. Write that on the green loop. Join it to your chain.

Teacher: Today I had steak. Steak would go on my orange [loop]. On my green [loop], I would put cow.

Teacher: If I am a cow, what do I eat? (grass) Does a plant eat anything? (no)
If you have an animal, you need another loop to put what the animal eats.

While there still seemed to be some focus on vocabulary, this excerpt appeared more focused on conceptual content knowledge and students developing a model, which are both components of disciplinary literacy.

Although there was a focus on content area literacy with components of disciplinary literacy throughout the observations, the reliance on teacher-centered instruction was apparent in both excerpts, with the teacher being in charge of the sensemaking. The students were not utilizing authentic practices of science to promote their own sensemaking or participating in the nature or norms of the discipline (e.g., questioning, observing, empirical evidence, peer reviews) as a general rule. Thus, while this observation excerpt contained aspects of disciplinary literacy, there seemed to be more of a content area literacy type of situation occurring, where the goal of instruction was for students to acquire content knowledge. Additionally, the theme of real-world application, which was discussed previously as a trend for Charlotte, was very evident in this part of the observation.

**Global Themes**

Analysis of the full transcription text along with analysis of the Basic Codes and Overall Themes for the interview, lesson plans, and observations again showed some distinct trends for Charlotte related to teacher conceptions and enactment of literacy appropriate for science instruction. These patterns were synthesized into the following Global Themes:
1. **Content Area Literacy:** Instruction focused on supporting comprehension in a subject through applying generic literacy strategies. For example, Charlotte consistently pointed out the general literacy components of reading, writing, speaking, and listening during the interview. Additionally, strategies to comprehend information were identified during the interview, lesson plans, and observations. These strategies included: developing vocabulary and gaining content knowledge.

2. **Real-World Application:** Instruction was relevant to the students’ lives. For example, in the second observation, Charlotte had students think about how a food chain related to what they ate for lunch.

**Comparison of Sally’s and Charlotte’s Case Study: Graduation Prior to 2012**

Both Sally and Charlotte, graduated from their teacher preparation programs prior to 2012. This may be important because new research for science instruction, The Framework (NRC, 2012) was released after they graduated. As was already delineated, the shifts to science instruction recommended by this research have direct correlations to three of the four disciplinary literacy components: authentic communication within the discipline, conceptual content knowledge of the discipline, and practices utilized within the discipline. Because these two teachers were already graduated at the time this research was released, they did not have the possibility of studying this research as part of their preservice training. Additionally, both of these teachers listed that they have had minimal professional development opportunities regarding the new SEEd Standards (USBE, 2019), which were developed based on this research. This may be a telling factor in how these two teachers viewed literacy appropriate for science instruction.
**Similarities Between the Two Cases**

Sally and Charlotte both had Content Area Literacy as one of their two Global Themes because both appeared to predominately view instruction from a foundational content area literacy conception. Additionally, both of them had the conception that literacy entails reading, writing, speaking, and listening and effective instruction in science focuses on developing these general literacy skills.

When considering their conceptions of text, both stated that text is anything you could read that has words. The difference between text, in general, and science texts is that science texts are informational texts with a science content. This, too, is a very content area literacy conception.

When providing rationales about their science scenario ratings, both Sally and Charlotte identified disciplinary literacy components within the scenarios as effective literacy for science. However, neither of them distinguished general content area literacy skills (e.g., basic literacy development of reading, writing, speaking, listening) and strategies to support reading comprehension (e.g., using graphic organizers, writing summaries) from disciplinary literacy components (e.g., communication appropriate for science, developing conceptual content knowledge, utilizing practices authentic to the field).

During enactment of science instruction, both Sally and Charlotte used teacher-centered instruction that relied upon the teacher as the sense maker, with Charlotte utilizing this teaching strategy more often than Sally. This method of instruction is also prevalent in content area literacy, where the teacher initiates and directs strategies that help students gain content knowledge.
Differences Between the Two Cases

While both Sally and Charlotte had the Global Theme of Content Area Literacy, their second Global Theme was different. Sally tended to focus on the conception that integration promoted better instruction in science and supported literacy in science as evidence in her scenario explanations that espoused using literacy not authentic to science (e.g., reader’s theaters, writing poems, promoting reading for rate and fluency). Charlotte’s second Global Theme was Real World Application, instruction relevant to students’ lives, which was displayed in her enactment of science instruction and also in her explanations of scenarios. For scenarios 6 and 11, which utilized integration as a means to promote literacy in non-authentic ways, Charlotte stated that these would be fun for students, but they also created a tension for her because these scenarios did not utilize real-world application. Although this was not a Global Theme for Sally, she did explicitly connect the science to students’ lives during instruction.

Sally and Charlotte also differed in their conceptions of what being literate in science entailed. For example, Sally’s conception of disciplinary literacy included general literacy notions (i.e., reading, writing, speaking, and listening), nature of science ideas (e.g., observations, logical thinking, formulating questions), making “real life connections”, and integrating and connecting science with other subjects. While these ideas aligned to her Global Themes, the nature of science and real-world connection ideas she delineated had minimal prioritization in her interview, lesson plans, and observation artifacts.

Charlotte’s conception of literacy appropriate for science was very different in that she did not discuss general literacy, despite her emphasis on this throughout the
remainder of the interview, lesson plans, and observations. Instead, she focused on using the practices of science (e.g., analyzing and interpreting data, reading graphs) and applying conceptual content knowledge. However, her data did not show a trend toward either of these ideas throughout the rest of the collected artifacts.

**Case Summary: Jack**

Jack, a white male, graduated in 2022. He was an intern for one year prior to graduating, which means he was the teacher of record for a classroom while he completed his final year in a teacher preparation program. As an intern, he had a mentor to support him both from the university teacher preparation program and from the school. Currently, he is in his first full year of teaching as a certified teacher. Both years he has been in fifth grade, and he has always been responsible for the instruction of all content areas (e.g., ELA, mathematics, science, social studies).

**First Five Open-Ended Interview Questions**

Jack initially conceived of literacy as reading and writing. However, after thinking for a minute, he explained, “I think that it has to do with, like, communication application and the transfer of ideas, and the way that we do that as humans.” That prompted him to add “audio” to his conception of literacy, which seemed like he was adding the speaking and listening components to literacy. His explanation of literacy then developed to include “being able to communicate and receive ideas.” To Jack, texts include “basically the information you’re consuming…generally written.” However, he explained that text could also be in video, audio, or picture form. Overall, though, to Jack text refers to written words. For texts that are used in science, he refers to them as “long and dense informational texts [or] documentary style videos.”
As for what it means to be literate in science, Jack explained this as being “able to understand what people are talking about when they’re talking about science.” He inferred that being literate in science included content knowledge. Additionally, he inserted the idea that being literate in science encompassed “understand[ing] common science language…so things like hypothesis and experimentation, and words like that.” Again, this leaned toward understanding science knowledge. He further explained that “understanding means…[to] know what a word means, or a concept means when somebody talks about it to you, and to be able to use it in talking to someone else.” This idea is related to the disciplinary literacy notions of authentic communication in science and conceptual content knowledge.

Jack explained that effective science classroom instruction includes “the integration between, like, literacy skills and science.” Both of these are separate, with literacy being general skills “just like comprehension, or writing…things like that” that students should develop “in association with or yah, at the same time as science skills”, so students are “confident in the field of science.” During science instruction students could, therefore, complete tasks such as “reading an article and talking about it… asking and answering questions…designing an experiment…[or] creating an argument.” Jack viewed instruction of literacy appropriate for science as a combination of content area literacy instruction and disciplinary literacy instruction, which aligned with his description of a person who is literate in science.

**Scenario Ratings and Rationale**

Overall, Jack rated scenarios consistent with the designed ratings with two exceptions: scenario 8, a moderate disciplinary literacy example, and scenario 11, a low
disciplinary literacy example. These he rated slightly higher than the designed ratings (see Table 15).

Table 15

<table>
<thead>
<tr>
<th>Scenario 6</th>
<th>Scenario 7</th>
<th>Scenario 8</th>
<th>Scenario 9</th>
<th>Scenario 10</th>
<th>Scenario 11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Designed Rating</td>
<td>1-2</td>
<td>5-6</td>
<td>3-4</td>
<td>5-6</td>
<td>3-4</td>
</tr>
<tr>
<td>Jack Rating</td>
<td>2</td>
<td>6</td>
<td>5</td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>

Throughout all of Jack’s science scenario rating explanations, a major theme developed: Disciplinary Literacy, which means using the components of disciplinary literacy to help students become literate in science in ways that scientists are literate in science as they work in the field. For example, in scenario 11, Jack reasoned that while he personally could see himself doing a reader’s theater with students, “it’s not [a] very, very scientific example of literacy” meaning that was not how scientists actually work in the field. Additionally, in scenario 8, he included the caveat that he thought students were using literacy authentic to science because they were researching and citing that research. Thus, he assumed that writing a claim also included the notion that students were researching and citing evidence to support their claim. This pointed to the disciplinary literacy component of utilizing practices authentic to the discipline (i.e., engaging in argument from evidence) instead of just the generic notion of writing a claim.

In scenario 7, he stated his rating of a six out of six was because the instruction started with a scientific question. Then, students were making observations, working with peers, generating and revising models, and writing explanations. In other words, students were working in “a scientific setting” as scientists do because “scientists are literate
people.” Jack’s explanation demonstrated a regard for all of the disciplinary literacy components: authentic communication (e.g., students were creating authentic modalities and genres of text as well as engaging in science discourse), gaining conceptual content knowledge (e.g., students were making sense of the function of organelles through modeling, researching, and peer collaboration), nature or norms of the discipline (e.g., instruction included investigating a scientific question, making observations, working with peers), and utilizing practices authentic to the discipline (e.g., students were developing models and constructing explanations).

Additionally, Jack rated scenario 9 a five out of six and his reasons included that instruction started with a question and students “[wrote] a claim, and that claim [was] based on credible sources of text, science text.” Then, students developed and conducted an investigation, compiled findings, displayed the finding in a graph, and wrote an argument. All of these things Jack explained were “part of literacy and science.” Through this explanation, Jack delineated the following disciplinary literacy components: authentic communication (e.g., students were using and creating text genres and modalities appropriate to science), conceptual content knowledge (e.g., students were researching a topic to create a claim and conducting an investigation to make sense of the science concepts within their claims), nature or norms of science (e.g., students were conducting scientific investigations based on questions and drawing conclusions from empirical evidence), and utilizing the practices of science (e.g., students were planning and carrying out investigations and engaging in argument from evidence).

Furthermore, Jack pointed out in scenario 10 both disciplinary literacy components and content area literacy components. For example, he started his rating
explanation by stating, “I think that the students in this example [were] getting some value, valuable content knowledge. I’m not sure if it’s necessarily helping them become literate scientists.” His reasoning included, “I’m not sure the examples of literacy [in this scenario] [were] that close to what an actual scientist would be doing if an actual scientist was studying paramecium, algae, and stuff.” He discussed that drawing an example was different than developing a model. Also, he stated that a concept web graphic organizer seemed more likely to promote students “memoriz[ing] the content [rather] than as scientists would do to make discoveries.” Additionally, “reading a science text and then writing a summary of that text” was not something scientists do as they conduct their work in the field. Within this explanation, Jack clearly delineated components of content area literacy such as reading to get information, filling out graphic organizers, and writing summaries of the information from the text. He contrasted these uses of literacy with disciplinary literacy components such as authentic communication in science (e.g., using the discourse of science through citing appropriate sources) and utilizing practices of the discipline (e.g., developing and using models).

Even for examples that were designed with low levels of disciplinary literacy, Jack noted why these were not examples of literacy appropriate for science using disciplinary literacy components as justification. In scenario 6, which he rated as a two, he explained that writing poetry and creating with watercolors were not “generally what scientists do when they’re studying” the world around them. Thus, he was reasoning using the disciplinary literacy component of authentic communication or using genres appropriate for science. Additionally, for this scenario, he further explained that writing a poem was not something that a scientist would do. Rather, a scientist would “write an
explanation.” Thus, he was justifying his low rating of a two for this scenario using the disciplinary literacy component of utilizing practices authentic to the discipline (i.e., constructing explanations).

**Basic Codes and Overall Themes**

**Interview.** For Jack, coding of the scenario text depicted the same trends as were noted in the complete text (see Table 16). For example, a couple of the major Basic Codes utilized in coding were Disciplinary Literacy (e.g., how literacy was used in the discipline of science) and Not Disciplinary Literacy (e.g., not authentic to the work of scientists). These codes were used when Jack wanted to clearly point out that either what was happening during instruction was authentic to science or was not. For example, a Not Disciplinary Literacy coding from scenario 11 was, “like the KWL chart…I think those are helpful, for like comprehension and fluency, which are important literacy skills that I guess scientists may need to have, but I don’t know if those methods, in themselves, [are] very authentic to the field of science.” On the other hand, an example of text coded as Disciplinary Literacy read, “I think a model would be more scientific [than drawing a picture].”

**Table 16**

*Jack Coding for Interview: Science Scenarios*

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<tbody>
<tr>
<td>Not DL Integration</td>
<td>SEPs DL</td>
<td>DCIs/CCCs</td>
<td>NoS</td>
<td>Not DL Member of the Discipline DL</td>
<td>Integration Not DL Content Area Literacy</td>
</tr>
<tr>
<td>SEP Discourse DL Science Text</td>
<td>Not DL</td>
<td></td>
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Jack also included ideas of integration into his explanations. These again were discussed through the lens of when integration aligned with disciplinary literacy and when it did not. For example, when using computers to draw models in scenario 7, Jack explained “there’s use of computers, which is some integration…computer integration in this sense, or in this instance, makes a lot of sense.” However, when integration was utilized in scenario 6, he had a different view of integration as depicted here: “Integration of, like, art and stuff, that didn’t really make sense, too much sense to me.”

Additionally, Jack pointed out authentic uses of disciplinary literacy in scenarios. The Basic Codes that contained these ideas were categorized under the Organizing Themes. For example, some of the phrases used to create the Basic Codes for each Organizing Theme were: Students were “discussing their claim” and “they use[ed] a graph” (i.e., DL: Communication); “[students came] up with a claim, and then an argument…yeah, they [had] to support it” (i.e., DL: Practices); students needed “concept knowledge” (i.e., DL: Conceptual Content Knowledge); and “it start[ed] with the question, which I think [was] very scientific” and students were “observing” and “researching” (i.e., DL: Nature or Norms of the Discipline).

In contrast, when coding the interview for Jack’s conceptions of enactment for literacy appropriate in science, there was less of an emphasis on disciplinary literacy components and more of a focus on content area literacy development. This is depicted in the graphic of the Basic Codes and Organizing Themes as shown in Table 17. For example, Jack explained that in his instruction students would be “reading an article and talking about it” as well as maybe “asking and answering questions.” These conceptions of literacy were much vaguer and more general than what he described in his
explanations to the science scenarios and seemed to connote a more content area literacy focus.

Table 17

*Jack Coding for Interview: Conceptions of Enactment*

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<tbody>
<tr>
<td>SEPs</td>
<td></td>
<td></td>
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<td></td>
<td>Content Area Literacy</td>
</tr>
</tbody>
</table>

**Lesson Plans.** After completing the first two rounds of coding, the lesson plans submitted by Jack showed less of an emphasis on the disciplinary literacy components and more of an alignment to content area literacy (see Table 18). In fact, almost all of the Basic Codes related to the Organizing Theme: Content Area Literacy. Jack focused on students gaining content knowledge through building vocabulary and cookbook labs (e.g., step-by-step procedures prescribed for investigations). This occurred through teacher-centered instruction where the teacher was doing the sensemaking as seen in the following lesson plan excerpt:

- Teach the vocabulary: clay, silt, sand, gravel, pebbles, and humus. Point out each of these in the vials.

- Ask students again what soil is made of. This time they should answer that it is made up of sediments, or pieces of weathered rock, and humus (waste from living things).
Table 18

*Jack Coding for Lesson Plans*

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<tbody>
<tr>
<td>Discourse</td>
<td></td>
<td>NoS</td>
<td></td>
<td></td>
<td>Content Knowledge Cookbook Lab Teacher-Centered Instruction Vocabulary Content Area Literacy</td>
</tr>
</tbody>
</table>

**Observation (Actual Enactment).** When observing Jack, the same pattern occurred as in the lesson plans. Jack focused on content area literacy using teacher-centered instruction for the majority of the three observations. This shows up in the Organizing Themes (see Table 19).

Table 19

*Jack Coding for Observations*

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<tbody>
<tr>
<td>Discourse</td>
<td>SEPs</td>
<td>DCIs/CCCs</td>
<td>NoS</td>
<td></td>
<td>Content Area Literacy Integration Content Knowledge Teacher-Centered Instruction Vocabulary Cookbook Lab Integration</td>
</tr>
</tbody>
</table>
For example, the following excerpt from Observation #3 depicted this focus on content area literacy:

Teacher: Reads out loud a text on Weathering and Erosion: Glaciers.
Students: Follow along with reading
Students: Continue reading the text in pairs and answer comprehension questions on a Reading Response question page:

1. What is the author’s purpose for writing this article?
2. What is the difference between mechanical and chemical weathering?
3. Explain how caves are formed.
4. How does a glacier provide both weathering and erosion?
5. If you hear that sediment was carried by the stream down to the valley, which is this? Weathering or erosion?

Teacher: Asks students the answer to question #1.
Students: Answer the questions one at a time.
Teacher: Remember there are three reasons an author writes: Persuade, inform, entertain.
Teacher: Fills out the answer on the overhead to question #1. (To inform us about weathering and erosion)
Teacher: What is the answer to question #2?
Students: Answer one at a time.
Teacher: Writes answer (mechanical weathering is when it physically weathers). What is a synonym for weathering?
Teacher: Chemical weathering is when chemicals break down the rock.
Teacher: What is the answer to question #5.
Students: Answer one at a time.
Teacher: Writes answer (Erosion).
Teacher: What is the answer to question #4?
Students: Answer one at a time.
Teacher: Writes answer (When water mixes with CO2).
Teacher: What is the answer to question #5?
Students: Answer one at a time.
Teacher: Let’s look at this part in the article.
Teacher: Points to the answer in the article and writes the answer (It scrapes rocks and moves the pieces).
During instruction, Jack facilitated sensemaking through teacher-centered instructional strategies. The focus was on students acquiring knowledge through vocabulary building and comprehension strategies. The main purposes for this lesson were building general literacy skills and gaining content knowledge in the form of facts about science.

**Global Themes**

Turning the Basic Codes and Organizing Themes into Global Themes for Jack was a bit challenging. There seemed to be two different versions of his conceptions about literacy appropriate for science. During the scenario rating portion of the interview, the components of disciplinary literacy were the main observable pattern. However, the rest of the interview, the lesson plan artifacts, and the observations depicted a heavy focus on content area literacy. Therefore, both themes were represented as Global Themes.

1. **Disciplinary Literacy**: Instruction used the components of disciplinary literacy to help students become literate in science in ways that scientists are literate in science as they work in the field.

2. **Content Area Literacy**: Instruction focused on building content knowledge through applying generic literacy strategies such as vocabulary acquisition and reading comprehension.

**Case Summary: Jenna**

Jenna, a white female, graduated after 2012. She taught third grade for four years and is in her second-year teaching fifth grade. During this time, she has always been responsible for the instruction of all content areas (e.g., ELA, mathematics, science, social studies).
First Five Open-Ended Interview Questions

To Jenna, literacy is reading any text that children can read, and text is anything that has written words and could occur in different genres such as: books, published papers, and articles. Also, text could be from different sources, like the internet, “teachers pay teachers, or things that other teachers have created.” Science texts are “mostly books and research papers” with science content. These include published science curriculum. Additionally, when asked what being literate in science means, she responded that it means you have conducted research on a science topic and have extensive knowledge about that topic. She stated, “I don’t think you can be just like a teacher and be literate in science, like, unless that’s your specialty…I don’t think I’m literate in science because I teach what I read…I don’t consider myself an expert in science.” This seemed to depict that being literate in science means having deep content knowledge, beyond what an average person may possess.

When it came to students using literacy appropriate to science during instruction, Jenna explained her science included a lot of experiments, and she “tend[ed] to do literacy…maybe in a pre-lesson.” “I’m not really using a lot of literacy with science. I use [literacy], like, when I do centers during ELA time two days a week. I feel like centers gives you a lot of extra [time] where you can fit things in.” For centers, Jenna said she had students “do things on Readworks and A to Z Reading” where students were reading, and the text content included science content. It appeared that Jenna’s conception of literacy appropriate for science was really general literacy that was developed outside of science instruction but where texts included science content.

Scenario Ratings and Rationale
Overall, Jenna rated scenarios 6, 7, and 9 the same as the designed ratings (see Table 20). Both scenarios 7 and 9 were the ones developed with high levels of disciplinary literacy. Scenarios 8, 10, and 11, she rated higher than their designed ratings for disciplinary literacy in science. Scenarios 8 and 10 were both designed to be scenarios with some content area literacy and some disciplinary literacy components. Thus, they were developed as moderate disciplinary literacy scenarios. Again, her explanations for ratings seemed focused around two major themes: content area literacy ideas and science content knowledge, where content area literacy promoted literacy used in general ways to comprehend or gain knowledge; and content knowledge means having knowledge about a topic that you could access.

**Table 20**

_Jenna’s Ratings of Science Scenarios_

<table>
<thead>
<tr>
<th>Scenario</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Designed Rating Jenna</td>
<td>2</td>
<td>5</td>
<td>4.5</td>
<td>6</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Designed Rating</td>
<td>1-2</td>
<td>5-6</td>
<td>3-4</td>
<td>5-6</td>
<td>3-4</td>
<td>1-2</td>
</tr>
</tbody>
</table>

For the content area literacy theme, her rating explanations for three of the six scenarios included significant mention of content area literacy skills being an effective way to develop literacy in science. For example, Jenna explained in scenario 7 that she would rate the scenario higher if instead of students observing a video of a euglena, drawing a model including its organelles and their functions, and then working in partners to compare models to each other and with a textbook, students would read the textbook, watch the video “and then without the book [draw the model to] see what they remember.” Furthermore, she stressed that this change to the instructional flow would
show students were developing “listening comprehension.” This explanation displayed a conception of content area literacy where reading and listening were utilized to comprehend and gain content knowledge as facts in comparison to students utilizing disciplinary literacy components such as authentic communication, nature or norms of the discipline, and science practices to gain conceptual content knowledge.

Additionally, Jenna explained in scenario 10 that her high rating of a five out of six was because students were reading their science text and recording information in a graphic organizer. She stated, “so yeah, I, like, still recording information in a [graphic organizer] because they’re studying text structures” in class. However, she also explained that “I would almost prefer, I think you know, reading something to introduce [students to the information] …then, after completing the observation.” Furthermore, she continued, “I love that students record information in a concept web graphic organizer because they are studying text structures as a way to improve comprehension. I think that’s, you know, brilliant.” This explanation again demonstrated a clear conception of literacy in science as content area literacy, which promotes comprehending or acquiring content knowledge about science.

The third time where Jenna’s explanations demonstrated a conception of content area literacy was scenario 11. She explained her rating of five out of six was because students were “reading this reader, which is good, and it’s probably factual…then some of them are doing the KWL graphic organizer. So, I love that because then they’re also doing listening comprehension.” This explanation clearly described content area literacy strategies such as reading, utilizing graphic organizers, and focusing on listening comprehension as ways to acquire knowledge.
Additionally, Jenna rated scenario 7 highly, despite the fact that it was designed utilizing content area literacy strategies, not disciplinary literacy components. For example, she noted that students were “observing a video…they’re drawing a model…they’re labeling it,…then, they’re reading the textbooks.” She also elaborated by saying “the science textbook is literacy, and then what they’re actually labeling, that’s literacy.” She also discussed the importance of listening comprehension, which is a content area literacy idea. It seemed her conceptions of literacy still focused on content area literacy notions. She did not note any of the components of disciplinary literacy found in this scenario such as nature or norms of the discipline, creating text authentic to the discipline, or utilizing the practices of science. Rather, she focused on content area literacy conceptions.

However, in scenario 9, which was a scenario designed using disciplinary literacy components, Jenna explained that “I love this one. Yeah, I think this one’s a six, right, because right away they’re using literacy.” While she did mention disciplinary literacy notions aligned with using science practices, such as engaging in argument from evidence and carrying out investigations, she discussed them from a content area literacy perspective. For example, she stated, students were “given an assignment. What do living organisms need to survive?” Instead of discussing this as a scientific question to investigate, it was viewed as an assignment to complete through researching. Additionally, she explained students used this information to write “a claim based on the information.” This was also using content area literacy language instead of disciplinary literacy language, which would incorporate notions of engaging in argument from evidence.
The second theme of content knowledge, meaning having knowledge about a topic that you can access, was less obvious, but still evident throughout her explanations. In scenario 8, she expressed concern that “I don’t know what knowledge space they have before, like, I don’t… I don’t [sic] know if they know anything about celestial objects, or [sic] if not so, if they know something about it, then to me, it makes sense.” In this situation, Jenna was concerned that students didn’t have access to the content knowledge they needed to complete the task asked of them. It was not about sensemaking to gain conceptual knowledge. Her explanation was about accessing and using content knowledge. Additionally, this was also noted in scenario 10 where Jenna explained, “I feel like that, again, I kind of have to wonder about how much their previous knowledge [was].” She then continued to explain that by reading text to gain information students would have enough information or content knowledge to make observations of the euglena in the video they were watching. This was in contrast to students sensemaking through observations as a way to gain conceptual understanding.

Overall, Jenna’s ratings were founded on a conception of literacy in elementary science that aligned with content area literacy notions. Students were using reading, writing, and listening, which are general literacy skills, to comprehend and gain content knowledge. Additionally, content knowledge was about having access to knowledge on a topic that you could utilize. This was consistent with her description of being literate in science, which implied that a person had extensive content knowledge about a topic.

**Basic Codes and Overall Themes**

**Interview.** For Jenna, Table 21 depicts the same trends in the codes of the science scenario ratings as was noted in the complete text. The coding depicted a heavy emphasis
on content area literacy for the purpose of developing general literacy skills and acquiring content knowledge.

**Table 21**

*Jenna Coding for Interview: Science Scenarios*

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Science Text</td>
<td>SEPs</td>
<td>DCIs/CCCs</td>
<td>NoS Sensemaking</td>
<td>Content Area Literacy</td>
<td>Not DL Content Knowledge</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Text Integration</td>
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</table>

The Basic Code, Content Knowledge, which was identified as a focus of the scenario ratings, was placed under the Organizing Theme, Content Area Literacy because Jenna discussed content knowledge from the perspective of acquiring facts that you could utilize about a topic. In scenario 11, Jenna’s explanation for the task of reading a reader’s theater was, “So then [students] are reading this reader, which is good, and…it’s probably factual. So, a lot of readers’ theaters, you know, are fun.” In this explanation, Jenna’s comments seemed to imply the importance of gaining factual knowledge through reading the readers’ theater.

Integration also emerged as a Basic Code through the coding process. This was additionally organized under the Organizing Theme, Content Area Literacy, because the intent was for general literacy and science to be used together. Jenna rated scenario 11 as a five out of six because “I think it’s a really good way to bring science and literacy together,” suggesting that using the readers’ theater and KWL graphic organizer to
support science instruction were both content area literacy strategies. Similarly, in scenario 10, she cited “that's a really good way to blend the two, you know” meaning that the integration of ELA through content area literacy strategies to gain knowledge in science was effective instruction.

Furthermore, the coding of teacher conceptions of appropriate literacy for science enactment also showed a reliance on content area literacy as seen in Table 22. During the interview, Jenna maintained that she does not use literacy during science, per se. Instead, she uses science content in texts during centers to support literacy acquisition.

Table 22

*Jenna Coding for Interview: Conceptions of Enactment*

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<tbody>
<tr>
<td>SEPs</td>
<td></td>
<td>Not Literacy</td>
<td></td>
<td></td>
<td>Content Area Literacy</td>
</tr>
</tbody>
</table>

**Lesson Plans.** After completing the first two rounds of coding, the lesson plans submitted by Jenna really confirmed her focus on content area literacy (see Table 23).

Table 23

*Jenna Coding for Lesson Plans*

<table>
<thead>
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<tr>
<td></td>
<td></td>
<td>NoS</td>
<td></td>
<td></td>
<td>Content Knowledge Cookbook Lab Vocabulary Teacher-Centered Instruction</td>
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</table>
New codes that emerged for the lesson plans were organized under the Organizing Theme, Content Area Literacy, because the focus of the lessons was acquiring content knowledge as discrete pieces of information. This can be seen in the following excerpt from Lesson Plan #2:

Review yesterday - what did we learn about matter
Review definitions
Mass, volume, and density lab

Pre-lab Questions:
1.) What is mass?
2.) What instrument (tool) is used to measure the mass of an object?

3.) What is the standard unit for mass in the SI (Metric) system of measurement?
4.) What is volume?
5.) What instrument (tool) is used to measure the volume of a solid object?
6.) What is density?
7.) What two things must you know in order to calculate the density of any substance?

In this excerpt, there was an emphasis on vocabulary acquisition through teacher-centered facilitation. Also, the designed focus of instruction appeared to be accessing content knowledge that would then be utilized in a cookbook lab.

Observation (Actual Enactment). The coding for Jenna’s observations indicated a heavy emphasis on content area literacy (see Table 24). Also, the code Real-World Application and NoS appeared in the first observation. In this lesson, Jenna used a lesson from district resources, SEEEd Storylines (Davis School District, n.d.), which included a
PowerPoint to follow along with the instruction. Additionally, all lessons from this resource start with a phenomenon, real-world scenario, where the science concept is utilized. Students are instructed to make observations about the phenomenon and generate questions about why the phenomenon occurred. The instruction, then, provides tasks that help students to make sense of what is occurring in the phenomenon. Because Jenna followed the PowerPoint, real-world application and NoS were built into the instruction and appeared in this observation but not in the other two observations. The other two observations were heavily focused on content area literacy conceptions as denoted by the Basic Codes: Content Knowledge, Teacher-Centered Instruction, Vocabulary, and Cookbook Lab.

**Table 24**

*Jenna Coding for Observations*

<table>
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<tr>
<td></td>
<td></td>
<td>NoS</td>
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<tr>
<td></td>
<td></td>
<td>Authentic Application</td>
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**Global Themes**

Analysis of the full transcription text along with analysis of the Basic Codes and Overall Themes for the interview, lesson plan artifacts, and observations depicted distinct trends for Jenna related to teacher conceptions and enactment of literacy appropriate for science instruction. These patterns were synthesized into the following Global Themes:
1. **Content Area Literacy**: Instruction focused on gaining content knowledge through applying generic literacy strategies.

2. **Content Knowledge Acquisition**: Instruction focused on acquiring content knowledge about a topic.

**Comparison of Jack’s and Jenna’s Case Study: Graduation After 2012**

Both Jack and Jenna, graduated from their teacher preparation programs after 2012. This may be important because as was previously discussed, new research for science instruction, The Framework (NRC, 2012) was released before they graduated. As was delineated, the shifts to science instruction recommended by this research have direct correlations to three of the four disciplinary literacy components: authentic communication within the discipline, conceptual content knowledge of the discipline, and practices utilized within the discipline. Since these two teachers graduated after this research was released, they may have had the possibility of studying this research as part of their preservice training. Additionally, both of these teachers indicated that they had minimal professional development opportunities regarding the new SEEd Standards (USBE, 2019). Thus, if there were differences in how they viewed and used literacy in science it may have been because of their preservice experience. This section compares how these two teachers conceived of and actually enacted science instruction.

**Similarities Between the Two Cases**

Jack and Jenna both have Content Area Literacy as one of their two Global Themes. This theme did not appear as part of Jack’s scenario rating explanations. However, it was evident in his conceptions of enactment of science instruction, lesson
plan artifacts, and actual enactment of science instruction. For Jenna, this theme was consistent throughout all of the interviews, lesson plans, and observations.

An additional similarity between the two case studies was their conception of text as written words. Neither teacher seemed to really consider that text included different modalities (e.g., graphs, tables, symbols) and different genres (e.g., articles, textbooks, blogs, science notebooks, fieldnotes), which are all characteristics of science text.

**Differences Between the Two Cases**

While both Jack and Jenna had Content Area Literacy as a Global Theme, their second Global Theme was different. During the interview when Jack explained his ratings for the scenarios, he emphasized disciplinary literacy ideas such, ‘this was how scientists work in the field’ or ‘this was not how scientists not work in the field.’ For this reason, his second Global Theme was Disciplinary Literacy. Jenna’s second Global Theme was Content Knowledge Acquisition because of her belief that good instruction supported students gaining content knowledge as facts that can be recalled.

These differences in rating the scenarios were evident in Jack’s and Jenna’s explanations for their ratings of scenarios 10 and 11. For example, in scenario 10, Jack rated the scenario a three. His reasoning was that the instruction used graphic organizers and writing summaries, which are not how scientists work in the field. He explained, “I’m not sure the examples of literacy are that close to what an actual scientist would be doing.” In contrast, Jenna rated this scenario as a five out of six. She liked the use of graphic organizers and summaries stating, “brilliant. I think that’s what we need to be doing in our classrooms” meaning utilizing content area literacy strategies to teach science content.
For scenario 11, while Jack admitted he would use readers’ theater as fluency practice, he rated this scenario as a three out of five because he explained, “it’s not a very very [sic] scientific example of literacy.” In contrast, Jenna rated this scenario a five out of six. Her explanation included, “I think it’s a really good way to bring science and literacy together.” Thus, Jack based his evaluation of the scenario on how scientists are literate in their work, and Jenna saw general literacy instruction combined with learning about science.

Another difference between Jack and Jenna emerged in their conceptions of being literate in science. Jack discussed the conception that this entailed understanding the “common science language” and being able to “understand what people are talking about when they’re talking about science.” This was a very norms or nature of science type of description, where being science literate means the ability to enter the Discourse (Gee, 2004) of science. In other words, a person has both an understanding of how communication occurs within the discipline as well as conceptual knowledge (Norris & Phillips, 2003). In comparison, Jenna saw being literate in science as not achievable unless a person has deep content knowledge in a field where only experts can obtain the status of being science literate.

Comparison According to Graduation Date: Prior to or After 2012

While Jack’s interview was very disciplinary literacy focused, his planning and enactment of instruction did not follow this trend. Additionally, Jenna, who also graduated after 2012, was not focused on disciplinary literacy at all. The teachers who enacted more disciplinary literacy components during instruction were the two teachers who graduated prior to 2012. However, this seemed to be the result of meeting students’
needs, in the case of Sally, and enacting instructional plans that focused on disciplinary literacy but were not written by Charlotte in the case of Charlotte. Neither instance appeared to be completely intentional with regard to implementing components of disciplinary literacy. Thus, it appeared that teacher graduation date was not a decisive factor in teacher conceptions and/or enactment of disciplinary literacy components.

**Comparison of All Case Studies**

After the two case studies of participants who graduated prior to 2012 (i.e., Sally and Charlotte) were completed, there was a discussion about how their findings compared. This process was repeated for the two case studies of participants who graduated after 2012 (i.e., Jack and Jenna). The findings then compared the two groups, graduation prior to and after 2012. This section provides a comparison of all four cases for the interview, lesson plan artifacts, and observations.

**First Interview Question: What Do You Think of as Literacy?**

Sally, Charlotte, and Jack all conceived of literacy as the general literacy skills reading, writing, speaking, and listening. Charlotte and Jack added the nuance that literacy also entails the ability to communicate in effective ways. Jenna’s view of literacy focuses on just being able to read, with the caveat that students are able to read grade level texts.

**Second Interview Question: What Do You Consider to be Text?**

All four conceived of text as anything that contained written words. All but Jenna included the delineation that text must be able to be read. However, this may also be
present for Jenna because her conception of literacy included the ability to read grade level text.

*Third Interview Question: What Types of Text Do You Think of as Being Used in Science?*

All four participants conceive of science text as informational text with science content. However, Jenna and Jack both seemed to focus on science text being research type papers. Sally also described science text as genres of text that are utilized in science such as research articles, science websites, and curricula as well as informational texts used for general literacy purposes that have science content.

*Fourth Interview Question: What is Entailed in Being Literate in the Field of Science?*

The answer to this question was very different for each participant. For Sally, this was complex and multifaceted. She explained that being literate in science means a person can read, write, speak, and listen or has general literacy skills. However, it also included NoS conceptions such as asking questions, observing, evaluating, and logical thinking based on data. She continued that being literate in science was the ability to connect science to your life and to see the integration of other subjects including math, ELA, and social studies. Charlotte’s explanation focused on being able to use the practices of science even though she did not use this rationale for rating any of the science scenarios. She also focused on the idea that being literate in science means a person can apply content knowledge when needed. Jack focused on communication as a delineating factor in a person being literate in science meaning a person should be able to become part of the Discourse (Gee, 2004) of the science community. This conception entailed both authentic communication and conceptual content knowledge. And finally,
Jenna viewed being literate in science as deep content knowledge, being an expert in a specific area of science, which goes beyond what a typical teacher who has not specialized in science, would possess.

If combined, these teachers’ conceptions included all of the components of disciplinary literacy: authentic communication in the discipline, conceptual content knowledge, nature or norms of the discipline, and utilizing the practices of the discipline. However, individually, each teacher’s explanation contained only partial disciplinary literacy conceptions and many content area literacy conceptions.

_Fifth Interview Question: In the Upcoming Observation, Are There Places Where Students Are Working on and Using Authentic Literacy in Science? Where?_

Three out of the four teachers answered this question with both content area literacy and disciplinary literacy conceptions. Sally, Charlotte, and Jack all included that students read informational text and would use it in some way. Additionally, all three discussed ways that writing would be included. For Sally, this included students making charts and filling in graphic organizers. Charlotte explained that writing would include students taking notes and writing in journals. Both of their conceptions delineated content area literacy and disciplinary literacy ideas. On the other hand, Jack’s explanation of writing was very disciplinary literacy focused as he envisioned students asking and answering questions, designing experiments, and creating arguments. In addition to reading and writing, both Charlotte and Jack described instruction as including general speaking and listening tasks, which is a very content area literacy focused conception. Thus, at some point, all three shared both disciplinary literacy and content area literacy conceptions about instruction that supports literacy authentic to science.
Unlike the other teachers, Jenna had a conception that students work on literacy during ELA time (e.g., centers that have informational texts with science content) and experiments during science instruction. When observing actual enactment, the experiments were more step-by-step procedure based to get the right answer. Both working on literacy during ELA time and step-by-step labs to get a correct answer depict content area literacy ideas.

**Science Scenario Explanations**

Jack’s ratings were closest to the designed disciplinary literacy ratings (see Table 25). His rationales for his ratings were heavily focused on the components of disciplinary literacy. Sally, Charlotte, and Jenna all rated the scenarios higher than their designed disciplinary literacy ratings. Their rating rationales were more aligned to a content area literacy conception.

**Table 25**

*Ratings of Science Scenarios*

<table>
<thead>
<tr>
<th>Scenario 6</th>
<th>Scenario 7</th>
<th>Scenario 8</th>
<th>Scenario 9</th>
<th>Scenario 10</th>
<th>Scenario 11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Designed Rating</td>
<td>1-2</td>
<td>5-6</td>
<td>3-4</td>
<td>5-6</td>
<td>3-4</td>
</tr>
<tr>
<td>Charlotte</td>
<td>5.5</td>
<td>5.5</td>
<td>2.5</td>
<td>5.5</td>
<td>4</td>
</tr>
<tr>
<td>Sally</td>
<td>5</td>
<td>6</td>
<td>4.5</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Jack</td>
<td>2</td>
<td>6</td>
<td>5</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Jenna</td>
<td>2</td>
<td>5</td>
<td>4.5</td>
<td>6</td>
<td>5</td>
</tr>
</tbody>
</table>

**Lesson Plans**

When analyzing the submitted lesson plans, all four teachers relied heavily on content area literacy conceptions. For example, planned instruction tended to be teacher-
centered with the teachers providing the sensemaking through comprehension strategies, vocabulary, and step-by-step labs. The main focus seemed to be acquiring content knowledge. An exception to this is that Charlotte seemed to select phenomena-based, three-dimensional instruction. While her first lesson plan did not depict this and was more content area literacy based, the second two lesson plans were from sources that utilized more disciplinary literacy notions (i.e., Genetic Sciences Learning Center, 2006; BetterLesson, 2020) Additionally, Sally embedded disciplinary literacy components into instruction at times. When this occurred, instructional plans shifted to being student-centered with a focus on student sensemaking.

**Observations (Actual Enactment)**

Enactment of instruction followed closely with the submitted lesson plan conceptions of literacy appropriate for science instruction. For example, both Sally and Charlotte had periods of instruction that were heavily content area literacy focused and other times that focused on disciplinary literacy. When content area literacy was utilized, instruction was teacher-centered, but student-centered instruction seemed to be utilized when disciplinary literacy was the focus. Conversely, Jack and Jenna consistently utilized content area literacy that was teacher-centered during instruction.

**Global Themes**

Content Area Literacy emerged as a major Global Theme and was a constant thread that emerged prominently for all of the teachers in this study. Each teacher also had a different second Global Theme that emerged and seemed to have a less prominent role in their conceptions and/or enactment of instruction. For example, Sally focused on integration during her interview, while Jack focused on disciplinary literacy ideas. In
comparison, Charlotte focused on real-world application during the science scenario explanations and showed signs of applying this during instructional enactment. Furthermore, Jenna seemed to view content acquisition as the focus of science instruction. Because each of these themes was unique as a focus for a particular case study, the second, less prominent Global Theme was labelled Teacher Preferences. The reasoning for this Global Theme was to honor the perspectives that underly the thinking and/or actions of each teacher while still showing that the main conception of teachers appeared to be a focus on content area literacy. Thus, the two Global Themes were:

1. **Content Area Literacy**: Instruction focused on gaining the basic literacy skills of reading, writing, speaking, and listening along with acquiring science content knowledge through applying content area literacy skills.

2. **Teacher Preferences**: Conceptions of education that underly teacher thinking about and/or enactment of science instruction.

*Hierarchy Tree for All Four Cases Combined*

Figure 5 depicts the relationships that emerged through the coding process. The box sizes within the Global Themes column are meant to accentuate the difference in prominence of each Global Theme. Because Content Area Literacy played a major role in each of the case studies and across all four cases as a whole, this Global Theme is displayed in a larger box. The smaller box for the Global Theme, Teacher Preferences, honors that each teacher also had an underlying conception of education that seemed to play a role in their thinking and/or enactment of science instruction.
Figure 5

Combined Codes for all Case Studies

Basic Codes

- Communication
- Science Text
- Science Discourse
- SEPs
- Student Centered Instruction
- Discourse
- Not DL
- Integration
- DL

Overall Themes

- DL Communication

- DL Practices

Global Themes

Teacher Preferences

- DL Conceptual Content Knowledge

- DL Nature or Norms of the Discipline

Real-World Application

- Real-World Application

Content Area Literacy

- Content Area Literacy

- Vocabulary
- Cookbook Lab
- Communication
- Science Text
- Integration
- Teacher-Centered Instruction
- Not DL

NoS

- Student-Centered Instruction

DCIs/CCC5

- 3D Instruction
- SEPs
- Content Knowledge
- Student-Centered Instruction

DL

- No DL
- Member of the Discipline
- DL
Chapter V Discussion

The purpose of this study was to explore elementary teacher conceptions and enactment of disciplinary literacy and the connections between them to address the following main research questions:

1. What are fifth-grade teachers’ conceptions of disciplinary literacy in elementary science instruction?
2. How do these teachers enact disciplinary literacy during elementary science instruction?
3. In what ways do these teachers’ conceptions and enactments interact with one another?

This chapter includes a discussion of the conclusions for each research question and the research as a whole, the implications for possible future research, and a final summary of the research.

Research Question 1: Teacher Conceptions of Disciplinary Literacy

Overall, it seemed the teachers in this study conceive of literacy as the ability to read, write, speak, and listen and text as anything with written words. When addressing the notion of text appropriate for science, these teachers’ conceptions added that science text is informational text with science content. These conceptions are important to highlight because they underly teachers’ conceptions of literacy appropriate for science, disciplinary literacy.

In this study, teachers’ conceptions of disciplinary literacy appeared to fall under a content area literacy perspective, where instruction focuses on gaining the basic literacy skills of reading, writing, speaking, and listening along with acquiring science content
knowledge through applying content area literacy skills (e.g., using graphic organizers, summarizing, implementing comprehension strategies, building vocabulary). This was seen through the emergence of the overarching Global Theme: Content Area Literacy.

Existing research from different subject areas (e.g., social studies, mathematics) also seems to agree with this trend. Studies about teachers’ conceptions of disciplinary literacy indicate that teachers often utilized and focused on content area literacy instead of disciplinary literacy (Fang & Coatoam, 2013; Shanahan & Shanahan, 2012; Wilder & Herro, 2016). For example, literature suggests teachers use generic literacy strategies (Bean et al., 2011; Fang & Coatoam, 2013; Shanahan & Shanahan, 2012) to increase student comprehension of text. If the content of the text is science, this may be equated to students learning science. However, while students are utilizing reading, writing, speaking, and listening in general ways through applying content area literacy skills, they are likely not learning how scientists actually conduct their work in the field. This conception, therefore, diminishes students’ ability to develop the four components of disciplinary literacy (i.e., authentic communication within the discipline, conceptual content knowledge of the discipline, nature or norms of the discipline, and practices utilized within the discipline) and results in students just acquiring content knowledge as discrete pieces of information (National Academies of Sciences, Engineering, & Medicine [NASEM], 2021; NRC, 2012).

This specific situation also occurred in a study of science instruction conducted by Wilder and Herro (2016). A conclusion of this research was that enactment of disciplinary literacy was thwarted because a literacy coach stressed implementation of content area literacy skills as a strategy to improve science instruction. The literacy
coach’s lack of conceptual content knowledge and understanding of the authentic ways scientists work and norms of the discipline posed barriers to enacting disciplinary literacy instruction.

**Research Question 2: Teacher Enactment of Disciplinary Literacy**

Similar to teachers’ conceptions of disciplinary literacy, teacher enactment of disciplinary literacy during science instruction coalesced around the Global Theme of Content Area Literacy. Jack and Jenna utilized this approach to instruction almost exclusively, which was unexpected after Jack’s explanations of the scenario ratings that included disciplinary literacy conceptions. Jack’s ability to identify disciplinary literacy components at a surface level but not implement them in practice matches previously described research where teachers needed continued support (Koomen et al., 2006) and extended professional development time (Lemley et al., 2019) to move beyond this surface level understanding of disciplinary literacy to actually implementing it into instruction.

Additionally, Jenna, Sally, and Charlotte, seemed to have a general lack of understanding about disciplinary literacy. Again, this was a common thread found in the small number of available research studies that addressed teacher conceptions and enactment of disciplinary literacy (Harkness & Brass, 2017; Koomen et al., 2016; Lemley et al., 2019; Monte-Sano and Harris, 2012). This makes sense as new research about best practices in science instruction shifts teacher practice to a three-dimensional model (NRC, 2012) that integrates practices, conceptual knowledge acquisition, and ways of thinking. This is not how science instruction was envisioned, or most likely experienced, prior to the release of The Framework (NRC, 2012) research. In reality, this new research
has re-noviced all teachers that graduated before 2012 and those who did not receive instruction about these shifts that graduated after 2012 because these shifts in instruction are not what teachers most likely experienced during their own education. Also, research has concluded that science teacher knowledge affects classroom instruction (Abell, 2007). If teachers do not have knowledge of disciplinary literacy and its components, they are not likely to include them into their classroom science instruction (Abell, 2007).

Furthermore, while Charlotte and Sally did, at times, implement disciplinary literacy components, it seems this was not intentional. Data points to Charlotte selecting lesson plans from sources that embedded disciplinary literacy as a by-product of focusing on real-world applications, so her instruction was adjusted to include disciplinary literacy. This finding indicates that providing teachers with appropriate teaching resources that include accurate uses of disciplinary literacy can also support shifts in instruction.

Additionally, Sally changed her lesson designs as she taught in order to promote student sensemaking. This shifted the instruction from teacher-centered instruction to more student-centered instruction. Making this adjustment promoted a specific underlying belief that students actively construct knowledge (Mayer, 1996; Nussbaum, 1999) instead of acquiring it through information processing (Lachman et al., 1979; Mayer, 1996). This shift in learning conceptions may have supported an adjustment away from content area literacy where students utilize vocabulary building and comprehension skills to process and acquire knowledge (Nussbaum, 1999) to a disciplinary literacy lens that promotes students actively constructing conceptual content knowledge (Mayer, 1996) to make sense of real-world phenomena (Moulding & Bybee, 2017; NRC, 2012).
This shift also supports a sociocultural learning theory underpinning that in science instruction could manifest as students utilizing discourse, practices, and ways of being that are authentic to the field of science as a way of making sense of information in context (John-Steiner & Mahn, 1996; Wertsch, 1980; Wertsch & Tulviste, 1992).

**Research Question 3: Interactions Between Teacher Conceptions and Enactment of Disciplinary Literacy**

In addition to teachers’ conceptions and enactment of disciplinary literacy as content area literacy in this study, it appeared that these teachers’ individual conceptions regarding overall effective instruction interacted with conceptions of disciplinary literacy in unique ways that emerged during science instruction. Specifically, it seemed teachers have individual beliefs about what constitutes effective instruction in general, and these conceptions affected how teachers conceive of disciplinary literacy. This was captured through the other less prominent Global Theme that emerged, Teacher Preferences. This notion indicates that there are basic individual conceptions of education that affect science instruction.

**Integration**

Sally, for example, valued integration and therefore saw it as an effective way to support science instruction. Integration was viewed as increasing the value of instruction regardless of whether or not it promoted the ways literacy is utilized in the discipline of science. This idea was described by Mendenhall (2018):

> It seems participating teachers may view any decision to integrate as an improvement in the quality of instructional practice. It is as if integration is considered an “unqualified good” (Hall-Kenyon & Smith, 2013, p. 96).
This may not be surprising given some previous research has promoted this idea (Sen & Ay, 2017; Switzer & Voss, 1982, p.76).

If integration of different disciplines with science instruction does not support authentic disciplinary literacy utilization, then students are missing an opportunity to develop literacy appropriate for science. A white paper by a collaborative group of organizations, who each specialize in a different discipline, suggests that effective integration should forward each individual discipline in authentic ways and occur at natural connection points between the disciplines (Advance CTE, Association of State Supervisors of Mathematics, Council of State Science Supervisors, & International Technology and Engineering Educators Association, 2018). For example, in the interview scenario 11, where students were learning about Galileo through a reader’s theater performance, ELA instruction was utilized appropriately because science content is appropriate in a reader’s theater text for practicing prosody. However, this is not a way that scientists authentically communicate, so this integration does not support students in the development of disciplinary literacy because the connection between the disciplines is not a natural “way of being” for both disciplines. Integration instances where integration does not support both disciplines and occur at natural connections between the disciplines may arise from a teacher’s lack of understanding of the components of disciplinary literacy (Mendenhall, 2018). This seemed to be the case for all four teachers but may be particularly prominent as a reason for Sally’s teacher preference.

**Content Knowledge**

Jenna was very concerned with students acquiring content knowledge. To her, a person who is literate in science has the disciplinary literacy knowledge and skills of a
specialist with expert content knowledge. Based on this conception, it is not a possibility for K-12 students and the majority of K-12 teachers to be literate in science. This conception also seemed to display a lack of understanding about disciplinary literacy in K-12 education where an outcome is for students to gain conceptual content knowledge that they can apply to make sense of the world around them (NRC, 2012). This lack of teacher understanding of disciplinary literacy was also noted as a prominent trend in the other limited number of available research studies that address teacher conceptions and enactment of disciplinary literacy (Harkness & Brass, 2017; Koomen et al., 2016; Lemley et al., 2019; Monte-Sano and Harris, 2012).

Real-World Application

During the research, Charlotte discussed her preference for including real-world application into instruction or making instruction relevant to students’ lives. This conception was also one of the guiding assumptions of research within The Framework (NRC, 2012) and was labeled Connecting to Students’ Interests and Experiences. Its importance to science instruction is described as the assumption that for “students to develop a sustained attraction to science and for them to appreciate the many ways in which it is pertinent to their daily lives, classroom learning experiences in science need to connect with their own interests and experiences” (p. 28).

The Framework, therefore, recommends that students have “ample opportunity to develop scientific thinking, argumentation, and reasoning in the context of familiar phenomena [relevant contexts] …and that…will best support science learning across the grades” (p. 34).
The role of real-world context in the endeavors of science learning was also forwarded by two well-known researchers in the realm of science instruction, Moulding and Bybee. In their book, *Teaching Science is Phenomenal: Using Phenomena to Engage Students in Three-Dimensional Science Performances Consistent with the NRC Framework and NGSS*, they insist that “everyday phenomena that exist in a student’s world provide a useful way to initiate learning. Engaging students with phenomena…is a central tenet to science” (Moulding & Bybee, 2017, p. 21).

Furthermore, STEM Teaching Tool Practice Brief #42, *Using Phenomena in NGSS-Designed Lessons and Units* (Achieve, Next Gen Science Storylines, & STEM Teaching Tools, 2016), an initiative funded through research grants by the National Science Foundation, explains that using real-world contexts or applications in science instruction shifts the focus of student learning from “learning about” (p. 1) to “figuring out” (p. 1). This adjustment to instruction, as previously described, promotes students actively constructing knowledge (Mayer, 1996; Nussbaum, 1999) in context (John-Steiner & Mahn, 1996; Wertsch, 1980; Wertsch & Tulviste, 1992) instead of acquiring it through information processing (Lachman et al., 1979; Mayer, 1996). This leads to “deeper and more transferable knowledge” (Achieve, Next Gen Science Storylines, & STEM Teaching Tools, 2016, p. 1). Thus, the concept of real-world application appeared to shift instruction to a more disciplinary literacy perspective by supporting the development of the disciplinary literacy component conceptual content knowledge.

**Disciplinary Literacy**

Jack was aware of the disciplinary literacy components (i.e., authentic communication in the discipline, conceptual content knowledge of the discipline, nature
or norms of the discipline, practices utilized within the discipline) as he displayed a preference for using them as rationales when rating the interview scenarios for components of instruction that supported literacy appropriate to science. However, his planning for and enactment of instruction was predominately structured from a content area literacy focus with occasional components of disciplinary literacy being implemented. The researcher is familiar with the science methods course Jack was required to take as part of his pre-service teacher preparation program, which stresses developing disciplinary literacy through the lens of The Framework’s (NRC, 2012) three-dimensions: DCIs, CCCs, and SEPs. This course also specifically addresses the NoS. Thus, Jack was exposed to all four components of disciplinary literacy before he graduated.

Jack’s pattern of using disciplinary literacy concepts to describe instruction, but not implementing them in actual planning and enactment for instruction was consistent with other research about implementation of disciplinary literacy during instruction. For example, research by Lemley et al. (2019) stresses that for teachers to have more than a surface level understanding of disciplinary literacy, it takes a long period of time, longer than a semester course can provide. Additionally, Koomen et al. (2006) determined that while teachers can gain understanding about authentic communication in science and adapt primary source texts to be developmentally appropriate while still maintaining authentic patterns of discourse for science, notions included in disciplinary literacy components, it takes considerable support for extended periods of time before teachers can do this independently. Thus, while pre-service and in-service teachers can gain the “gist” of disciplinary literacy in a short amount of time, it appears that extended exposure
and support is needed in order for disciplinary literacy conceptions to actually be independently realized in planning and instruction. Therefore, limited or short-term professional development about disciplinary literacy does not appear to move teacher conceptions of disciplinary literacy to actual enactment.

**Disciplinary Literacy Conceptions and Enactment Interactions Conclusion**

The Global Theme of Content Area Literacy was the major trend in teacher conceptions and enactment of disciplinary literacy during science instruction. Occasionally, however, teacher conceptions adjusted enactment. For Sally, this included her conceptions of how students learn. Her conceptions of students as sense-makers, shifted instruction from gaining information to students’ sense-making. Thus, because of her teacher preference, disciplinary literacy was able to occur, at times, during instruction.

The other Global Theme, Teacher Preferences, also appeared to be a factor that interacted with a content area literacy conception to shift instruction. For Charlotte, her focus on real-world application affected the selection of lesson materials and shifted instruction to include the disciplinary literacy component of conceptual content knowledge. Meanwhile, two other teacher preferences, integration and acquiring content knowledge, seemed to further promote content area literacy instructional choices. In these case studies, integration tended to focus on building general ELA literacy skills utilizing the content of science during instruction as a way to gain science content knowledge and conceiving of science instruction as a way to acquire content knowledge supported using content area literacy methods during instructional enactment. Thus, these two teacher
preferences seemed to move teacher conceptions and enactment further away from
disciplinary literacy and toward content area literacy.

**Conclusion**

The findings of this research suggest that these participating teachers “have not
been provided with the knowledge and skills required to teach...in science education”
(NRC, 2014, p. 13) using disciplinary literacy. There are likely many reasons for this.
One reason may be that, in reality, most teachers have not experienced science that
implements disciplinary literacy, such as student-centered instruction focused on student
sensemaking through authentic science communication, authentic practices used in the
discipline, and authentic norms or ways of being in science during their K-12 education
or college science courses (NASEM, 2015, 2021). In fact, what teachers have
experienced is science that “emphasizes discrete facts with a focus on breadth over depth,
and does not provide [them] with engaging opportunities to experience how science is
actually done” (NRC, 2012, p. 1). This means that teachers do not have a reference for
“how best to teach science, including [The Framework research], [which] represents a
significant transition in the way science is currently taught in most classrooms and will
require most science teachers to alter the way they teach” (NASEM, 2015).

A second conclusion logically follows. For teachers to shift the way they teach,
they need to experience student-centered instruction that promotes student sensemaking
through implementation of all components of disciplinary literacy (NASEM, 2015). This
can allow them to form new conceptions about what is entailed in effective science
instruction because what occurs during instruction tends to follow teacher knowledge and
beliefs about a situation or idea (Jones & Leagon, 2014).
Additionally, previous research in disciplinary literacy has concluded that just learning about disciplinary literacy was not enough to shift teaching practices (Koomen et al., 2006; Lemley et al., 2019). Extended professional development is needed (NASEM, 2015, 2021) because “all instructors of science across K-16 need to engage in ongoing learning designed to reduce reliance on lecture and increase application of student-centered instructional approaches” (NASEM, 2021, p. 32) and components of disciplinary literacy (Koomen et al., 2006; Lemley et al., 2019; NASEM, 2015).

Besides ongoing professional development, another conclusion of this research is the importance of effective instructional materials for teachers. Providing resources where disciplinary literacy is already embedded into instruction can support teachers from their initial understandings of disciplinary literacy to actually enacting disciplinary literacy during instruction (NASEM, 2021; NRC, 2012). This is a current issue because research depicts that curriculum resources in the U.S. favor students acquiring content knowledge as discrete facts with little attention given to components of disciplinary literacy (Schwarz et al., 2017). This means publishers, State Education Agencies (SEAs), and Local Education Agencies (LEAs) need to address the issue of “providing high-quality instructional materials and other resources to support” (NASEM, 2021, p. 41) educators to make disciplinary literacy shifts in instruction.

In conclusion, if teachers are provided with opportunities to (a) learn about the components of disciplinary literacy, (b) experience science instruction that implements the components of disciplinary literacy, (c) participate in extended professional development that supports teachers to implement disciplinary literacy, and (d) receive high-quality instructional materials and resources to support enactment of disciplinary
literacy, shifts to teacher conceptions and enactment can occur. Ultimately, if students in K-12 classrooms are to realize the vision of The Framework (NRC, 2012) research in which all students experience science instruction that supports them to make sense of the world around them, possess the knowledge and skills to participate in public discourse about science issues, have the ability to continue to learn about science outside of school, and have the foundation to enter careers in science fields if they so choose, they need teachers who can effectively incorporate disciplinary literacy into science instruction. For this to occur,

the task of realizing this vision rests with teachers. To provide students these opportunities, teachers will need new knowledge of the ideas and practices in the disciplines of science, an understanding of instructional strategies that are consistent with [this] vision and the skill to implement those strategies in their classrooms. To enable teachers to acquire this kind of learning will in turn require profound changes to current systems for supporting teachers’ learning across their careers, including induction and professional development. (NASEM, 2015, pp. 1-2)

**Implications for Future Research**

While extended professional development is suggested, more research is needed on how to structure the professional development opportunities to optimize teachers’ abilities to enact disciplinary literacy during instruction. For example, in his article about the characteristics of effective professional development, Hough (2011) concluded that in-service teachers should engage in extended professional development for a minimum of two years in conjunction with 18 months of sustained implementation of learned strategies for teacher conceptions and enactment to shift. Other researchers agree that professional development should be on-going for extended periods of time but disagree on what duration and format best supports improved teaching and learning (Abdal-Haqq,
1996; Desimone, 2009; Garet et al., 2016). More research regarding what specific extended professional development format best supports shifting instruction to include effective disciplinary literacy components is still needed.

Additionally, the effect of blending both content area literacy and disciplinary literacy instruction on students’ ability to develop disciplinary literacy in science is not known. Monte-Sano and Harris (2012) researched the effects of two middle school history teachers with different approaches on student outcomes for writing disciplinary text, one disciplinary literacy and one content area literacy. The study determined that “disciplinary literacy and general literacy are complementary rather than competing goals” (p. 127) in classroom instruction. Additional research is needed to study the affects of integrating both content area literacy and disciplinary literacy approaches on student development of disciplinary literacy in science instruction.

Another possible avenue for research is looking at the effect of different models for supporting preservice teachers to enact disciplinary literacy in science instruction during their teacher education programs and into their teaching careers. Howe (2006), in an international review of preservice teacher induction programs, found that extended internship opportunities and ongoing professional development that extended from preservice programs into teacher in-service was an effective way to improve teaching and learning. Alternately, Giebelhaus (1998), found a method of combining methods courses in teacher preparation programs and field experiences with cohorts of preservice and in-service teachers who collaboratively created and implemented instruction supported preservice teachers after graduation into their first and second years of teaching. Again,
more research is needed to determine which formats are effective and efficient for supporting preservice teachers to implement disciplinary literacy into science instruction.

Summary

Studies exploring conceptions and enactment (i.e., teacher use of disciplinary literacy during instruction and teacher development of student disciplinary literacy) of disciplinary literacy in instruction in any subject area are limited. Specific descriptions of teacher conceptions and enactment during instruction are extremely limited, and notions on this topic for elementary science instruction are rare. Additionally, the linkage between practitioner conceptions of disciplinary literacy and enactment has not been pursued.

Thus, there is a gap in the literature related to knowledge about teachers’ conceptions and enactment of disciplinary literacy in elementary science education and any interactions between the two. The purpose of this research was to explore that gap through a comparative case study with four fifth-grade teacher participants by addressing the following main research questions:

1. What are fifth-grade teachers’ conceptions of disciplinary literacy in elementary science instruction?

2. How do these teachers enact disciplinary literacy during elementary science instruction?

3. In what ways do these teachers’ conceptions and enactments interact with one another?

Knowledge about these notions is important because it contributes to the small amount of existing literature surrounding this topic, which may affect how future
elementary teachers are prepared and how current elementary teachers are supported as they shift to the new disciplinary literacy expectations promoted in recent research about effective science instruction (NRC, 2012). Thus, this research adds to the knowledge base and may be of practical use by providing foundational information about what is currently occurring in elementary classrooms similar to those of the participants in this study.

Overall findings delineated that the participating elementary teachers conceived of literacy as reading, writing, speaking, and listening; text as written words; and science text as informational text with a science content. This is important to understand because it underlies teachers’ conceptions of disciplinary literacy. To these teachers, conceptions of disciplinary literacy fell under a content area literacy perspective where instruction focuses on gaining the basic literacy skills of reading, writing, speaking, and listening along with acquiring science content knowledge through applying content area literacy skills (e.g., using graphic organizers, summarizing, implementing comprehension strategies, building vocabulary). Enactment of disciplinary literacy during instruction, generally, followed this same content area literacy perspective. However, teacher conceptions of what constitutes effective instruction in general tended to moderate the content area literacy enactment trend in two ways. First, when teachers viewed learning through a constructivist or sociocultural lens, instruction shifted from more teacher-centered to more student-centered instruction with the inclusion of student sensemaking learning tasks and real-world contexts for learning. When this occurred, the overall content area literacy method of instruction moderated to more closely align with components of disciplinary literacy. However, when teachers conceived of learning as
acquiring content knowledge, instruction became more entrenched in notions of content area literacy.

When considering if date of graduation, prior to or after the release of new research on science education (NRC, 2012), affected teachers’ conceptions and enactment of instruction, a couple of findings emerged. First, teachers who graduated prior to 2012 tended to moderate their instruction due to viewing effective instruction through a general constructivist or sociocultural lens even though science instruction, overall, was still heavily reliant on a content area literacy perspective. Participants who graduated after 2012 relied heavily on content area literacy methods as a way to develop general literacy skills and acquire content knowledge. This appeared to hold true even if the participant had been exposed to disciplinary literacy during preservice disciplinary methods courses.

If teacher conceptions and enactment of science instruction are to align with research regarding effective science instruction (McComas & Nouri, 2016; NRC, 2012) including components of disciplinary literacy (i.e., authentic use of communication within a discipline, conceptual content knowledge of the discipline, nature or norms of the discipline, practices utilized within the discipline), changes need to occur in either teacher preparation programs, teacher in-service professional development, or both. Recommendations for teacher preparation and in-service professional learning include providing teachers with opportunities to (a) learn about the components of disciplinary literacy, (b) experience science instruction that implements the components of disciplinary literacy, (c) participate in extended professional development that supports
teachers to implement disciplinary literacy, and (d) receive high-quality instructional materials and resources to support enactment of disciplinary literacy.

If students are “expected to use specialized literacy skills, strategies, and practices to engage in disciplinary learning and socialization” (Fang & Coatoam, 2013, p. 628) in the discipline of science, current teacher conceptions and enactment of disciplinary literacy in classroom instruction need to shift. As noted previously, The Framework (NRC, 2012) can provide support for how to enact three of the four components of disciplinary literacy: authentic communication within the discipline, conceptual content knowledge of the discipline, and practices utilized within the discipline. However, teachers need to augment this three-dimensional instruction with explicit instruction regarding NoS tenets in order to address the fourth component: norms of the discipline.

Ultimately, The Framework (NRC, 2012) delineates the following K-12 outcomes for science education:

*All* students have some appreciation of the beauty and wonder of science; possess sufficient knowledge of science and engineering to engage in public discussions on related issues; are careful consumers of scientific and technological information related to their everyday lives; are able to continue to learn about science outside school; and have the skills to enter careers of their choice, including (but not limited to) careers in science, engineering, and technology. (p. 1)

For K-12 students to achieve these outcomes, shifts in teacher conceptions and enactment of science instruction need to occur. Currently, “science education in the United States fails to achieve these outcomes because it…emphasizes discrete facts…and does not provide students with engaging opportunities to experience how science is actually done” (NRC, 2012, p. 1).
Supporting educators to enact disciplinary literacy with the focus of students authentically using communication within a discipline, developing conceptual content knowledge in the discipline, living the nature or norms of the discipline, and utilizing the practices of the discipline can help K-12 students achieve these desired outcomes. Ultimately, these outcomes, if achieved, will empower K-12 students to make informed decisions that can affect their current lives and resulting futures.
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APPENDICES
Appendix A. Demographic Questionnaire

1. At what school do you currently teach: ____________________

2. In which district does your school reside: ________________

3. What grade(s) do you currently teach? (Select all that apply)
   a. 4th grade
   b. 5th grade
   c. 6th grade
   d. Other: (Please Specify) __________

4. What subjects do you currently teach? (Select all that apply)
   a. Science (6th grade)
   b. Language Arts
   c. Mathematics
   d. Social Studies
   e. Special Education
   f. Computers/Technology
   g. Music/Art
   h. PE
   i. Other: (Please Specify) ______________

5. How many years of teaching experience do you have?
   a. 0-2
   b. 3-5
   c. 6-10
   d. 11-15
   e. 16-20
   f. 21-25
6. How many years has your teaching experience included science?
   a. 0-2
   b. 3-5
   c. 6-10
   d. 11-15
   e. 16-20
   f. 21-25
   g. 26-30
   h. 30+

7. Gender: How do you currently identify?
   a. Man
   b. Woman
   c. Non-binary
   d. Other
   e. Prefer not to say

8. When did you receive your original teaching certificate?
   a. Prior to 2012
   b. During 2012
   c. After 2012
   d. Other: (Please Specify) ______________

9. Have you obtained any endorsements or graduate degrees?
   a. No
   b. Yes: Please specify ______________
10. Select the level that best represents your exposure to the Utah Science with Engineering Education (SEEd) Standards:

   a. Have heard about them
   b. Have attended a minimal amount of professional learning regarding them
   c. Have attended some workshop sessions regarding them
   d. Have attended sustained professional learning over time regarding them

11. Please explain your answer to the previous question: ______________________

12. Contact Email: ________________________________

13. Contact Name: ________________________________
Appendix B. Informed Consent

Exploring Elementary Teacher Conceptions and Enactment of Disciplinary Literacy During Science Instruction

Introduction

You are invited to participate in a research study conducted by Melissa Mendenhall, a graduate student in School of Teacher Education and Leadership at Utah State University. The purpose of this research is to learn about elementary teacher conceptions and enactment of literacy during science instruction. Your participation is entirely voluntary.

This form includes detailed information on the research to help you decide whether to participate. Please read it carefully and ask any questions you have before you agree to participate.

Procedures

If you agree to participate in this, you will be asked to participate in a 45-60 min. interview, one observation of science instruction with the possibility of two short follow-up observations, provide three teacher lesson plans, and engage in two short checks for accuracy of information. It should take less than four hours of your time. This research involves minimal risk to you. However, your participation may benefit education by helping increase knowledge about current trends in science instruction.

I anticipate that one person will participate in this research study in four public elementary schools, and that a total of four people will participate among all four sites.

Before you read this form, you responded to some questions regarding personal and education demographics including demographic composition of school, years of teaching experience, level of exposure to the Utah Science with Engineering Education Standards as self-reported, educational degree, and gender. Researchers will maintain that data once you agree to enter the full study until it has been published for three years. Then, the data will be destroyed.

Risks

This is a minimal risk research study. That means that the risks of participating are no more likely or serious than those you encounter in everyday activities. The foreseeable risks or discomforts include feeling anxious about answering questions, being observed, and submitting lesson plans. There is also the slight risk of a loss of confidentiality. In order to minimize those risks and discomforts, the researcher will allow you to select a pseudonym so that only the researcher will know your identity and you will not be
identified in any future publication of the results of this study. All raw data will be stored on a password-protected computer in a locked desk to keep it secure.

**Benefits**

Although you will not directly benefit from this study, it has been designed to learn more about elementary teacher conceptions and enactment of disciplinary literacy during science instruction. Your participation may benefit education by helping increase knowledge about current trends in science instruction.

**COVID-19 Disclosures**

Risks associated with contracting COVID-19 cannot be eliminated. Please carefully consider whether you are comfortable participating in person, particularly if you or someone in your home is at higher risk of serious illness from COVID-19.

COVID-19 vaccination is strongly encouraged, but not required, for Utah State University employees and students. This means that we cannot guarantee that the people you interact with in this research project are vaccinated. Masking or using other face coverings is strongly encouraged, but not required, for Utah State University employees and students. This means that we cannot guarantee that the people you interact with in this research project will wear a face covering. Researchers and fellow participants are not required to share vaccination information with you or to wear a facial covering, unless this research is not on USU’s campus and the site where it will occur does require face coverings or vaccines. **Research participation is always completely voluntary, and you can decline or stop participating at any time.** Below, you will be permitted to request certain safety accommodations from the research team, but please know that they are not required to comply.

The researchers in this project are taking the following steps to ensure your safety and comfort during the in-person portions of this research project:

- Researcher has received all vaccinations and a booster
- Researcher will voluntarily agree to wear a mask

**Confidentiality**

The researchers will make every effort to ensure that the information you provide as part of this study remains confidential. Your identity will not be revealed in any publications, presentations, or reports resulting from this research study. However, it may be possible for someone to recognize your particular situation.

We will collect your information through an audio recording, interview, observation, and a Word document file. Online activities always carry a risk of a data breach, but we will use systems and processes that minimize breach opportunities. Data will be securely stored on a password protected computer in a locked drawer in a restricted-access office. You will be allowed to select a pseudonym. All data will be stored under that identifier. Only this
form will contain your identifiable information. Additionally, this form and all participant data will all be destroyed at the conclusion of the study.

It is unlikely, but possible that Utah State University may require the researcher to share the information you give from the study to ensure that the research was conducted safely and appropriately. The researcher will only share your information if law or policy requires her to do so. If the researcher learns that you are going to engage in self harm or intend to harm another, state law requires that the researchers report this intention to the authorities.

**Voluntary Participation & Withdrawal**

Your participation in this research is completely voluntary. If you agree to participate now and change your mind later, you may withdraw at any time by contacting the researcher. If you choose to withdraw after the researcher has already collected information about you, your information will be withdrawn from the study. If you decide not to participate, the minimal funds you received from completing each of the parts of the study will not be affected in any way. The researchers may choose to terminate your participation in this research study if it is discovered that your data contains fraudulent information. In this instance, the researcher will contact you.

**Compensation**

For your participation in this research study, you will receive a total of $150. This payment will be to offset participant time required to participate in the study. Specifically, $25 for participating in the interview, $25 for preparation time for each of the three lesson plan samples, $25 for a check to assure accuracy of original data interpretations, and $25 for a check of accuracy of final summary interpretations of data. Payment will be provided once the final data check has been completed. If participants withdraw, they are compensated for the parts of the research that were completed prior to withdrawal.

Because this study pays $150 for full participation, please know that if you receive more than $600 in payments from Utah State University in a calendar year (January through December), USU is required to report the payments to the Internal Revenue Service (IRS) and a W-9 will be required.

**Findings**

Your information, identified or de-identified, will not be used or distributed for future research studies, even if all of the identifying information has been removed.

Once the research study is complete, the researchers will email you the findings of the study, including individual results relating to your participation.

**IRB Review**

The Institutional Review Board (IRB) for the protection of human research participants at Utah State University has reviewed and approved this study, protocol #12773. If you have questions about the research study itself, please contact the Principal Investigator, Dr.
Kimberly Lott at 435-797-1103 or Kimberly.lott@usu.edu, or the Student Researcher, Melissa Mendenhall at 801-400-6440 or a02058144@usu.edu. If you have questions about your rights or would simply like to speak with someone other than the researcher about questions or concerns, please contact the IRB Director at (435) 797-0567 or irb@usu.edu.

Dr. Kimberly Lott
Principal Investigator
(435)-797-1103; Kimberly.lott@usu.edu

Melissa Mendenhall
Student Investigator
(801) 400-6440; a02058144@usu.edu
Informed Consent

By signing below, you agree to participate in this study. You indicate that you understand the risks and benefits of participation, and that you know what you will be asked to do. You also agree that you have asked any questions you might have, and are clear on how to stop your participation in the study if you choose to do so. Please be sure to retain a copy of this form for your records.

____________________________________________________
Participant’s Signature
Date

____________________________________________________
Participant’s Name, Printed

COVID-19 Safety Requests

Please note that the research team is not required to comply with these requests, but many researchers are happy to oblige where possible. The research team will inform you if they are unable to commit to any of your selections. You may decline to participate or withdraw your participation at any time.

☐ I would like the researchers I interact with to be up-to-date on their COVID-19 vaccines (two weeks after a booster dose of the vaccine)

☐ I would like the researchers I interact with to use a facial covering

☐ I would like the researchers I interact with to use a facial covering only if they are not up-to-date on their COVID-19 vaccines (two weeks past a booster dose)

☐ I would like the researchers I interact with to take additional safety measures related to COVID-19: _________________________________
Appendix C. Interview Protocol

Introduction

Study Purpose: Explore elementary teacher conceptions and enactment of disciplinary literacy and the connections between them.

Consent Form: Read and discuss the consent form together as a researcher and participant. Allow participant time to ask questions and to sign the form.

Equipment Check: (Complete the sound check with the recorder.) If it is all right with you, I would like to record the interview so that I can focus on what you are saying and not miss any important information.

Demographic Information Check:

1. What grade(s) do you currently teach? What other grade levels have you taught?
2. What subjects do you currently teach?
3. How many years of teaching experience do you have?

Interview Guide (see Appendix D)

Closure

Thank you for participating in this research. Your information will help the researchers to increase knowledge in education about current trends in science instruction.
Appendix D. Interview Guide—Questions

Adapted from Mendenhall (2018)

1. What do you think of as literacy?

2. What do you consider to be text?

3. What types of text do you think of as being used in science?

4. What is entailed in being literate in the field of science?

5. In the upcoming observation, are there places where students are working on and using authentic literacy in science? Where?

Questions 6-11 contain a variety of teaching scenarios. For each question, rate the teaching scenario from 1 - 6 with 6 demonstrating the highest level of best practices in teaching students to be literate in the field of science and 1 demonstrating the lowest level of best practices in teaching students to be literate in the field of science:

6. Students independently read a section in a science textbook that describes how force is used to hold celestial objects in orbit around larger objects of greater mass in the solar system. Based on the information in the textbook, each student is asked to create a Haiku or Cinquain poem that describes the role of gravity on the orbits of the earth and the moon in our solar system. Because the students have been learning about the Impressionist style and the works of the artists Monet and Renoir during art instruction, they are also asked to illustrate their poem using watercolors.

Please select one rating (1-6) for this scenario and provide a brief explanation for why you rated the scenario the way you did and provide evidence for where literacy appropriate for science instruction was found.

7. The teacher asks the question, "How do the individual organelles in a Euglena (protist) contribute to the function of the whole organism?" Students observe a video of Euglena under an electron microscope. They use a computer application to draw a model of a Euglena, label the organelles, and note the organelles' functions within the whole organism. In pairs, students compare their models and note discrepancies. The pairs then compare their models to a model of a Euglena found in a science textbook, revise their descriptions of organelle functions where appropriate, and write an explanation of how the individual organelles contribute to the function of the whole organism.
Please select one rating (1-6) for this scenario and provide a brief explanation for why you rated the scenario the way you did and provide evidence for where literacy appropriate for science instruction was found.

8. Each student in a class is given six lists of celestial objects found in the solar system that are ordered according to size. Some lists are accurate and others are not. Each student chooses one list that is correct and makes a claim as to why the objects are accurately classified. Students are then placed into groups of five. Within the group they discuss their claims, select one claim to research, and use technology to access online resources to justify their group's claim. After researching, students write an argument agreeing or disagreeing with their original claim based on the evidence they found.

Please select one rating (1-6) for this scenario and provide a brief explanation for why you rated the scenario the way you did and provide evidence for where literacy appropriate for science instruction was found.

9. Students are asked the question, "What do living organisms need to survive?" In groups of four, students find and use multiple resources to research an answer to the question. As a group, they write a claim based on information from credible sources of science text. Then, they design an investigation to test their claim, conduct the investigation, compile their findings and display the information in a table and/or graph, and write an argument based on their claim. The argument contains conclusions based on evidence found as a result of their investigation and supported by credible sources.

Please select one rating (1-6) for this scenario and provide a brief explanation for why you rated the scenario the way you did and provide evidence for where literacy appropriate for science instruction was found.

10. In the classroom, students observe producer and consumer microorganisms that are commonly found in pond water under a microscope (e.g., Paramecium, Amoeba, Euglena, Algae). After completing the observation, students draw examples of the microorganisms. Then, as a class they read a science text that describes the characteristics of producer and consumer microorganisms. While they read, students record information in a concept web graphic organizer because they are studying text structures as a way to improve comprehension. Finally, each student writes a summary of the text utilizing the information in the graphic organizer while also including details from the microorganism observation.

Please select one rating (1-6) for this scenario and provide a brief explanation for why you rated the scenario the way you did and provide evidence for where literacy appropriate for science instruction was found.
11. The students are taught that a variety of instruments are used to investigate the moon and planets in the solar system. Some students in the class are assigned a part to read in a reader's theater presentation that discusses Galileo's life as a scientist, making sure they read with appropriate rate and expression. The rest of the students in the class are asked to act as an audience and are given the task of listening for why and how Galileo improved the telescope. They record this information in a KWL graphic organizer.

Please select one rating (1-6) for this scenario and provide a brief explanation for why you rated the scenario the way you did and provide evidence for where literacy appropriate for science instruction was found.
Appendix E. Background and Scoring Rationale Regarding the Instructional Scenarios

Adapted from Mendenhall (2018)

Background Information:

All of the scenarios are based on correct science content, which was selected from the Utah Core Science Standards of the state where the research was conducted (Utah State Office of Education, 2010). This state since the time the instrument was developed has adopted new science standards. However, since this instrument was not designed for only one grade but for elementary teachers in general and the science content is correct, the researcher felt the content of the scenarios was still appropriate.

The scenarios focus on the degree to which teachers are attending to disciplinary literacy during science instruction as demonstrated through the use of the eight Practices for K-12 Science found in A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas (NRC, 2012) and the College and Career Readiness Anchor Standards for Reading and Writing found in the ELA CCSS (NGA & CCSSO, 2010). These documents provide the criteria for rating the disciplinary literacy in which students are engaged during instruction.

The specific criteria from the Practices for K-12 Science used in this document are found in Box 3.1 and include:

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information
   (NRC, 2012, p. 42)

The specific Anchor Standards for Reading and Writing are not written in this document because of their length but can be found in the complete ELA CCSS document (NGA & CCSSO, 2010).

Scenarios and Explanations of Rating:

A. Students independently read a section in a science textbook that describes how force is used to hold celestial objects in orbit around larger objects of greater mass in the solar system. Based on the information in the textbook, each student is asked to create a Haiku or Cinquain poem that describes the role of gravity on the orbits of the Earth and the moon in our solar system. Because the students have been learning about the Impressionist style and the works of the artists Monet and Renoir during art instruction, the students are also asked to illustrate their poem using watercolors.
This scenario is rated as a 1-2. As in each of the scenarios, the science is correct. However, the students in this situation are not using disciplinary literacy in authentic ways. According to the Practices, they are not analyzing and interpreting data or information. Instead, they are merely reading information. The explanation students are constructing does not communicate information in the formal way scientists write (e.g., journals, books, websites) or informal way scientists write (e.g., email, discussion, blogs, notes). Additionally, the Writing Anchor Standards call for students to “produce clear and coherent writing in which the development, organization, and style are appropriate to the task, purpose, and audience” (NGA & CCSSO, 2010, p. 41). Writing an illustrated poem is not an authentic task completed by scientists. Therefore, this scenario is an example of not authentic (low) disciplinary literacy.

B. The teacher asks the question, “How do the individual organelles in a Euglena (protist) contribute to the function of the whole organism?” Students observe a video of euglena under an electron microscope. They use a computer application to draw a model of a Euglena, label the organelles, and note the organelles’ functions within the whole organism. In pairs, students compare their models and note discrepancies. The pairs then compare their models to a model of a Euglena found in a science textbook, revise organelle functions where appropriate, and write an explanation of how the individual organelles contribute to the function of the whole organism.

This scenario is rated as a 5-6. The students are using disciplinary literacy in authentic ways during instruction. According to the Practices, students are answering a question that explores the natural world and “attempts to extend or refine a model” (NRC, 2012, p. 54). Students are also developing and revising these models, carrying out an investigation, analyzing and interpreting data, constructing explanations, and evaluating and communicating information. Additionally, students are using many of the Reading Anchor Standards. Students are “reading closely to determine what the text says explicitly and…making logical inferences from it” (NGA & CCSSO, 2010, p. 35). The students are comparing two texts by analyzing how their text is similar to another student’s model and the science textbook’s model. Also, students are using many of the Writing Anchor Standards including: Writing clear explanations that are appropriate for the audience (model and explanation), revising text, using technology to produce text, collaborating with others, investigating a research question, and collecting information from relevant sources. Therefore, this scenario is an example of authentic (high) disciplinary literacy.

C. Each student in a class is given six lists of celestial objects found in the solar system that are ordered according to size. Some lists are accurate and others are not. Each student determines one that is correct and makes a claim as to why the objects are accurately classified. Students are placed into groups of five. Within the group they discuss their claims, select one to research, and use technology to access online resources to prove or disprove their group’s claim. After researching, students write an argument agreeing or disagreeing with their original claim based on the evidence they found.

This scenario is rated as a 3-4. Students are using many of the Practices: Planning and carrying out investigations, analyzing and interpreting data, using mathematics and computational thinking, engaging in argument from evidence, and obtaining and
communicating information. The main issue with this scenario is how the instruction is constructed. Students are originally asked to determine the accuracy of a list and make a claim without evidence. Additionally, the scenario does not represent a natural situation for scientists to engage in argument. According to the Practices, students should use argument as “an opportunity to use their scientific knowledge in justifying an explanation and in identifying the weaknesses in others’ arguments…also to build their own knowledge and understanding” (NRC, 2012, p. 73). This situation is contrived and not a natural use of argument and so falls short of true argumentation.

In the Writing Anchor Standards, students are using multiple sources including technology to research the claims. However, students are not analyzing the credibility of their sources or writing for an authentic science reason. Therefore, this scenario is an example of partially authentic (moderate) disciplinary literacy.

D. Students are asked the question, “What do living organisms need to survive?” In groups of four, students find and use multiple resources to research an answer to the question. As a group, they write a claim based on information from credible sources of science text. Then, they design an experiment to test their claim, conduct the experiment, compile their findings and display the information in a table and/or graph, and write an argument based on their claim. The argument contains conclusions based on evidence found as a result of their experiment and supported by credible sources. This scenario is rated as a 5-6. Students are using many of the Practices: Asking questions, developing and using models, planning and carrying out investigations, analyzing and interpreting data, engaging in argument from evidence, and obtaining, evaluating, and communicating information. The scenario does represent a natural situation for scientists to engage in argument because students are “constructing a scientific argument showing how data support a claim…and using reasoning and evidence” (NRC, 2012, p. 72). According to the Reading and Writing Anchor Standards, students are conducting a research project, selecting valid evidence from multiple sources, “citing specific textual evidence when writing…to support conclusions drawn from the text” (NGA & CCSSO, 2010, p. 41), writing arguments using credible evidence, and producing writing for a specific purpose. Therefore, this scenario is an example of authentic (high) disciplinary literacy.

E. In the classroom, students observe producer and consumer microorganisms that are commonly found in pond water under a microscope (e.g., Paramecium, Amoeba, Euglena, Algae). After completing the observation, students draw examples of the microorganisms. Then, as a class they read a science text that describes the characteristics of producer and consumer microorganisms. While they read, students record information into a concept web graphic organizer because they are studying text structures as a way to improve comprehension. Finally, each student writes a summary of the text utilizing the information in the graphic organizer while also including details from the microorganism observation. This scenario is rated as a 3-4. The students are using science literacy to a minimal degree in authentic ways. According to the Practices, they are communicating information by drawing and writing about their observations. However, the purpose for observing is generic because students lack a focus question/reason to inform their observations and to help them develop a model or explanation. Students are reading text...
(the visual of the microorganisms in the microscope and the written text) and are writing text to accurately describe information according to the *Reading and Writing Anchor Standards*. However, students are using the standards in a general, content area literacy way that lacks a more exact focus for utilizing disciplinary literacy. Therefore, this scenario is an example of partially authentic (moderate) disciplinary literacy.

F. The students are taught that a variety of instruments are used to investigate the moon and planets in the solar system. Some students in the class are assigned a part to read in a reader’s theater presentation that discusses Galileo Galilei’s life as a scientist, making sure they read with appropriate rate and expression. The rest of the students in the class are asked to act as an audience and are given the task of listening for why and how Galileo improved the telescope. They record this information in a KWL graphic organizer.

This scenario is rated as a 1-2. While the students in this scenario are asked to read or listen (depending upon their assigned role), which are clearly literacy tasks, they are not using disciplinary literacy in authentic ways. Those listening are asked simply to recall information. They are not using any of the eight science *Practices* or any of the *Reading and Writing Anchor Standards*. Therefore, this scenario is an example of not authentic (low) disciplinary literacy.
Appendix F. Observation Protocol

Introduction

**Study Purpose:** Explore elementary teacher conceptions and enactment of disciplinary literacy and the connections between them.

**Descriptive Notes**

<table>
<thead>
<tr>
<th>Point in Lesson Plan/Time Stamp</th>
<th>Descriptive Notes</th>
<th>Reflective Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Closure**

*Thank you for participating in this research. Your information will help the researchers to increase knowledge in education about current trends in science instruction.*
## Appendix G. Data Gathering Log

<table>
<thead>
<tr>
<th>Date</th>
<th>Place</th>
<th>Time</th>
<th>Who</th>
<th>Activity (Interview, Observation, Lesson Plan, Member Check)</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/2/22</td>
<td>Zoom</td>
<td>4:30-5:30 pm</td>
<td>Sally</td>
<td>Interview</td>
</tr>
<tr>
<td>11/3/22</td>
<td>Zoom</td>
<td>9:20-9:55 am</td>
<td>Charlotte</td>
<td>Interview</td>
</tr>
<tr>
<td>11/4/22</td>
<td>Zoom</td>
<td>8:00-9:00 am</td>
<td>Jenna</td>
<td>Interview</td>
</tr>
<tr>
<td>11/4/22</td>
<td>Zoom</td>
<td>2:30-3:30 pm</td>
<td>Jack</td>
<td>Interview</td>
</tr>
<tr>
<td>11/5/22</td>
<td></td>
<td></td>
<td>Jenna</td>
<td>3 Lesson Plans</td>
</tr>
<tr>
<td>11/7/22</td>
<td>School</td>
<td>12:30-1:15 pm</td>
<td>Jenna</td>
<td>Main Observation</td>
</tr>
<tr>
<td>11/8/22</td>
<td>School</td>
<td>12:55-1:20 pm</td>
<td>Jenna</td>
<td>Observation #2</td>
</tr>
<tr>
<td>11/8/22</td>
<td>School</td>
<td>2:30-3:20 pm</td>
<td>Jack</td>
<td>Main Observation</td>
</tr>
<tr>
<td>11/10/22</td>
<td>School</td>
<td>2:45-3:30 pm</td>
<td>Charlotte</td>
<td>Observation #2</td>
</tr>
<tr>
<td>11/10/22</td>
<td>School</td>
<td></td>
<td>Sally</td>
<td>3 Lesson Plans</td>
</tr>
<tr>
<td>11/10/22</td>
<td>School</td>
<td></td>
<td>Charlotte</td>
<td>1 Lesson Plan</td>
</tr>
<tr>
<td>11/14/22</td>
<td>School</td>
<td>12:50-1:25 pm</td>
<td>Jenna</td>
<td>Observation #3</td>
</tr>
<tr>
<td>11/14/22</td>
<td>School</td>
<td>2:45-3:30 pm</td>
<td>Charlotte</td>
<td>Main Observation</td>
</tr>
<tr>
<td>11/14/22</td>
<td>School</td>
<td></td>
<td>Charlotte</td>
<td>2 Lesson Plans</td>
</tr>
<tr>
<td>11/15/22</td>
<td>School</td>
<td>2:30-3:15 pm</td>
<td>Sally</td>
<td>Main Observation</td>
</tr>
<tr>
<td>11/28/22</td>
<td>School</td>
<td>2:25-2:55 pm</td>
<td>Sally</td>
<td>Observation #2</td>
</tr>
<tr>
<td>11/28/22</td>
<td>School</td>
<td>2:55-3:25 pm</td>
<td>Jack</td>
<td>Observation #2</td>
</tr>
<tr>
<td>11/30/22</td>
<td>School</td>
<td>2:45-3:10 pm</td>
<td>Charlotte</td>
<td>Observation #3</td>
</tr>
<tr>
<td>12/1/22</td>
<td>School</td>
<td>2:30-2:55 pm</td>
<td>Jack</td>
<td>Observation #3</td>
</tr>
<tr>
<td>12/1/22</td>
<td>School</td>
<td>2:57-3:25 pm</td>
<td>Sally</td>
<td>Observation #3</td>
</tr>
<tr>
<td>12/1/22</td>
<td></td>
<td></td>
<td>Jack</td>
<td>3 Lesson Plans</td>
</tr>
</tbody>
</table>
## Appendix H. Code Book

### Sally Codebook

<table>
<thead>
<tr>
<th>Basic Code</th>
<th>Description</th>
<th>Representative Participant Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Literacy</td>
<td>All of language. Reading, writing, speaking, listening</td>
<td><em>Whole encompassing language</em> &lt;br&gt;<em>Reading, writing, speaking, I think listening has a part to do with it, too. But I think that’s what I think of when I think of literacy</em></td>
</tr>
<tr>
<td>Text</td>
<td>Written words in any length or genre</td>
<td><em>I guess anything would be more that you would read</em> &lt;br&gt;<em>So, it’s words, or I guess written words, whether it’s in a story, or you know, paragraph form, or information, or fiction…anything to do with words</em></td>
</tr>
<tr>
<td>Science Text</td>
<td>What use in the classroom for science instruction, informational text</td>
<td><em>TRB [Teacher Resource Book-science curriculum]</em> &lt;br&gt;<em>The resources that we used to implement our literacy instruction for science</em> &lt;br&gt;<em>Science informational texts and readings and things like that</em> &lt;br&gt;<em>Like actual student books, that they can have as well for text that they can…[use] in science, probably all just informational</em></td>
</tr>
<tr>
<td>Content Area</td>
<td>Literacy skills used in general to receive and express meaning such as reading, writing, speaking, and listening</td>
<td><em>So, a graphic organizer where they write the different states of matter that they’re seeing around them</em> &lt;br&gt;<em>And they had to read a science text and they’re recording information on a graphic organizer, which is great because graphic organizers do help</em> &lt;br&gt;<em>Then, they had to write a summary of it from the graphic organizer, which is great because taking that information and then putting it into text</em></td>
</tr>
<tr>
<td><strong>SEPs</strong></td>
<td>Using practices that scientists actually use in the field</td>
<td>Designing an investigation and compiling their findings</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td></td>
<td></td>
<td>They’re writing claims, and I like how it said, based on form credible sources of science text</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Science Discourse</strong></th>
<th>Students discussing science concepts as a way to make sense</th>
<th>They’re using like their their [sic] partners. I really am big into partner talking and and [sic] kind of whole class accountability talking</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>I’ve shifted my whole thinking of teaching that I’m just not the only one talking, that students need a chance to talk to each other when it’s, you know, in an organized fashion, not just you know, turn and talk to your neighbor. But I do think that this one’s a really good one [scenario] because then they can compare their models to someone else</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Integration</strong></th>
<th>Teaching different content areas at the same time. Use of technology</th>
<th>I think that that’s great that they can implement it into some sort of writing or some sort of language</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>There’s writing a poem or a synonym like a Haiku…and then obviously, they had to, from a previous lesson, learn about the the [sic] artist</td>
</tr>
</tbody>
</table>

|  |  | Implements not only that text part of it and and [sic] literature part of it, but also in implementing math with a table or graph. So, those kind of cross cutting concepts are there, which is awesome |

**Teacher:** Reads article out loud that is on the overhead. Students: Then, students choral read. Read fluently with expression.

And I think that’s huge we’re finding, you know, obviously their fluency has a huge part with their comprehension.
| Nature of Science | How scientists work in the field, dispositions, norms | They’re getting like they have a question to kind of get their brains thinking, and then they observe on their own. 
So, I think that that [sic] critical thinking is happening there 
They start out with a question 
Using multiple resources to research to answer the question |
| Teacher-Centered Instruction | Teacher is responsible for student sensemaking | Obviously, they’re listening to the teacher and the teacher’s talking |
| Content Knowledge | Subject matter knowledge as facts | They have to see it [the list] order to size and see if their lists are accurate or not 
Students will be able to identify what matter is and what the types of matter are with their properties and where matter is found |
| Student-Centered Instruction | Students are doing the sensemaking | What conclusions can you draw from the properties of matter? We need to categorize them into three states and come up with a definition that describes their properties: Students will work with their elbow buddies to come up with a definition for each of the properties of matter 
Students will sort heading cards of solid, liquid, and gas into categories along with characteristics |
| Authentic Application | Science concept in an authentic context | Phenomenon to start with 
Color a picture on the overhead projector. Ask the students what is happening and what this has to do with science |
| DCIs/CCCs | Gaining and applying conceptual knowledge; | Teacher shows different pictures on the computer and asks students, “What do these things have in common?” |
Ways of thinking about conceptual knowledge

*Teacher displays three different circles with “molecules” in them and asks students to identify which one would be classified as a solid, liquid, and as a gas, and why they chose that.*

**Vocabulary**

Comprehend the meanings of words

*What is matter? Students try to come up with a definition of matter. (Anything that takes up space and has mass)*

*Vocabulary words: Physical Change: Change in how matter looks, the size, color, shape, but it does not change what it is made up of.*

**Cookbook Lab**

Preset, step-by-step procedure

*Get 3 clear cups with the same amount of water (1 cup) in each. Review with the students that when two or more substances are combined, that makes a mixture, and they can be taken apart*

*Do the following activity with them: Mixing substances to see if a chemical reaction occurs*

<table>
<thead>
<tr>
<th>Overall Themes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DL: Comm: Genres/Text Modes/Discourse</td>
<td>Modalities, genres, and discourse patterns authentic to science</td>
</tr>
<tr>
<td>DL: Practices: SEPs</td>
<td>SEPs authentic to the discipline</td>
</tr>
<tr>
<td>DL: Knowledge: DCIs/CCCs</td>
<td>DCIs/CCCs authentic to the discipline</td>
</tr>
<tr>
<td>DL: Norms/NoS</td>
<td>Nature of Science</td>
</tr>
<tr>
<td>DL: Real World Application</td>
<td>Authentic to real world contexts</td>
</tr>
<tr>
<td>CAL: Comm/Words</td>
<td>Utilizes the general skills of reading, writing, speaking, and listening as well as general comprehension strategies as a way to acquire content knowledge</td>
</tr>
</tbody>
</table>

**Graphic Representation of Codes Related to Organizing Themes:**

**Overall:**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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<td>SEPs</td>
<td>DCIs/CCCs Student-Centered Instruction</td>
<td>NoS Student-Centered Instruction</td>
<td>Authentic Application</td>
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### Explanation of Instructional Scenarios:  

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<td>SEPs</td>
<td>NoS Student-Centered Instruction</td>
<td>Authentic Application</td>
<td>Content Area Literacy Science Text Integration Teacher-Centered Instruction Content Knowledge Vocabulary Cookbook Lab</td>
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### Interview/Enactment:  

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<td>NoS Student-Centered Instruction</td>
<td>Authentic Application</td>
<td>Content Area Literacy</td>
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### Lesson Plans:  

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<td>Student Discourse Student-Centered Instruction</td>
<td>DCIs/CCCs Student-Centered Instruction</td>
<td>NoS</td>
<td>Authentic Application</td>
<td>Content Knowledge Vocabulary Content Area Literacy</td>
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## Enactment:

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<tbody>
<tr>
<td>Student Discourse</td>
<td>SEPs Student-Centered Instruction</td>
<td>DCIs/CCC's</td>
<td>NoS</td>
<td>Authentic Application</td>
<td>Teacher-Centered Instruction Content Area Literacy Vocabulary Content Knowledge Cookbook Lab</td>
</tr>
</tbody>
</table>

### Global Themes

<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content Area Literacy Instruction focused on supporting comprehension in a subject through applying generic literacy strategies</td>
</tr>
<tr>
<td>Integration Teaching with at least two different content areas during the same instruction</td>
</tr>
</tbody>
</table>

### Charlotte Codebook

<table>
<thead>
<tr>
<th>Basic Code</th>
<th>Description</th>
<th>Representative Participant Responses</th>
</tr>
</thead>
</table>
| Communication | Reading, writing, speaking, listening | Reading and writing and listening and speaking  
Components of communication  
We’re gonna [sic] be talking about food chains  
Applying that writing  
Oral responses, so they’ll be speaking and things like that, and listening |
<table>
<thead>
<tr>
<th>Science Text</th>
<th>Different genres of text used in science, informational text</th>
<th>They are having a discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Text</td>
<td>Anything to read, words</td>
<td>Word format</td>
</tr>
<tr>
<td>SEPs</td>
<td>Using practices that scientists actually use in the field</td>
<td>Look at data and interpret</td>
</tr>
<tr>
<td>DCIs/CCCs</td>
<td>Gaining and applying conceptual knowledge; Ways of thinking about conceptual knowledge</td>
<td>Read graphs and interpret those</td>
</tr>
<tr>
<td>NoS</td>
<td>How scientists work in the field, dispositions, norms</td>
<td>Support their claims with evidence</td>
</tr>
<tr>
<td>Real-World Application</td>
<td>Phenomena, relevance to students</td>
<td>Apply that knowledge in different areas</td>
</tr>
<tr>
<td>Content Area Literacy</td>
<td>Literacy skills used in general to receive and express meaning such</td>
<td>To me this is them thinking critically</td>
</tr>
</tbody>
</table>

- Science textbook
- Articles
- Research on the internet
- Writing responses in their journals
- Informational
- Word format
- Information on the internet
- Article
- Textbook
- Look at data and interpret
- Read graphs and interpret those
- Support their claims with evidence
- Apply that knowledge in different areas
- They’re being asked to to [sic] describe how each of these individual organelle’s function
- To me this is them thinking critically
- I think for me, science is is [sic] being able to think critically
- What would the real-world application be
- It doesn’t have that real world application
  Teacher: I think as humans, we are starting to realize that we use a lot of energy like gasoline, water. In the last 20 years, we are starting to realize that we need to conserve
- Reading of the textbook and then they’re creating the poems, that’s definitely literacy, science literacy
as reading, writing, speaking, and listening  

<table>
<thead>
<tr>
<th>Content Knowledge</th>
<th>Subject matter knowledge as facts</th>
<th>Where does the energy from all food come from</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Teacher: I have been looking at your loops and wondering what you guys made here. Students: Answer one at a time (food chain)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Three-Dimensional Instruction</th>
<th>Instruction that contains all three dimensions (i.e., SEPs, CCCs, DCIs)</th>
<th>Objective: Obtain, evaluate, and communicate information that animals obtain energy and matter from the food they eat</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Standard 5.1.3 Ask questions to plan and carry out investigations that provide evidence for the effects of weathering and the rate of erosion on the geosphere</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cookbook Lab</th>
<th>Preset, step-by-step procedure with a correct answer</th>
<th>They will be assigned to 1 of 6 stations as follows. Each station should have the materials for the first exercise (bucket, gravel and soil) as well as the ones listed</th>
</tr>
</thead>
</table>
|              |                                                       | 1. With a partner, label six cups as shown  
|              |                                                       | 2. Arrange the cups as shown above and place six pom-poms in the cups, following the directions below |
Vocabulary | Comprehend the meaning of words |
---|---|
**Teacher:** Bio means what? **Teacher:** So in a biosphere you would find anything that has life  
**Teacher:** What does geo mean? **Students:** Answer one at a time

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<td><strong>DL: Comm:</strong> Genres/Text Modes/Discourse</td>
<td>Modalities, genres, and discourse patterns authentic to science</td>
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<td><strong>DL: Practices:</strong> SEPs</td>
<td>SEPs authentic to the discipline</td>
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<td><strong>DL: Knowledge:</strong> DCIs/CCCs</td>
<td>DCIs/CCCs authentic to the discipline</td>
</tr>
<tr>
<td><strong>DL: Norms/NoS</strong></td>
<td>Nature of Science</td>
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<tr>
<td><strong>DL: Real World Application</strong></td>
<td>Authentic to real world contexts</td>
</tr>
<tr>
<td><strong>CAL:</strong> Comm/Words</td>
<td>Utilizes the general skills of reading, writing, speaking, and listening as well as general comprehension strategies as a way to acquire content knowledge</td>
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**Graphic Representation of Codes:**

**Overall:**

| DL: Comm  

**Explanation of Instructional Scenarios:**

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<tr>
<td>Communication Science Text</td>
<td>SEPs</td>
<td>DCIs/CCCs</td>
<td></td>
<td></td>
<td>Communicating Content Area Literacy DCIs/CCCs</td>
</tr>
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### Lesson Plans:

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<td>SEPs</td>
<td>DCIs/CCCs 3D Instruction</td>
<td>NoS</td>
<td>Real-World Application</td>
<td>Content Knowledge Content Area Literacy Cookbook Lab</td>
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### Enactment:

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<tr>
<td>Content Area Literacy</td>
<td>Instruction focused on supporting comprehension in a subject through applying generic literacy strategies</td>
</tr>
<tr>
<td>Real-World Application</td>
<td>Instruction was relevant to the students’ lives</td>
</tr>
</tbody>
</table>
## Jack Codebook

<table>
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<tr>
<th>Basic Code</th>
<th>Description</th>
<th>Representative Participant Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication</td>
<td>Ways to communicate ideas</td>
<td>I think that it has to do with like communication application and the transfer of ideas, and ways that we do that as humans</td>
</tr>
</tbody>
</table>
| Text                   | Mediums that allow you to consume information | *Basically, the the [sic] information you’re consuming*  
<p>|                        |                                          | <em>Generally written</em>                                                                                   |
| Science Text           | Texts used in science                    | <em>Long and dense information texts</em>                                                                     |
|                        |                                          | <em>I think the drawing examples could be. I think it would just depend on how you did it</em>                 |
| Vocabulary             | Comprehend the meaning of words          | <em>Understand common science language</em>                                                                    |
|                        |                                          | <em>Hypothesis and experimentation and words like that</em>                                                    |
|                        |                                          | <em>Teach the vocabulary: Clay, silt, sand, gravel, pebbles, and humus</em>                                   |
| Integration            | Integration of science and literacy      | <em>Integration between like literacy skills and science</em>                                                 |
|                        |                                          | <em>Then teaching or learning those in association with or, yeah, at the same time as science skills</em>     |
| Content Area Literacy  | Literacy skills used in general to receive and express meaning such as reading, writing, speaking, and listening | <em>So, literacy skills is in just like comprehension, or writing things like that</em>                       |
|                        |                                          | <em>I think the readers’ theater. Yeah. He was a teacher who struggles to teach fluency</em>                   |
|                        |                                          | <em>It might be you’re reading an article and talking about it.</em>                                           |
| Member of the Discipline Literacy | Being able to participate in the discipline with confidence | <em>Scientists are literate people</em>                                                                        |
| Not Disciplinary Literacy | Not authentic to the work of scientists | <em>Because writing haiku and using watercolors is not sharing generally what scientists do when they’re</em> |</p>
<table>
<thead>
<tr>
<th>Nature of Science</th>
<th>How scientists work in the field, dispositions, norms</th>
<th>It starts with the question, which I think is very scientific</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>There’s observation happening</td>
</tr>
<tr>
<td>SEPs</td>
<td>Using practices that scientists actually use in the field</td>
<td>There’s modeling</td>
</tr>
<tr>
<td></td>
<td></td>
<td>There’s writing, but the writing like it’s in, it’s an explanation</td>
</tr>
<tr>
<td>Disciplinary Literacy</td>
<td>How literacy is authentically used in the discipline</td>
<td>A lot of like relevant literacy activities happening</td>
</tr>
<tr>
<td></td>
<td></td>
<td>They use a graph</td>
</tr>
<tr>
<td>Discourse</td>
<td>Talking to each other to understand ideas</td>
<td>Discussing their claim</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Groups record their observations for each sample and discuss differences</td>
</tr>
<tr>
<td>DCIs/CCCs</td>
<td>Gaining and applying conceptual knowledge; Ways of thinking about conceptual knowledge</td>
<td>Concept knowledge</td>
</tr>
<tr>
<td></td>
<td></td>
<td>So, what does that website say about rockslides? What causes them?</td>
</tr>
<tr>
<td>Content Knowledge</td>
<td>Subject matter knowledge as facts</td>
<td>Ask students again what soil is made of. This time they should answer that it is made up of sediments, or pieces of weathered rock, and humus (waste from living things)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Teacher asks clarifying question for student answers. Where [do you] find soil where we would not have to move anything? Students answer individually</td>
</tr>
<tr>
<td>Cookbook Lab</td>
<td>Preset, step-by-step procedure with a correct answer</td>
<td>Teacher describes materials and procedures: 1. Four different types of soil put together out of different sediments and materials. 2. Take a sample of each. 3. Make observations about each of the four.</td>
</tr>
</tbody>
</table>
Grab four vials, four lids, one tray. Take turns. For each jar of soil, open the jar, fill vial just over ½ full

**Teacher-Centered Instruction**

Teacher is responsible for student sensemaking

Ask students to name the examples of weathering and erosion they have learned about. Make a list of these examples on the board

Show the class the plastic jars and ask how they could be used to break the rocks into smaller pieces

Teacher: Let me show you what your notes should look like: Teacher models the entry

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**Graphic Representation of Codes:**

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<td>Science Text Not DL SEPs Discourse Disciplinary Literacy</td>
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<tr>
<td>Content Area Literacy Communication Content Knowledge Text Vocabulary Cookbook Lab Integration Not DL</td>
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<tr>
<td>Not DL Integration SEPs DL Not DL</td>
<td>SEPs DL</td>
<td>DCIs/CCCs</td>
<td>NoS</td>
<td>Not DL Member of the Discipline DL</td>
<td>Integration Not DL Content Area Literacy</td>
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<td>NoS</td>
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<td>Discourse</td>
<td>SEPs</td>
<td>DCIs/CCCs</td>
<td>NoS</td>
<td></td>
<td>Content Area Literacy Integration Content Knowledge</td>
</tr>
</tbody>
</table>
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<tr>
<th>Disciplinary Literacy</th>
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<tbody>
<tr>
<td></td>
<td>Instruction used the components of disciplinary literacy to help students become literate in science in ways that scientists are literate in science as they work in the field</td>
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<tr>
<td></td>
<td>Instruction focused on building content knowledge through applying generic literacy strategies such as vocabulary acquisition and reading comprehension</td>
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</tbody>
</table>

### Jenna Codebook

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<tr>
<th>Basic Code</th>
<th>Description</th>
<th>Representative Participant Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading</td>
<td>Ability to read text</td>
<td>Reading any <em>any</em> [sic] <em>text that kids can read</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td>You can read text</td>
</tr>
<tr>
<td>Text</td>
<td>Anything with words that you can read</td>
<td><em>So, a text basically, to kind of sum it up, would be anything with words</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Published papers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Articles</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Internet</td>
</tr>
<tr>
<td>Science Text</td>
<td>Texts used in science</td>
<td><em>Books</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Research papers</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Text for science</em></td>
</tr>
<tr>
<td>Not Literacy</td>
<td>Science activities that are not literacy related</td>
<td><em>We’re doing an experiment. So, we’re not doing a lot of literacy</em></td>
</tr>
<tr>
<td>Content Area Literacy</td>
<td>Literacy skills used in general to receive and express meaning such as reading, writing, speaking, and listening</td>
<td><em>I’m not really using a lot of literacy with science...like when I do centers during ELA time</em></td>
</tr>
<tr>
<td>Literate in Science</td>
<td>Extensive knowledge of science content</td>
<td>Had to do extensive research to get where she’s at</td>
</tr>
<tr>
<td>---------------------</td>
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<td>-----------------------------------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I don’t think you can be just like a teacher and be literate in science like, unless that’s your specialty</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I don’t think I’m literate in science because I teach what I read, and I [sic] but I don’t consider myself an expert in science</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Being literate in science would mean you have pretty deep understanding of a certain content</td>
</tr>
<tr>
<td>Not Disciplinary Literacy</td>
<td>Not authentic to the work of scientists</td>
<td>I just think it would focus too heavily on the literacy part, and not enough about understanding the science</td>
</tr>
<tr>
<td></td>
<td></td>
<td>It doesn’t get you deep into the understanding</td>
</tr>
</tbody>
</table>

I’ll do things on read works for science

They’re noting...they’re reading the textbooks

You’re doing listening comprehension in that

But I would rather have them learn about something, so read about it, watch something, do something where they’re learning with literacy

Because if they’re observing something, and if they’ve had knowledge about it before, then that’s great. But I would almost prefer, I think you know, reading something to introduce them

They are studying text structures as a way to improve comprehension. I think that’s, you know, brilliant.
| DCIs/CCCs | Gaining and applying conceptual knowledge; Ways of thinking about conceptual knowledge | You’re diving deep into what it is You’re labeling the functions |
| SEPs | Using practices that scientists actually use in the field | They’re drawing a model Then it’s compiling their findings and writing an argument |
| Content Knowledge | Subject matter knowledge as facts | And then, without the book, draw, and then see what they remember by going back and checking it with the book Pretest in quiz to see what they know about properties of matter |
| Student Sensemaking | Students are trying to make sense of information | So that, I think you know, yeah, is using your brain |
| Nature of Science | How scientists work in the field, dispositions, norms | You use multiple research resources to research the answer to the question Share with the group on what you observed, what questions do you have |
| Integration | Using both general literacy, ELA, and science at the same time | I think that’s what we need to be doing in our classrooms is integrating that ELA that we’ve been studying I just did a graphic organizer the other day, and I wish you know...I could use that in science, too, because, yeah, that’s a really good way to blend the two |
| Cookbook Lab | Preset, step-by-step procedure with a correct answer | Do experiment in partnerships, fill small cups about halfway with water, one for each student. Have straws ready to hand out. Have them create a T-chart outlined below In table on next page, write properties of the baking powder in the unmixed column. Teacher: Each group gets a spoon. Teacher: Separate the baking powder into three little piles. Teacher: Put water in one pile and vinegar in another pile. Teacher: What did the water do to the baking powder |
| Vocabulary | Memorize the meanings of words | Create vocabulary list of words. Write in notebooks  
Review definitions |
| --- | --- | --- |
| Teacher-Centered Instruction | Teacher is responsible for student sensemaking | Teacher: Did a reaction happen?  
Teacher: Is it soluble? Teacher: Soluble, the ability of matter to dissolve in a liquid |
| Authentic Application | Science concept in an authentic context | When I blow air through a straw into water, the air pushes water out of the way  
Have you ever been to a lake and it looks like you are on glass? Have you been to a lake and you are on waves? Where does the air come from? Story: On lake Powell, waves were six feet tall |

**Overall Themes**

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<td>Authentic to real world contexts</td>
</tr>
<tr>
<td>CAL: Comm/Words</td>
<td>Utilizes the general skills of reading, writing, speaking, and listening as well as general comprehension strategies as a way to acquire content knowledge</td>
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</table>

**Graphic Representation of Codes:**

**Overall:**

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<tbody>
<tr>
<td>Science Text</td>
<td>SEPs</td>
<td>DCIs/CCC's Literate in Science Content Knowledge</td>
<td>NoS Not Literacy Literate in Science</td>
<td>Literate in Science Authentic Application</td>
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<td>Content Area Literacy Reading Text</td>
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<td>Not DL</td>
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### Explanation of Instructional Scenarios:

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<tbody>
<tr>
<td>Science Text</td>
<td>SEPs</td>
<td>DCIs/CCCs</td>
<td>NoS Student Sensemaking</td>
<td>Content Area Literacy Not DL Content Knowledge Text Integration</td>
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### Interview/Enactment:

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<tr>
<td>SEPs</td>
<td>Not Literacy</td>
<td>Content Area Literacy</td>
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### Lesson Plans:

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<tbody>
<tr>
<td>Content Knowledge Cookbook Lab Vocabulary Teacher-Centered Instruction</td>
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### Enactment:

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<tbody>
<tr>
<td></td>
<td></td>
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<td>NoS</td>
<td>Authentic Application</td>
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### Global Themes

<table>
<thead>
<tr>
<th>Global Themes</th>
<th>Description</th>
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<tbody>
<tr>
<td>Content Area Literacy</td>
<td>Instruction focused on gaining content knowledge through applying generic literacy strategies</td>
</tr>
<tr>
<td>Content Knowledge Acquisition</td>
<td>Instruction focused on acquiring content knowledge about a topic</td>
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</table>

### Global Themes Across All Four Cases:

<table>
<thead>
<tr>
<th>Global Themes</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>Content Area Literacy</td>
<td>Instruction focused on gaining the basic literacy skills of reading, writing, speaking, and listening along with acquiring science content knowledge through applying content area literacy skills</td>
</tr>
<tr>
<td>Content Knowledge Acquisition</td>
<td>Conceptions of education that underly teacher thinking about and/or enactment of science instruction</td>
</tr>
</tbody>
</table>
CURRICULUM VITAE

Melissa P. Mendenhall

melissa.mendenhall@schools.utah.gov
sciencemmendenhall@gmail.com

CURRENT POSITION
Elementary Science & STEM Specialist, 2019-present
Utah State Board of Education, Salt Lake City, Utah

EDUCATION
Doctor of Philosophy, Education, Curriculum and Instruction: Science Education
Utah State University, Logan, Utah May, 2023
Dissertation: Teacher conceptions and enactment of disciplinary literacy in elementary science instruction: A comparative case study
Adviser: Kimberly Lott, PhD

Master of Arts, Teacher Education, Integrated STEM emphasis 2018
Brigham Young University, Provo, Utah
Thesis: Sixth-Grade Elementary and Seventh- and Eighth-Grade Middle School Teachers’ Knowledge and Beliefs about Science Literacy
Adviser: Leigh K. Smith, PhD

Elementary STEM Endorsement 2017
Brigham Young University, Provo, Utah

Advanced Reading Endorsement 2015
Utah State Board of Education, Salt Lake City, Utah

Reading Endorsement 2012
Brigham Young University, Provo, Utah

English as a Second Language Endorsement 2008
Brigham Young University, Provo, Utah

Bachelor of Science, Elementary Education 2005
Utah Valley University, Orem, Utah

Associate in Science, Integrated Studies 2002
Utah Valley University, Orem, Utah

PROFESSIONAL EXPERIENCE
Adjunct Faculty Spring 2022-present
Utah State University, Statewide Campus
Instructor for Teaching Elementary Science methods course in virtual and hybrid format
Supervisor for Elementary Education Methods Practicum course for statewide campus

Elementary Science Specialist, Curriculum and Development 2016-2019
Alpine School District, American Fork, Utah

Clinical Faculty Associate, Elementary Education 2014-2016
Brigham Young University Public School Partnership, Provo, Utah

Elementary Teacher 2010-2014
Traverse Mountain Elementary, Lehi, Utah
Sixth Grade Teacher

Elementary Teacher 2008-2010
Ridgeline Elementary, Highland, Utah
Sixth Grade Teacher

Elementary Teacher 2006-2008
Barratt Elementary, American Fork, Utah
Fifth Grade Teacher

Elementary Teacher 2005-2006
Meadow Elementary, Lehi, Utah
Fifth Grade Teacher

PUBLICATIONS


PRESENTATIONS

National/International Presentations:


Local/Regional Conferences:

Mendenhall, M. P. (2023, February). *Elementary Science Workshop (Grades 5-6).* Utah Science Teaching Association, Farmington, UT.


Mendenhall, M. P. (2022, November). *Elementary Science Workshop (Grades K-2).* Utah Science Teaching Association, Cedar City, UT.


Mendenhall, M. P. (2018, October). *To integrate or not to integrate. Is that the question?* Paper presented at Science Education at the Crossroads Annual Conference, Alta, UT.

**GRANTS**


PROFESSIONAL DEVELOPMENT FACILITATION/CURRICULUM DESIGN

State:

Instructional Coaches Academy: Science
Utah State Board of Education, Salt Lake City, Utah 2022-present

Developing Microcredentials for Elementary Science and STEM Endorsements
Utah State Board of Education, Salt Lake City, Utah 2021-present

Developing Formative Assessment Clusters for the SEEd Standards K-6
Utah State Board of Education, Salt Lake City, Utah 2021-2022

STEM Institute
Utah State Board of Education, Salt Lake City, Utah 2020-present

Doing and Talking Science/Engineering
Utah State Board of Education, Salt Lake City, Utah 2020-2021

Developing Open Educational Resource Textbooks K-5 for the SEEd Standards
Utah State Board of Education, Salt Lake City, Utah 2020-2022

Developing Core Guides for the SEEd Standards K-6
Utah State Board of Education, Salt Lake City, Utah 2020-2022

Tour of Utah: Supporting Effective Science Instruction
Utah State Board of Education, Salt Lake City, Utah 2019-present

Developing an Elementary Science Endorsement
Utah State Board of Education, Salt Lake City, Utah 2019-2020

Developing an Elementary STEM Endorsement (Revised)
Utah State Board of Education, Salt Lake City, Utah 2019-2020

Science and Engineering Education Standards Professional Learning Series
Alpine School District, American Fork, Utah 2016-2019

ESL: Family and Parent Involvement, ESL Endorsement
Salt Lake City School District, Salt Lake City, Utah 2017-2021

ESL: Professionalism in School and Neighborhood, ESL Endorsement
Utah State Board of Education, Salt Lake City, Utah 2017

Secondary ELA: Reading for Argument Writing
Utah State Board of Education, Salt Lake City, Utah 2016
Utah State Office of Education, Salt Lake City, Utah

English Language Arts Lead Facilitator Sixth-Grade 2012-2014
Utah State Office of Education, Salt Lake City, Utah

Engineering Design Pilot, Design Thinking 2012-2013
Utah State Office of Education & Stanford University, Stanford, California

English Language Arts Utah Common Core Academy Facilitator Sixth-Grade 2010-2011
Utah State Office of Education, Salt Lake City, Utah

Math/Science Utah Core Academy Sixth-Grade 2009-2010
Utah State Office of Education, Salt Lake City, Utah

Local:
Science and Engineering Practices, STEM Endorsement 2017
Brigham Young University, Provo, Utah

Engineering Design Workshops 2015-2017
Granite School District, Salt Lake City, Utah

English Language Arts Sixth Grade Professional Development 2013
Provo School District, Provo, Utah

English Language Arts Core Academy for Sixth-Grade 2013
Washington County School District, St. George, Utah

English Language Arts Academy for Sixth-Grade 2013
Alpine School District, American Fork, Utah

English Language Arts Utah Core Standards Sixth-Grade 2012
Catholic Diocese of Salt Lake City, Salt Lake City, Utah

Survival Strategies for Literacy 2009
Alpine School District, American Fork, Utah

SERVICE COMMITTEES

National:
Presidential Awards for Excellence in Mathematics and Science Teaching (PAEMST):
Elementary Science/Engineering National Selection Committee 2022
National Science Foundation

Professional Learning Committee 2019-2022
National Science Teaching Association (NSTA)
**State:**

<table>
<thead>
<tr>
<th>Role</th>
<th>Organization</th>
<th>Start Date</th>
<th>End Date</th>
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<tbody>
<tr>
<td>Utah State Board of Education Strategic Plan Goal 4a Team</td>
<td>Utah State Board of Education</td>
<td>2022</td>
<td>present</td>
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<td>Higher Education Collaborative: Elementary</td>
<td>Utah State Board of Education</td>
<td>2022</td>
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<tr>
<td>Elementary Integrated Content Advisory Committee Co-Chair</td>
<td>Utah State Board of Education</td>
<td>2022</td>
<td>present</td>
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<td>Combined Advisory Team</td>
<td>Utah State Board of Education</td>
<td>2022</td>
<td>present</td>
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<td>USBE Board Representative</td>
<td>Utah Science Teachers Association</td>
<td>2021</td>
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<td>Elementary Advisory Team</td>
<td>Utah State Board of Education</td>
<td>2021</td>
<td>present</td>
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<tr>
<td>Microcredential Advisory Committee</td>
<td>Utah State Board of Education</td>
<td>2020</td>
<td>present</td>
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<tr>
<td>Elementary State Science Education Coordinating Committee Lead</td>
<td>Utah State Board of Education</td>
<td>2020</td>
<td>present</td>
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<tr>
<td>Combined State Science Education Coordinating Committee Co-Chair</td>
<td>Utah State Board of Education</td>
<td>2020</td>
<td>present</td>
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<td>Standards Implementation Institute Elementary Science Lead</td>
<td>Utah State Board of Education</td>
<td>2020-2022</td>
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<tr>
<td>Standards Implementation Institute Elementary Integrated Content Lead</td>
<td>Utah State Board of Education</td>
<td>2020-2022</td>
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<td>Presidential Awards for Excellence in Mathematics and Science Teaching (PAEMST): Elementary Science/Engineering</td>
<td>Utah State Coordinator National Science Foundation</td>
<td>2019</td>
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<td>Elementary STEM Endorsement Committee</td>
<td>Utah State Board of Education</td>
<td>2018-2019</td>
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<tr>
<td>Science with Engineering Standards (SEEd) Writing Committee</td>
<td>Utah State Board of Education</td>
<td>2018-2019</td>
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</table>
Elementary Science Endorsement Committee
Utah State Board of Education
2018-2019

Local:
Space Center Committee
Alpine School District
2018-2019

Elementary Benchmarking Committee
Alpine School District
2018-2019

DISTINCTIONS

LETRS Training
2021-2023

Teacher of the Year
Lehi Cluster, Alpine School District
2013

PTA Teacher of the Year
Traverse Mountain Elementary
2013

ETS Recognition of Excellence
(Top 15th percentile) Principles of Learning and Teaching: Grades K-6, Praxis Series
2006

ETS Recognition of Excellence
(Top 15th percentile) Elementary Education Content Knowledge, Praxis Series
2005

Valedictorian for Elementary Education
Summa Cum Laude, Bachelor of Science, Utah Valley University
2005

Exemplary 4-Year Scholarship
Utah Valley University
2003-2005

Service Scholar Award
Utah Valley University
2003-2005

High Honors
Associate in Science, Utah Valley University
2002

PROFESSIONAL ORGANIZATIONS

International Society of the Learning Sciences (ISLS)
2022

National Science Education Leadership Association (NSELA)
2020-present

Council of Chief State School Officers (CCSSO)
2019-present

Council of State Science Supervisors (CSSS)
2019-present

Association for Science Teacher Education (ASTE)
2018-present

National Association for Research in Science Teaching (NARST)
2018-present

Literacy Research Association
2018-2021

Utah Science Teaching Association (UtSTA)
2016-present
National Science Teaching Association (NSTA) 2016-present
International Literacy Association (ILA) 2016-2019