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**Negotiating Disciplinary Literacy Instruction in Secondary Science: A Multi-Case Study**

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NEGOTIATING DISCIPLINARY LITERACY INSTRUCTION IN SECONDARY SCIENCE:
A MULTI-CASE STUDY

A Dissertation
Presented to
the Graduate School of
Clemson University

In Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy
Literacy Language, and Culture

by
Arsenio Silva
May 2021

Accepted by:
Dr. Phillip Wilder, Committee Chair
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Abstract

National science proficiency scores in America have failed to show significant improvement for years (www.nationsreportcard.gov, 2019). Although policy reforms have come and gone in attempt to influence these trends, Disciplinary Literacy (DL) theory currently stands center-stage as one of the most recently espoused approaches to improving students’ scientific illiteracy. However, the field of DL theory is ideologically fragmented and offers little in terms of applicable strategies for practitioners (Fang, 2012a). Consequently, enacting DL instruction requires teachers to draw on highly specialized disciplinary knowledge and experience to inform their application of an incomplete DL theoretical framework (Saraceno, 2019). Yet, research shows that specialized disciplinary education and experience has been a weakness of many teacher certification programs (Brown & Melear, 2007). Therefore, the goal of this multi-case study was to examine the DL instructional practices of three secondary science educators—who did have professional disciplinary experience and acquired their teaching credentials through alternative certification programs—to better understand how DL theory can and cannot be operationalized in secondary science classrooms. Findings revealed that institutional expectations and lack of support/resources were the most significant contributors to instructional challenges faced by participating teachers. Findings also suggested an effective pattern of approaches to solving common problems among participants. The conclusions drawn from this study have implications for teacher preparation programs, professional development designers, and administrators who want to support DL instruction in their schools. Moreover, each participant demonstrated practical responses to real classroom challenges that can inform other teachers’ future instructional decisions in similar contexts. Lastly, the findings of this study lay
groundwork for future research on the challenges to DL instruction, practical applications of DL theory, DL in teacher certification and professional development programs, and using GOAT and/or DLPCK as theoretical frameworks for analyzing teachers’ classroom instructional activities.
Dedication

To my daughter Leena, I dedicate this little brick in the wall to you. Let it be a reminder that no ambition is too grand, and no achievement is insignificant. You can accomplish anything to which you dedicate yourself, and I will always love and support you along the way.
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Chapter 1: Introduction

Background and Purpose

According to the Equality of Opportunity Project (EOP), “The ability to think critically and challenge standards is the basis of innovation . . . innovation is a critical component of economic growth. Innovative thinkers are the movers and shakers that have the potential to change the world” (www.invent.org, 2019). In a prepared speech at the March for Science in Raleigh, North Carolina, Sigma Xi Executive Director and CEO Jamie L. Vernon echoed that sentiment while pointing to science, specifically, as an essential form of innovative thinking; “The beauty of investing in science is that it guarantees economic success. For decades, the United States has enjoyed tremendous wealth thanks to our previous technological achievements. We want the same for the next generation of Americans” (www.sigmaxi.org, 2019). In other words, it is critical to our national economic and existential future for Americans to be literate in science.

Being literate in science involves critical processes; yet, “we live in an age when all manner of scientific knowledge—from climate change to vaccinations—faces furious opposition. Some even have doubts about the moon landing” (nationalgeographic.com, 2019) or believe that the Earth is flat (theflatearthsociety.org, 2019). Despite ever-increasing access to information, many American students remain reluctant to accept the findings and conclusions of professional scientists. As a result, scientific conspiracy theories abound and are propagated just as easily (perhaps more easily through social media) as reliable, empirical evidence can be disseminated. Not only does this create a culture of distrust toward the scientific community, but it has implications for social policies that could affect health, education, the economy, international relations, and even the life of our planet (van der Linden, 2015). Adding to the challenge of
cultural resistance and distrust of the scientific community, rapid advancement in scientific
knowledge and technological innovation in recent decades have yielded texts and concepts that
are increasingly complex and require an ever-expanding amount of background knowledge to
comprehend. Consequently, “it's more important than ever that our nation's youth are prepared to
bring knowledge and skills to solve problems, make sense of information, and know how to
gather and evaluate evidence to make decisions” (www.ed.gov, 2019).

In addition to economic and critical motivations, there are personal incentives for
tomorrow’s youth to investigate and learn about science—to become literate in science.
“Science . . . contributes to ensuring a longer and healthier life, monitors our health, provides
medicine to cure our diseases, alleviates aches and pains, [and] helps us to provide water for our
basic needs” (en.unesco.org, 2019). Science is an integral part of everyday life, and it helps us
answer the questions we have about ourselves and the most mysterious elements of the world
around us. In short, we rely on science to “respond to societal needs and global challenges”
(en.unesco.org, 2019).

In order to prepare tomorrow’s youth to be literate in science and equip them with the
skills to meet those needs and overcome those challenges, educational reforms have responded to
a growing emphasis on the importance of literacy instruction to adolescent education as outlined
by several policy reports (Lee & Spratley, 2010; International Literacy Association, 2015;
National Center for Literacy Education, 2013). Moreover, Next Generation Science Standards
(NGSS, 2013) have highlighted literacy as an integral part of building scientific knowledge.

For the last fifty years or so, content area literacy strategies have prevailed as the most
common approach to supporting literacy development in science. CAL instruction typically
involves explicitly teaching students how to use cognitive reading strategies when confronted with challenging texts to help them “locate, comprehend, remember, and retrieve information that is contained in various styles of writing across the curriculum” (Moore, 1983, p. 420). However, disagreement among researchers has persisted over the years regarding the focus of content area literacy instruction; some argue that it should concentrate on those generic skills that can be applied in any content area, while others contend that students need and should be provided with more content-dependent skills (Moore, Readence, & Rickelman, 1983). Unfortunately, few content area literacy strategies address the specialized literate practices that are germane to individual scientific disciplines. As a consequence, disciplinary literacy theory has been espoused by many as another approach for developing our students’ scientific literacy (Fang, Lamme, & Pringle, 2010; Lee & Spratley, 2010; Moje, 2007, 2008; Shanahan & Shanahan, 2008). Like the NGSS, disciplinary literacy calls for a shift in emphasis from general cognitive reading and writing strategy instruction to discipline-specific literacy practices. However, even though these policy and curricular shifts reflect a “call for disciplinary literacy instruction [that] is clear, the path for implementation is not” (Di Domenico et. al, 2018).

Moje (2008) distinguished between subject-matter knowledge (understanding of school subject-specific concepts and information) and disciplinary knowledge (a product of human interaction that is dependent on the situation, context, and participants) and defined disciplinary literacy as a question of “learning the different knowledge and ways of knowing, doing, believing, and communicating that are privileged” among various discourse communities (p. 99). Academic discourse communities (disciplines)—such as biology, chemistry, and physics—collectively constitute the domain of science. Disciplinary knowledge, then, is a more formalized
subset of domain knowledge (Di Domenico et al., 2018)—that is, there are rules in the scientific community of practice, and there are even more specific practices that distinguish astronomy from geology, for example. Moje (2008) argued disciplinary literacy instruction, then, should focus on more than access to subject-matter knowledge, but the means of knowledge production and criticism within discourse communities. She also described academic disciplines, such as biology, as communities of practice that have developed discourses central to the acquisition of the literate practices of those disciplines, criticizing skills-based literacy instruction (content area literacy) as reducing disciplinary concepts to “stuff” that can just be memorized. Instead, she argued that teachers should focus on the authentic disciplinary practices and experiences they can facilitate as experts (Moje, 2015).

However, teachers’ expertise is complex and diverse. Shulman (1987) argued that teachers’ expertise is comprised of the following seven knowledges: content knowledge, pedagogical knowledge, curricular knowledge, pedagogical content knowledge, knowledge of students, knowledge of context, and knowledge of educational goals. Ball and Cohen (1999) went further to argue that, in order to teach well, teachers must employ their knowledge of subject-specific meanings and connections, procedures and information, as well as habits of mind embedded within the discipline, knowledge of the students (in general and individually), knowledge of students’ cultural differences, and knowledge of pedagogical practices (ways to engage learners effectively and the ability to modify instruction in response to student needs). These knowledgebases link the subject-related information teachers possess, “the instructional actions they employ, and the learning, attitudes, and beliefs of the students they teach” (Gess-
Newsome & Lederman, 2001, p. 52). It is through leveraging these knowledges in balanced concert with each other that effective instructional methods are produced.

In order to develop students’ scientific literacy, then, teachers must have a deep understanding of “the structure and nature of their discipline, have skill in selecting and translating essential content into meaningful learning activities, maintain fluency in the discourse of the community, and recognize and highlight the applications of the field to the lives of their students (Gess-Newsome & Lederman, 2001, p. 53). With these understandings, teachers can help students utilize the discipline-specific practices that constitute the disciplines on which their content areas (school subjects) are based. Such instruction in science would require teachers to become “serious learners in and around their practice, rather than amassing strategies and activities (Ball and Cohen, 1999, p. 4). However— notwithstanding some shared literate practices— most science teachers are not scientists, and classrooms differ from professional disciplinary spaces in significant ways. Moreover, teachers’ and professional scientists’ subject-matter and disciplinary knowledge are often organized and used differently (Cochran, 1997). Unlike scientists, teachers must blend pedagogical knowledge with subject-matter knowledge to enact disciplinary literacy instruction. They don’t typically engage in authentic scientific inquiry inside the classroom themselves. Therefore, it is important for teachers to acquire a deep understanding of, have experiences with, and continue to engage in the literate practices of scientific communities of practice—doing science.

However, teaching discipline-specific practices to impact the scientific literacy and learning of diverse groups of adolescents brings about complex challenges for all science teachers, no matter how informed or connected to scientific communities of practice they might
be. Such challenges highlight the difficulty of teaching scientific concepts and specialized processes to secondary students. For example, Smagorinsky (2014) highlighted a common belief among subject-area teachers that “English teachers teach writing in all of its glorious complexity so teachers of other subjects could assign writing, confident that elsewhere in the building they had learned how to do it” (p. 141). Yet, some students inevitably struggle to produce specialized subject-area texts without basic and intermediate writing skills support (Shanahan & Shanahan, 2008). Even teachers who buy into the shared responsibility of literacy instruction are required to do so with highly complex texts using discourses comprised of highly complex lexicons (Pearson, Moje, & Greenleaf, 2010) that might even be challenging for their most advanced students.

Adding to the challenge, teachers themselves may not have had preservice experiences with literate practices and processes that disciplinary experts use to access, produce, and critique the knowledge within their field (Duggan-Haas, 1998; Brown & Melear, 2007), making it even more challenging to teach those skills to students. Traditional teacher preparation programs often fail to provide coursework that adequately prepares teachers to engage in genuine scientific inquiry (Lewis-Spector, 2016). Although there has been a national increase in alternative certification programs, and alternatively certified teachers are typically bachelor’s degree holding graduates from disciplines outside of education or career changers from science-based occupations—possibly possessing a stronger fluency in the discourse of the community, deeper understanding of the structure and nature of their discipline, and a closer connection to the practical applications of the field (Brenner et al, 2015, p. 41)—science continues to be a subject in which teachers are difficult to find and retain (Aragon, 2016).
In this study, my aim was to garner a deeper understanding of the ways career-changing secondary science teachers with past experience engaging with authentic scientific communities of practice utilized their knowledge and experience to negotiate solutions to instructional challenges. I hope to highlight the complexity of this teaching task as well as the expertise of the three teachers in this study. In doing so, I aim to contribute to an underdeveloped research base on disciplinary literacy instruction in secondary school contexts and to use the practices related to teachers’ choice of texts, tasks, and purposes to prompt the reader to assess their own practices as disciplinary experts and educators.

**Significance of the Study**

Recent reforms to science standards have responded to the limitations and criticisms of traditional views or outright dismissal of the importance of scientific literacy education. For example, The Next Generation Science Standards, which were released in 2013, explicitly call for greater attention to social/participatory components of scientific literacy by organizing their standards by disciplinary practice as well as by topic and by including performance-based expectations. For students (and teachers) to be science-literate, then, they must acquire “a set of skills that marries knowledge of science concepts, facts, and processes with the ability to use language to articulate and communicate about ideas” (Their & Daviss, 2003, p. 423). For teachers attempting to enact literacy instruction in science, the demands of their own scientific literacy in the classroom are no longer limited to the ability to communicate scientific concepts but asks them to facilitate student participation in scientific practices and engagement in scientific processes. Drew & Thomas (2018) conducted a survey of over 340 secondary science teachers’ implementations of NGSS practices in their classrooms and found that the majority of
teachers reported that they had been “using these practices across the range of occasionally to very often” (p. 277). Yet, the most recent 2015 NAEP science scores across the nation still showed no statistically significant change from 2009, stalling at just twenty-two percent of students at or above Proficient (www.nationsreportcard.gov, 2019).

If “science literacy enables individuals to lead fuller lives, to make wise personal decisions, to engage intelligently in public debates about matters related to science, to be economically productive, and to respect the natural world” (Champagne, 1997, p 5), then our public education system has an obligation to raise science proficiency rates far above twenty-two percent—not only for the future of our environment, economy, and social welfare, but for the individual empowerment of students who will inherit whatever challenges the future holds. Such a pedagogy should prepare them to be producers of scientific knowledge rather than mere consumers. Moreover, it should “help youth gain access to the accepted knowledge of the disciplines, thereby allowing them also to critique and change that knowledge” (Moje, 2008, p. 97).

Unfortunately, the stagnation of our students’ science proficiency in the face of curricular reform efforts suggest that there are obstacles beyond the standards and policies themselves to effective literacy instruction in secondary science. An expanded definition of scientific literacy along with increased curricular demands of teachers’ knowledge are examples of such obstacles to teaching for scientific literacy. By investigating the challenges secondary educators face when attempting to improve students’ literacy in scientific disciplines, we can provide teachers with the support needed to overcome those obstacles in an ever-growing effort to make access to disciplinary knowledge more equitable for students and to empower them as learners and future
citizens. Such an investigation holds the potential to inform education policy and teacher professional development for secondary science literacy education.

**Research Questions**

In this research study, I employed a holistic multiple case study design (Yin, 2014). Genre-Oriented Activity Theory (GOAT) (R. Fisher, 2019) and Disciplinary Literacy Pedagogical Content Knowledge (DLPCK) (Saraceno, 2019) theory served as analytical lenses for each case, providing deeper understanding of the following:

1. What are the subject, objects, mediational tools, and outcomes of the disciplinary literacy teaching activity of career-changing, non-traditional secondary science teachers?
2. What challenges and contradictions do career-changing, non-traditional secondary science teachers identify and experience within their disciplinary literacy teaching context?
3. How do career-changing, non-traditional secondary science teachers negotiate solutions to challenges and contradictions within their disciplinary literacy teaching context?

These questions will help to understand the values that inform the disciplinary literacy instruction of career-changing, non-traditional teachers, the obstacles they face when trying to enact literacy instruction in science, as well as the roles their unique knowledge bases play in negotiating those tensions. For career-changing, non-traditional teachers who do not typically take teacher education courses (including courses in literacy) what do they think it means to be literate in science? What do they feel are the most important things for their students to learn? How do they perceive their own students’ knowledge and learning? What makes disciplinary literacy instruction difficult? What scaffolds, resources, and texts do they employ in attempt to
enact disciplinary literacy despite those difficulties? Exploring these questions can provide a deeper understanding of how career-changing, non-traditional teachers enact disciplinary literacy instruction in science.

Disciplinary literacy theory itself is concerned with the highly specialized language and practices of academic content areas—how the reading, writing, speaking, and meaning making processes for math, science, social studies, English, etc. differ (Shanahan & Shanahan, 2008; Fang, 2012b). Some view literacy in the disciplines as apprenticeship (Shanahan & Shanahan, 2012) or as participation or membership in a discourse community (Moje, 2015). If teachers view scientific literacy from this perspective, what would support or impede their literacy instruction? Others argue that literacy in a discipline is defined by the linguistic features found in disciplinary texts (Fang, 2012b). If that is the case, what challenges might teachers face, then? There are even those who present literacy in the disciplines as a critical and contemplative practice (Wilder & Msseemaa, 2019). When consciousness is framed in critical and contemplative ways, what then affords or hinders literacy instruction? In short, the field is being pulled in multiple theoretical directions, and a consensus or synthesis of viewpoints has yet to take hold. How does that impact teachers who are trying to enact disciplinary literacy instruction in science? If students are going to receive the disciplinary literacy instruction which empowers them inside and outside of the classroom, how these teachers view and enact literacy in disciplines—as well as what hinders their enactment of disciplinary literacy—is an important starting point for building an understanding of their teaching practices and for improving teacher education.
While perspectives on disciplinary literacy continue to compete on a theoretical front, teachers have been left to find their own answers to the questions: How do I “do” disciplinary literacy instruction? How can I actually design lessons that build students’ literacy in my discipline? Hence, this study sought to explore how three career-changing, non-traditional teachers leveraged their expertise and experience across disciplinary communities of practice to support the scientific literacy of students.

Outline of Chapters

In chapter two, I first briefly review the history of scientific literacy education. Then, I will discuss theoretical perspectives on disciplinary literacy, specifically related to secondary science. I will discuss the four dominant perspectives (cognitive, linguistic, sociocultural, critical) as well as how they are (or not) reflected in the Next Generation Science Standards. After distinguishing between major theories on disciplinary literacy, I will discuss the value of Genre-Oriented Activity Theory as a lens for analyzing disciplinary literacy instruction in secondary science classrooms (Fisher, 2019). This lens views disciplinary texts (genres) as both a mediating tool and outcome of an activity system while viewing typified activity systems as mediated by tools analogous to disciplines themselves. Then, with regard to disciplinary literacy instruction, chapter two explores the requisite knowledge educators must possess in order to teach discipline-specific habits of mind, processes, language, and values.

Chapter three will explain how a multi-case methodological design is most appropriate for this investigation because case study is “interested in insight, discovery, and interpretation rather than hypothesis testing” (Merriam, 1998, p. 29). The three individual cases in this study were viewed as one among other systems (Stake, 1995) that are intrinsically bounded by that
real-life context (Miles & Huberman, 1994) in order to generate rich descriptions and new theoretical understandings where an existing theory of disciplinary literacy instruction is incomplete or insufficient (Yin, 2014). I will provide background on the school, the teacher participants, and the ways in which my analysis during and after data collection supported my inquiry into the disciplinary literacy instruction of non-traditional secondary science teachers.

Because I believe all meaning making is socially and culturally situated, the units of analysis using this design type will be the contextualized instructional activity systems of three individual non-traditional teachers situated in three different secondary science classrooms (multiple contexts). This chapter will explain how I use a Genre-Oriented Activity Theory lens (Fisher, 2019) to collect and analyze data including fieldnotes of observations, teaching artifacts, analytical memos, and transcribed semi-structured interviews with teacher participants to provide opportunities to understand the multiple participant perspectives on disciplinary literacy instruction in science.

In chapter four through six, I will present each of the three teacher cases individually. Each chapter will use data to describe their individual teaching contexts and the interactive components of their respective instructional activity systems. Then, I will present the most pressing pedagogical challenges identified by each teacher participant. Finally, I will discuss the pedagogical decisions each teacher made in response to those challenges and the knowledge that informed those decisions.

Chapter seven will contain a cross case analysis of all three science teachers’ disciplinary literacy instruction that highlights overlapping patterns as well as significant differences among participants’ contexts, challenges, and negotiated solutions. Chapter seven will conclude with
implications for secondary science instruction, science teacher professional development, university and teacher certification programs, educational policy, and future research.

Key Terms

Throughout this study, I use several key terms that carry assumptions related to their meaning. The term activity system refers to the contextualized interaction between individual actors, mediating tools, and motives (Engeström, 1999). The activity system itself is a map of those interactions, though individual components of the mediated activity may vary from one context to another. When discussing those interactive components, I will use the term subject to refer to the teacher participant who was the individual actor in the observed activity system. I will use the term object to refer to the goals or purposes driving the activity. I will use the term mediational or mediating tools to refer to the texts, environments, resources, manipulatives, or any other meaning-making materials used by the actor in order to achieve the object. Finally, I will use the term outcomes to describe the product of the activity system. Breakdowns that might occur among those interacting components of an activity system that lead to outcomes misaligned with the target object of the activity will be referred to as tensions, conflicts, and contradictions, interchangeably.

According to Fisher (2019), when enough actors habitually engage in similar activities for similar purposes in similar contexts, similar contradictions emerge and thus, similar solutions. Over time, mediation pursuant to specific objects becomes typified. It is from this collective, typified activity that disciplines emerge (Fisher, 2019). Disciplines are loosely bound by shared rules, mediating tools, and motives. Individuals who engage in activity systems with an understanding of those typified processes of mediation collectively constitute communities of
practice. Therefore, *disciplines* are defined by the *activity systems* shared among contextually similar *communities of practice* (Lave & Wenger, 1991).

For example, some hospital employees are tasked with drawing blood from patients for medical screening. While there might be some contextual differences from one hospital to another, all hospitals share certain acceptable and standard practices and procedures that have been developed as a product of countless iterations of that activity. Consequently, phlebotomy emerged as a discipline defined by the typified activities of those who draw blood for medical purposes in all hospitals. Phlebotomy is the *discipline*. Phlebotomists at Our Lady of Mercy Hospital are a *community of practice*. When any medical employee engages in drawing blood from a patient, they are participating in a disciplinary *activity system*.

Another key term I will use through this study is *content area*. The term *content area* refers to school subjects such as biology, physics, and chemistry. Collectively, those content area courses constitute the *domain* of science. Similarly, algebra, geometry, and calculus constitute the domain of mathematics, and so on. I will also use the terms *subject-matter knowledge* and *content knowledge* interchangeably to refer to the knowledge of information, facts, and concepts related to a curricular topic. The term *disciplinary knowledge*, on the other hand, will refer to the knowledge of those typified activities and processes that bind disciplinary *communities of practice*. Lastly, I will use the term *scientific literacy* in reference to the ability to apply domain-specific process knowledge to construct meaning with and from scientific texts.

In addition to teachers’ *disciplinary knowledge* and *subject-matter or content knowledge*, I will also use five other terms borrowed from Carney & Indirisano’s (2013) DLPCK framework to refer to different knowledge bases teachers used to inform their instructional *activity systems*. 
I will use the term *pedagogical knowledge* to refer to knowledge of common methods for engaging learners effectively and the ability to modify instruction in response to student needs. I will use the term *knowledge of the curriculum* or *curricular knowledge* to refer to teachers’ knowledge of the sequence and scope of localized academic content area standards. *Knowledge of students* will refer to teachers’ knowledge of their students’ ability levels, interests, values, believes, habits, strengths, weaknesses, etc. The term *knowledge of context* or *contextual knowledge* will refer to teachers’ knowledge of situational variables other than the *subject*, *object*, and *mediational tools* of the *activity system* that might influence the *outcomes* of their teaching activity. Such knowledge includes but is not limited to knowledge of events and circumstances at the global, national, regional, state, district, community, school, department, and classroom level. Lastly, I will refer knowledge of curricular objectives set forth by local *content area* standards and standard assessments as *knowledge of educational goals*. 
Chapter 2: Literature Review

Leading up to the late 19th century, science education was often in tension with theological education and popular religious ideologies. It wasn’t until the Second Industrial Revolution (late 19th century), sparked by scientific and technological advancements, that the general public began to appreciate how scientific thinking was needed to solve contemporary societal problems. In response, The National Education Association of the United States Committee on Secondary School Studies (NEA) Committee of Ten (a group of educators charged with evaluating current practices in American high schools) issued their first policy recommendations emphasizing the importance of science education for all students in 1893. However, subsequent debate over the purpose of such education—to prepare students to be informed consumers in an era of unprecedented technological advancement and scientific understanding or to teach them the processes and habits of mind required to contribute to genuine scientific inquiry—persists to this day (Bybee, 2010).

A Brief History of Scientific Literacy and Education

While the idea that people should have some measure of everyday scientific knowledge has been around since the beginning of the 20th century (Shamos, 1995), and John Dewey (1910) argued such knowledge should extend beyond subject-matter facts to include scientific processes and habits of mind, the term “scientific literacy” did not appear in the literature base until the publication of “Science Literacy: Its Meaning for American Schools” by Paul Hurd in 1958 (as cited in DeBoer, 1991). Before that, literacy espoused two meanings in the scientific community: the ability to read and write, and the possession of scientific knowledge (Miller, 1983). Consequently, the issue of students being learned rather than able to communicate scientific
knowledge became the focus of lectures such as “Science and Culture” (Huxley, 1882) and arguments like “Literature and Science” (Arnold, 1882). Then, the National Education Association (NEA) released a report in 1920 that stated the role of education was to prepare students for effectiveness in a social world, and the Commission chair said life applications of scientific knowledge should be the important focus of scientific learning for students (NEA, 1918).

However, in 1934, John Dewey argued that, for students to become scientifically learned, they must adopt “scientific attitudes” (p. 3). This marked yet another diversion of perspectives between those who value broader understandings of the natural world through scientific processes and those who believe science should only be studied to the extent that it is practically useful to individuals (DeBoer, 2000). This theme of social relevance was revisited by the National Society for the Study of Education (NSSE) in a 1945 Science Education in American Schools report that asserted the comparison of scientific thinking with that of other subjects and even within the domain of science, along with the historical relationship between science and society should be a focus of science instruction (NSSE, 1947).

Even after Hurd (1958) contributed the term “scientific literacy” to the discourse around students’ scientific understanding, a universally accepted meaning has yet to be defined (Roberts, 2007). For several subsequent years, authors went through a period of trying to legitimize the concept of scientific literacy without any clear definition before seriously confronting its interpretations (Roberts, 1983). Around the same time, the National Assessment of Educational Progress (NAEP) began collecting data on precollegiate student’s scientific knowledge, including knowledge of scientific norms and processes (Miller, 1983). Although authors like
Agin (1974) and Pella (1976) tried to unify different interpretations, a single definition remained elusive. Then, the 1970’s brought a shift in perception that scientific literacy was a desirable goal for all students, not just those who were not college-bound, which as was the dominant view in the 1960’s (DeBoer, 1991). In 1971, the National Science Teachers Association (NSTA) released a report in School Science Education for the 1970s supporting the relationship between science and society as the most important goal of science education. However, continued lack of consensus concerning what it really means for students to be literate in science rendered the concept less useful for educators (Graubard, 1983). Meanwhile, NAEP science achievement scores saw declines between 1969 and 1977.

As emphasis grew on the science and society relationship in education leading into the 1980’s, controversy arose over the suggestion that scientific instructional units be organized around social issues rather than structured around disciplinary content (DeBoer, 2000). Low achievement scores reported by the National Commission on Excellence in Education (NCEE) (1983) in A Nation at Risk: The Imperative for Educational Reform were followed by arguments that American academic standards were too low and contributing to a decline in global economic position. In response, the American Association for the Advancement of Science (AAAS) released Project 2061’s Science for All Americans report, which sought to clarify the goals of scientific literacy education in 1989—once again, emphasizing connections between science, individual purposes, and societal needs.

Derived from those goals, the National Academy of Sciences began constructing National Science Education Standards (1996) in 1992, which consolidates “virtually all of the objectives of science education that have been identified over the years. . . [and] are all-inclusive
and formidable” (DeBoer, 2000, p. 590). Some argue too formidable. Shamos (1995), for example, argued that it is naïve to try and get students to think like scientists, and that many student-friendly social issues involve little science to investigate. He concluded that empowering students is a futile effort, and that providing them basic knowledge about technology (to understand the technology itself, not as a means to broader scientific learning) and access to expert advice on science-related social issues is realistically the most important thing we can offer. In a similar vein, Hazen and Trefil (1991) argued for a distinction between doing (being able to do what scientists do as they do it) and using (having the knowledge required to understand public issues) science. They concluded that scientific literacy only concerns the latter. Such perspectives mark another trend toward emphasizing the practical view of scientific literacy as for personal and societal objectives, rather than to acquire scientific dispositions, practices, and processes.

Then, just before the turn of the century (1999), the National Commission on Mathematics and Science Teaching for the 21st Century began investigating strategies to improve mathematics and science education. The Commission released a report in 2000, “Before It’s Too Late,” that argued bonus incentives and higher salaries are needed if the market is going to attract more science teachers. However, the 2001 No Child Left Behind Act diverted focus and resources away from science in favor of math and reading, only to be undermined six years later by the America COMPETES Act (2007), which again redirected funding toward math and science education. Meanwhile, Norris & Philips (2003) highlighted just how fragmented our vision of scientific literacy goals had become over the decades to include the following:
“(a) Knowledge of the substantive content of science and the ability to distinguish from non-science;
(b) Understanding science and its applications;
(c) Knowledge of what counts as science;
(d) Independence in learning science;
(e) Ability to think scientifically;
(f) Ability to use scientific knowledge in problem solving;
(g) Knowledge needed for intelligent participation in science-based issues;
(h) Understanding the nature of science, including its relationship with culture;
(i) Appreciation of and comfort with science, including its wonder and curiosity;
(j) Knowledge of the risks and benefits of science; and
(k) Ability to think critically about science and to deal with scientific expertise.” (as cited in Coll & Taylor, 2009).

This overwhelming vision of what students should be taught and learn in school led some to advocate for removal of the term as a desired outcome for science education (Fensham, 2008).

Moreover, DeBoer (2011) and Fang et al. (2010) argued that North American science education communities had not taken calls to provide an evidence base for professional practice seriously enough, leaving teachers with a laundry list of learning goals and no guidance on how to achieve them.

Regarding biology, specifically, Klymkowsky, Garvin-Doxas, and Zeilik (2003) argued that being biologically literate or having “bioliteracy” is not limited to categorizing and classifying biological terms and information, but “requires conceptual understanding, the ability
to transfer knowledge and understanding to other domains” (p. 156). They also listed introductory genetics, molecular, cellular, and developmental biology as concepts around which bioliteracy should be developed. They went on to describe the skills and knowledge possessed by students who would be, in their view, biologically literate:

“A bioliterate person not only comprehends scientific terms but has the ability and confidence to apply knowledge learned in one setting to another and to make informed judgments about new discoveries based on a solid understanding of fundamental principles (e.g., Bloom et al., 1956). Thus, bioliteracy includes a working knowledge of scientific method and practice” (p. 156).

Using this perspective to guide their own inquiry into bioliteracy teaching and learning, Maulina, (2020) specified the following six biological process skill indicators to measure changes in their subjects’ bioliteracy: observing, classifying, predicting, measuring, communicating, and drawing conclusions. They argued that these “Science Process Skills are mostly learning that emphasizes understanding of concepts” (p. 32). However, while the bioliteracy perspective acknowledges the importance of “recogniz[ing] the technical meaning of certain content and concepts” (p. 35), it mainly emphasizes the ability to apply that knowledge and skill effectively.

Today, the current Next Generation Science Standards (NGSS), released in 2013, which began construction in the early 2000’s, are performance-based standards designed to reflect the practices of science in the professional world—that is, the standards emphasize the application of scientific content, rather than just the acquisition of it. They are deliberately aligned with ELA and math standards to provide a more comprehensive education. For example, “obtaining new information from texts. . . . communicating information. . . .[and] constructing explanations” are
all explicitly written into the NGSS standards. In addition, they focus on practices that are applicable to various subject-matters within the domain of science, including physical sciences, life sciences, earth and space sciences, engineering, technology, and applications of science. The primary scientific practices outlined by the NGSS are as follows: asking questions and defining problems, developing and using models, planning and carrying out investigations, analyzing and interpreting data, using mathematics and computational thinking, constructing explanations and designing solutions, engaging in argument from evidence, and obtaining, evaluating, and communicating information.

However, these new standards ask students to think like scientists via question asking and computational thinking, but do not list specific cognitive processes. They ask students to construct models and communicate scientific information without any linguistic parameters, guidelines, or expectations. They more specifically outline sociocultural practices in which students ought to be engaged and ask them to conduct their own investigations and evaluate knowledge produced by the scientific community; yet, there are no standards that require students to examine scientific practices in comparison/contrast with other academic disciplines or home discourse communities. Moreover, NGSS standards do not emphasize that students contribute to, critique, or transform scientific knowledge. In some ways, we appear to still be in a cycle of values related to scientific literacy education—that is, the newest standards demonstrate a shift back towards turning students into mini-scientists and away from a functional, utilitarian view of scientific literacy.
Content Area Literacy (CAL).

The idea that every teacher, including science teachers, is a teacher of reading has been around since the 1920’s, and researchers established connections between reading comprehension and content area achievement throughout the 1940’s, 50’s, and 60’s, along with the realization that reading processes involved different strategies for different subjects (Anders & Guzzetti, 1996). In fact, it was as early as 1919 that W. S. Gray presented a paper at the National Education Association calling for educators to focus on specific reading skills that were necessary for successful study, and in 1927 he called for attention to reading as it relates to different school subjects. In 1925, The National Society for the Study of Education’s 25th Yearbook emphasized reading across the disciplines (Whipple, 1925), and its 36th yearbook, published in 1937, argued that reading instruction should be part of all teachers’ curriculum. In 1938, Wagner tested the legitimacy of such calls and found various positive correlations in her quantitative study of the relationship between multiple reading skills and achievement in various content-areas. She concluded that comprehension had a strong correlation to achievement. More foundational research was established throughout the 20’s and 30’s, including investigations into recall and retention (Yoakam, 1922), descriptions of work-type reading tasks (Horn, 1923), different challenges to comprehension across content areas (Ayer, 1926), the relationships between reading, learning, and content area teaching (Yoakam, 1928), and reading- to-learn (McKee, 1934).

However, because of the prevalence of behavioristic viewpoints, few innovative theoretical or practical responses to existing reading-related research were produced until the 1970s (Moore, Readence, & Rickelman, 1983). It was the cognitive revolution in psychology
that brought about notions that some reading processes might be generalizable across content areas, and publications like Herber’s (1978) *Teaching Reading in Content Areas* began to advocate for the explicit teaching of comprehension strategies in all content area classrooms. It is this thinking that informed the emergence of the Content Area Literacy instructional framework.

Content area literacy (CAL) theory is concerned with the “reading behaviors of expert comprehenders” (Neufeld, 2005, p. 303) as they make meaning from texts, which involves reading and writing to build on prior knowledge and access content specific knowledge using general literacy skills (McKenna & Robinson, 1990). One of the key premises of CAL is that “reader comprehension depends heavily on metacognition” (Urquhart & Frazee, 2012, p. 4); therefore, CAL instruction typically involves explicitly teaching students how to use cognitive reading strategies when confronted with challenging texts to help them “locate, comprehend, remember, and retrieve information that is contained in various styles of writing across the curriculum” (Moore et al., 1983, p. 420). Literacy, then, becomes integrated with the teaching/learning of subject-specific content across academic curricula (Musthafa, 1996).

Although many secondary school teachers believe literacy instruction is the English department’s responsibility (Lester, 2000), the CAL framework suggests that all teachers, including science teachers, are teachers of reading, and they should “capitalize” on reading and writing as language-mediated tools for learning (Fisher & Ivey, 2005). In other words, literacy instruction can and should be taught, reinforced, and leveraged by every content area teacher in every classroom.

In practice, content area literacy (CAL) strategies are typically implemented in three phases based on Laverick’s (2002) B-D-A reading approach. Phase one involves pre-reading
strategies that successfully activate students’ background knowledge (Vacca & Vacca, 1993) and set a purpose for reading a text (Vacca & Vacca, 2005). Phase two involves during reading strategies to help scaffold comprehension, such as interactive read-aloud (Fisher et al., 2004) or shared reading, which involve modeling thinking processes and meaning making aloud (Fisher et al., 2008). Finally, phase three incorporates after reading strategies that promote reflection and extend students’ thinking, such as summarizing, evaluating, synthesizing, commenting, and reflecting (Saricoban, 2002). Through these processes, CAL instruction “not only will serve to build reading ability but will increase knowledge acquisition and improve content learning due to students’ improved reading abilities” (Swanson et al., 2016, p. 200).

Over 30 years of research findings have supported the theory that students of all levels can comprehend content area texts, including scientific ones, if provided with CAL instruction (Bos et al., 1989; Horton et al., 1990; LeSourd, 1985; Lederer, 2000; Lyda & Duncan, 1967; Montali & Lewandowski, 1996; Weiss, 1983). Yet, disagreement among researchers has persisted regarding the focus of content area literacy instruction; some argue that it should concentrate on those generic skills that can be applied in any content area, while others contend that students need and should be provided with more content-specific skills (Moore et al., 1983).

**Disciplinary Literacy (DL)**

In 2008, Timothy and Cynthia Shanahan sought to clarify this question of general vs. specific skills instruction by proposing a model for literacy development in the form of a specialization pyramid. At the base lies basic literacy skills—those required for decoding, for example. The middle level is intermediate literacy skills—those that are common to many reading tasks, such as fluency. Finally, at the top lies what they refer to as DL skills—those that
involve highly specialized cognitive skills and strategies typically used by disciplinary experts. It is their view that CAL instruction should be dedicated to those generalizable skills, and the more advanced content-specific skills be reserved for DL instruction. However, defining the boundaries between intermediate and disciplinary skills and across content areas as well as how those skills could or should be taught sparked new disagreement among educators, theorists, and researchers.

**Cognitivist Orientation.** A cognitivist view of disciplinary literacy (DL)—those highly specialized skills at the top of the pyramid—focuses on discipline-specific cognitive processes used by experts and generalizable across the discipline that can and should be taught to students. Research on the thinking processes of disciplinary experts, such as Wineburg’s (1999) study of the historical reading processes of history professors, paved the way for similar studies and deeper understanding of the discipline-specific literacy skills that should be taught to students. Shanahan and Shanahan (2008) went a step farther in their research, conducting think-aloud readings with experts from multiple disciplines and comparing them. During their think-aloud sessions, they identified several distinct practices that reflected the specialized nature of each discipline and how those experts made meaning from disciplinary texts. The historians, for example, read with author bias in mind. They did not read the text as documented facts, but rather as an interpretation of historical events that carries inherent bias. Conversely, scientists read scientific texts without any consideration of bias. Rather, they focused on recursively using text and corresponding visual representations (graphs, charts, images, etc.) to help them understand the text and construct meaning (Shanahan & Shanahan, 2008).
McConachie et al. (2006) offer several examples of teachers who they believe have enacted DL in creative ways. Their definition of literacy is based on the DL instructional framework developed by the Institute for Learning at the University of Pittsburgh in 2002. They view DL as teaching and apprenticeship—as a means of acquiring skills necessary to access complex content knowledge in a specific discipline. Other researchers have leveraged this understanding of the unique cognitive processes in which scientists engage while making meaning with texts to inform comprehension strategy instruction for students.

Such approaches as active monitoring and regulation (Alvermann & Wilson, 2011), the Concept-Oriented Reading Instruction (CORI) (Cervetti, & Pearson, 2012), and Scientific Discovery as Dual Search (SDDS) (Zimmerman, 2000), have demonstrated usefulness in identifying processes experts use to access disciplinary texts, but assume those processes are generalizable across scientific genres. Moreover, such a cognitivist perspective on DL only addresses some of the literate practices unique to scientific disciplines. Beyond mental habits and processes of reading, DL must also address the unique language, activities/practices, norms, and values held by members of the scientific community.

**Linguistic Orientation.** There are also language-based perspectives on how disciplinary experts construct meaning through grammatical patterns and habits. After conducting functional language analysis (FLA) on disciplinary texts, Fang & Schleppegrell (2010) found, for example, that biology texts often utilize sentences with embedded clauses to compact information into dense noun phrases. This enables concise “construction of technical definitions and description of biological processes” (p. 589) but is in stark contrast with the language found in other disciplinary texts. Drawing attention to these differences, Fang & Schleppegrell (2010) also
analyzed the language of historical texts. Here, it is common practice to use “nominalizations [to] repackage processes (normally expressed by verbs) and qualities (normally expressed by adjectives) into things (expressed in nouns)” (p. 589). This approach enables the author to bundle, relate, and evaluate events that occurred over time through connotative language while maintaining concision.

Fang & Coatoam (2013) contribute to the linguistic perspective on DL by defining it as the “ability to engage in social, semiotic, and cognitive practices” consistent with those used by content experts” (p. 628). He goes further to explicate the foundational beliefs behind his understanding of DL: “(a) school subjects are disciplinary discourses recontextualized for educational purposes; (b) disciplines differ not just in content but also in the ways this content is produced, communicated, evaluated, and renovated; (c) disciplinary practices such as reading and writing are best learned and taught within each discipline; and (d) being literate in a discipline means understanding of both disciplinary content and disciplinary habits of mind (i.e., ways of reading, writing, viewing, speaking, thinking, reasoning, and critiquing).

Fang (2010) argued that DL in science would require attention to more than just the cognitive processes of scientists, but to the specific grammatical patterns and presented formats across scientific texts, suggesting that these linguistic habits are just as important as the cognitive processes. For example, in addition to being riddled with dense noun phrases, scientific texts tend to integrate verbal and visual forms of representation to create multisemiotic texts. Making meaning with such complex forms of representation would require “teaching about the use of language of science” as “central to the process of learning science” (Fang, 2005). However, this linguistic perspective of DL requires science teachers to have some foundational linguistic
knowledge, which most likely do not. This perspective also fails to account for non-linguistic practices, values, and norms unique to scientific communities.

**Sociocultural Orientation.** Billman and Pearson (2013) offer a five-point definition for DL that considers sociocultural perspectives on learning. First, they assert “knowledge and insight, not just more finely-honed skills, should always be the result of participation in a literacy activity” (p. 25). Second, students already possess knowledge that can be used as resources for disciplinary learning. Third, literacy and literate skills are the means to content knowledge, not the ends of learning. Fourth, texts are not the only source of disciplinary knowledge. Fifth, participation is central to disciplinary knowledge acquisition.

Moje (2015) described disciplines as communities of practice that have developed discourses central to the acquisition of the literate practices of a discipline. She critiqued skills-based literacy teaching as reducing disciplinary concepts to “stuff” that can just be memorized. She argued instead that teachers should focus on the disciplinary practices and authentic experiences that teachers facilitate as experts. However, those disciplinary practices are not static or fixed within enclosed disciplinary spaces; they are fluid and constantly being changed and influenced by participants within that disciplinary community. Therefore, Prior & Bilbro (2012) argued that teachers should attempt to enculture students into disciplinary communities of practice by focusing on disciplinarity—the “open-ended, sociohistorical processes that produce, represent, and contest disciplinary practices and identities (p. 3). In this way, students can gradually acquire the “totality of processes that are involved in the ongoing production of cultural forms of life” (p. 2), which include “ongoing negotiations of disciplinary practice” (p. 3). Therefore, it is the cultural knowledge attained, what students do as they engage in disciplinary
work, and how their identities are shaped and developed in the process that drives enculturation into disciplinary communities of practice.

Building on the ideas of socioculturalists like Bhabha (2012), Soja & Chouinard, (1999), and Gutiérrez (2008), Moje et al. (2004) explored a pedagogical approach to enacting DL enculturation by creating an environment where the languages and practices of the academic space were equally valued and hybridized with the language and practices (funds of knowledge) of students’ home-based cultures and communities to create a new socially transformative space. This space allowed for students to make meaningful connections between the science curriculum and the science of their own everyday lives, highlighting the practices in which they and experts both engage. Moreover, it allowed students to see themselves as having scientific identities, fostering a metadiscursive awareness of the discourse communities in which they engage and the processes/practices that distinguish them.

In this way, socioculturalists have made room for what cognitivists and linguists have not – the social and activity-based practices that are unique to the scientific community. However, like the cognitivist and linguistic perspectives, socioculturalists still concern themselves with accessing and applying scientific knowledge. All three orientations position students as scientific tourists—outsiders who can merely visit science-town and look around, if they have the skills to understand what they are looking at. These orientations are less concerned with contributing to, critiquing, or transforming scientific practices and knowledge itself.

**Critical Orientation.** Moje (2008), however, also called for a more expansive view of DL, conceptualizing it as a question of “learning the different knowledge and ways of knowing, doing, believing, and communicating that are privileged” among the disciplines (p. 99). She
suggests DL should focus on more than access to disciplinary knowledge, but the means of knowledge production and criticism within the disciplines in order to empower students.

In 2008, Moje distinguished between two terms: socially just instruction (instruction that provides students equitable access to mainstream knowledge) and instruction that produces social justice (instruction that allows students to critique knowledge and even transform it). In order to do this, students must be provided with opportunities to examine the relationship between their everyday discourses and identities and those of the academic disciplines, and to try out new identities. In this way, students can develop a metadiscursive awareness of the identities they enact in various contexts and the social positioning/power relations associated with those engagements. It is a humanizing approach to DL instruction that can deepen students’ “awareness of the tools of oppression and of their inherent worth” (Wilder & Msseemmaa, 2019, p. 1). It is an approach that can elevate their consciousness of that which seeks to deprive them of their humanity, connecting “the will to know with the will to become” (Wilder & Msseemmaa, 2019, p. 423). It is this critical perspective that speaks most directly to a more equitable education system and offers students the most practical incentive/motivation for engaging in the work of doing science—personal empowerment. However, on its own, a critical orientation does not provide students with any specific habits of mind, social practices, or ways of communicating that make such transformative participation possible.

**Summary.** Cognitivists contribute to our understanding of the habits of mind and cognitive processes in which disciplinary experts engage, informing cognitive strategy instruction for science educators. Linguists contribute to our understanding of the language-based patterns that constitute acceptable modes of discourse among scientific communities,
informing methods of scaffolding student analysis of scientific texts. Socioculturalists add the importance of participation in and among communities of practice and highlighted the value of students’ background knowledge. And, a critical orientation aims to convert students into full-fledged members of the scientific community by allowing them to contribute to, challenge, and transform scientific knowledge and communities themselves. However, the first three orientations ask students to role-play, and a critical orientation does not provide students with any specific habits of mind, social practices, or ways of communicating that make transformative participation possible. Doing so would actually require the contribution of all four perspectives on DL.

**Genre-Oriented Activity Theory (GOAT).**

As Fang (2012a) explained, the four DL orientations “are not mutually exclusive, however; they complement one another in ways that allow teachers to tailor instruction to student needs” (p. 107). Without an integrated synergy of these four approaches, inherent challenges present themselves to any educator attempting to enact DL instruction. First, teachers are left to figure out on their own how to blend these theories into a comprehensible framework to inform their own instruction. Second, understandings of how DL informed instruction should be enacted will grow as fragmented as their underlying theory. Reconciling these approaches will help bring greater attention to how texts are used in disciplinary communities of practice and how teachers can better support the disciplinary literacy development of their students. One proposed method of integrating these orientations is by supplanting them within a broader interactive framework (Activity Theory). By thinking of disciplines as analogous to text genres and filtering all four DL orientations through an Activity Theory lens, disciplinary instruction can be viewed as typified
systems (genres) in which each component represents one of the four DL approaches and contributes equally to the produced outcome of instructional activity (Fisher, 2019). In other words, Genre-Oriented Activity Theory, specifically, can be the thread that binds all four perspectives on disciplinary literacy while explaining how disciplines themselves are developed over time.

**Activity Theory (AT).** Extending the work of Vygotsky (1981), Engeström (1987) posited that learning occurs through interactive activity systems. Individuals form goals and—based on the complex interactions between discrete elements of the systems in which they are situated (contexts)—identify contradictions, which require creative solutions in order to achieve the desired outcome. According to Engeström (1987), those discrete components of a given activity system include subject (the individual actor), object (goal or motive driving the activity), mediational tools (texts used to facilitate the achievement of those goals and motives), and outcomes (the product of the activity). Through repeated cycles of situated action and negotiation, solutions to conflicts among those interactive components and the produced outcomes become internalized by the actor, informing their practices in future activity systems, contributing to the development of existing activity systems, and creating new ones. In this way, knowledge, creativity, and learning are expanded through constant situated action/participation.

Reading a novel, then, is an example of an activity in which the reader is the actor (subject), the novel itself is the mediating tool, and the purpose or goal of personal entertainment is the object. After completing the activity, the produced outcome should align with the object of the activity—that is, the reader should feel entertained. If the reader was not entertained as an outcome of the activity, that means there was a contradiction among two or more of the
components of the activity. Perhaps there was a contradiction between the subject and mediational tool; maybe the novel was written in antiquated language, making it difficult for the reader to even comprehend the story, never mind being entertained by it. Perhaps there was a contradiction between the mediational tool and object; maybe the reader wanted to be entertained, but the world atlas they checked out at the library actually caused them to feel bored and confused after reading. Whatever the case, the actor must negotiate these contradictions if they want to achieve the desired outcome of entertainment. So, they might keep a dictionary handy when reading the antiquated drama, adding a supplementary tool to help them understand the story and be entertained. Or, they might choose to put down the atlas in exchange for a comedy, a mediational tool better aligned with the purpose of entertainment. In these negotiations, solutions become internalized and, over time and through repetition, inform more refined activity pursuant to set goals and purposes. The reader in this example would learn over time and through repeated activity and negotiation (reading) what books they might find entertaining, what books are boring, what genres of novel incite laughter, suspense, curiosity, fear, etc. In short, they would learn how to better achieve the desired outcome of entertainment via the activity of reading.

**The Emergence of Genres and Disciplines.** However, the actor in an activity system does not do so in complete isolation. As Russell (1997) explained, reading and writing are mediated activity within a broader system. When a person reads or writes, they are entering an interaction between their own ideas and the tool mediating their ideas through meaningful symbols (words) that were written by or are read by people from communities with specific values and for specific purposes. Each time an individual reads or writes (acts), their ideas,
purposes, and language will change with the context. These elements will also change in response to the produced outcomes of previous activity and negotiated solutions to contradictions within their past literate activities. Yet, in similar contexts, similar motives for activity and contradictions within activity systems tend to recur. In these cases, over time, typified solutions and produced outcomes emerge. Regarding texts, these typified solutions lead to outcomes that often take the form of genres, which can be defined as “tool-mediated ways of purposefully and dialectically interacting among people in some social practice (and across various linked social practices), some activity system(s)” (p. 6). In other words, when enough people with similar values read and write for similar purposes in similar contexts over enough time, they begin to produce similar texts. Therefore, activity systems produce genres over time, and genres shape the nature of activity within those systems.

The variety of genres produced by typified activity emerges from various disciplinary contexts. Bazerman (1988), for example, explains the origins of scientific writing, specifically, and how norms and practices were developed over time and as a consequence of social activity within that community of practice. Early scientists, who were unable to visually observe or verify the results of others’ experiments due to physical separation, started a system of letter writing that became increasingly empirical in its descriptions over time. This was necessary in order to ensure methodological rigor and validity, as well as replicability. In this way, mediated action accumulated historically to shape the scientific discipline, its values, and its literate practices to form a typified system of writing (text genre) we now call lab reports.

However, from this perspective, a genre of texts is not just the product of historically typified mediation of language in a recurring disciplinary context. A disciplinary text (genre), in
effect, is a map of the activity system that produced it. Within each genre of texts is embodied all
the elements of the activity system by which it was created. The lab report, then, is a tool that
reflects scientific ideas in addition to the language, values, processes, and motives shared by
scientific communities. The clarity and concision of scientific genres reflect the values of
empiricism and replicability in the scientific discipline. Those values reflect a history of problem
solving unique to scientists. In this way, disciplines themselves (e.g., scientific communities of
practice) can and are also developed through this same process of typification. The repetition of
activity pursuant to similar goals using similar tools in similar ways under similar circumstance
over time leads to a loosely defined set of shared norms, values, and processes that bind
individuals and scientific communities. Disciplines, thusly, are analogous to text genres.

Reconciling Four Disciplinary Literacy (DL) Orientations. Using Engeström’s (1987)
earlier and more simplified model of activity systems, Russell’s (1997) genre framework
includes four major components that parallel the four major orientations toward DL (See Figure
1). First, Russell’s “subject” is the individual acting in the larger system whose behavior is being
studied. Similarly, cognitivists are concerned with the mental processes of the individual as they
engage in disciplinary activity. The subject is the mind in action. Second, Russell’s “mediational
means/tools” characterizes the language and other mediums used in the system for learning—a
clear parallel with linguistic perspectives of DL. Tools and texts alike carry information that
require decoding on the part of the user. While the linguistic orientation is primarily concerned
with grammatical patterns in disciplinary speech and writing, disciplinary communities of
practice produce specific disciplinary genres in locally situated contexts. Attending to the
genres—and all they entail—illuminates the disciplinary knowledge demands facing teachers
(and students) in the disciplinary community of practice. Third, Russell’s “object and motive” constitute the shared purpose that determines the direction of the activity. This idea aligns well with a view of disciplines as communities of practice—a sociocultural perspective that is concerned with shared norms, values, goals, purposes, and practices/activities. Finally, Russell’s “outcomes”—which are sometimes achieved via newly created solutions to contradictions—often take the form of genres as both mediating tools within and consequences of an activity system. The product of the activity—which reflects a contribution on the students’ part to the production of knowledge in the discipline—then serves as another tool to help mediate the subject’s navigation across boundaries between other activity systems/genres/disciplines (Fisher, 2018) in the future and construct new identities as they become aware of the various contexts and the social positioning/power relations associated with those engagements (Moje, 2008). While Engeström (2015) did acknowledge that there was more involved in human activity systems than subject, mediating tools, and object alone, he argued that a simplified view of the activity system may “naturally be useful when applied in contexts” (p. 65). From this perspective, simplified reconstructions of local activity systems themselves can be valuable units of analysis for examining and deconstructing disciplinary instructional activity using all four (cognitive, linguistic, sociocultural, and critical) DL orientations.
For educators, this framework can be used to design authentic scientific activities for their students. Attention to the four elements of the activity system they construct and the corresponding orientations toward DL can help teachers provide students with learning experiences that more closely resemble the practices of real-world scientists. They can address the cognitive, linguistic, sociocultural, and critical concerns of DL instruction by infusing the activity system with elements that directly address each of those orientations.

From this perspective, DL instruction can be viewed as learning activities engaged in by individuals who bring schema into the system and apply cognitive processes with a purpose/motivation that is shared by other members of a disciplinary community, mediated by language-based tools that are codified into genres, producing outcomes that overlap with and contradict other activity systems with shared points of attachment, highlighting boundaries between discourse communities (disciplines), and fostering metadiscursive awareness. Key teaching practices, then, would include activating schema and modeling disciplinary thinking.
(cognitive), purposefully selecting and deconstructing mediating tools (linguistic), designing authentic scientific tasks where students’ and disciplinary experts’ motives/purposes align (sociocultural), and engaging students in reflection on activity system outcomes in relation to other similar activity systems and contexts (critical).

**Secondary Science Classroom as an Activity System.** From a GOAT perspective then, teachers come to the classroom as former and current participants in various science and education-based activity systems. Their individual experiences represent their participatory knowledge of those typified, socially mediated activities across scientific and pedagogical communities of practice. However, because secondary classrooms differ so greatly from other scientific contexts, and students come to science classrooms with such wide variety of schema and experience, teaching for DL would involve purposeful manipulation of individual components of a classroom activity system to reflect the typified mediational practices among select scientific communities of practice. To accomplish this, teachers must consider a multitude of potential factors that could lead to tensions and contradictions in their practice. Negotiating those obstacles to enhance student learning would require a deep knowledge of the subject (student), object (disciplinary norms, values, goals, purposes, processes, and practices/activities), mediating artifacts (disciplinary tools and texts), and desired outcomes (content-specific knowledge, texts or tools, and disciplinary skills) within their teaching context.

**Disciplinary Literacy Pedagogical Content Knowledge (DLPCK)**

In 1986, Shulman proposed a theoretical framework for understanding and defining teacher knowledge called Pedagogical Content Knowledge (PCK). PCK identified the specific components of teacher knowledge as subject-matter (content) knowledge, pedagogical
knowledge, and knowledge of the curriculum. The blending of these knowledges, along with knowledge of students, knowledge of context, and knowledge of educational goals, allow teachers to produce the “most useful forms of representations of ideas, the most powerful analogies, illustrations, examples, and demonstrations—in a word, the most useful ways of representing and formulating the subject that makes it comprehensive to others” (Shulman, 1987, p. 39). Understanding “how to present content area information and what makes learning in a specific discipline easy or hard for students” are essential components of teachers’ PCK (Saraceno, 2019, p. 27). Simply put, PCK is knowing what to teach and how.

While DL is concerned with the literate practices that distinguish domains and their constituent disciplinary communities of practice, DL instruction is concerned with the teaching of those literate practices. To do so requires, “understanding of the relationship between how classroom instruction and student learning transform in response to the content area information being learned and its connection to the various ways of reading, thinking, and knowing that are connected to a specific discipline” (Saraceno, 2019, p. 94). This broadens the scope of subject-matter (content) knowledge—what teachers teach—from “the amount and organization of knowledge per se in the mind of the teacher” (Shulman, 1986, p. 9) to include domain and discipline-specific processes such as “developing and activating schema, understanding vocabulary and concepts, metacognition, awareness of text structures and genre, adopting a reader stance, and engagement in goal-directed learning” that are germane to a disciplinary community of practice (Carney & Indirisano, 2013, p. 43). In other words, it requires a great deal of disciplinary expertise.
This expanded view of teachers’ content knowledge (integrated with pedagogical knowledge and knowledge of the students and context) constitutes what the International Reading Association (2015) refers to as Disciplinary Literacy Pedagogical Content Knowledge (DLPCK). The possession of disciplinary process knowledge as described by Shulman (1986) enables teachers to teach with flexibility and provide students with subject-matter knowledge similar to the ways in which disciplinary experts interact with texts (Carney & Indirisano, 2013). In short, teachers must possess DLPCK in order to enact authentic DL instruction.

However, if scientific knowledge is constructed via situated activity (Engeström, 1999) among scientific communities of practices, it would follow that, in order to acquire the process knowledge component of DLPCK, teachers must also participate or have had participated in scientific activity systems themselves. Saraceno’s (2019) study of two middle grades science teachers’ DL instruction reflected this sentiment, as she concluded that teachers needed additional pre-service training, job-embedded professional development, and collegial support to grow their DLPCK. She argued that part of this knowledge growth required “teachers to think of themselves as disciplinary insiders who help their students navigate complex texts in a given discipline” (p. 194). She continued to assert that “as disciplinary insiders, teachers need a full understanding of the different types of literacies and DL skills needed to read, write, speak, and think critically about texts like an expert in a given field of study” (p. 194). In other words, science teachers must be acutely familiar with the activity systems of expert scientists to effectively enact DL instruction in secondary science contexts.

**Teacher Preparation and Alternative Certification.** However, not all secondary science teachers have had authentic experience working in scientific communities or even
“experienced the processes of inquiry” (Brown & Melear, 2007)—genuinely doing science; nor have they all had coursework or training in literacy (Lewis-Spector, 2016). Those who become secondary science teachers through alternative certification programs such as the American Board for the Certification of Teacher Excellence (ABCTE), Teach for America, or the National Board for Professional Teaching Standards (NBPTS), on the other hand, are often baccalaureate degree holding graduates from disciplines outside of education or career changers from science-based occupations. In fact, approximately half of teachers who go through alternative certification programs did so after leaving previous careers in a nonteaching field (Shen, 1997). These teachers, “because of their experience . . . [,] might be more knowledgeable about their subject matter than many traditionally certified teachers” (Brenner et al, 2015, p. 41)—possibly possessing a stronger fluency in the discourse of the community, deeper understanding of the structure and nature of their discipline, and a closer connection to the practical applications of the field. However, despite “704 different entities … providing alternate route certification” (Walsh & Jacobs, 2007) across the nation as of 2014, science teachers are still in particularly high demand, and challenges to staffing have persisted since the last Education Commission report on national teacher shortages in 2003 (Aragon, 2016).

Summary

For the last century, views on literacy in science have been divided. Many disagree over the ultimate goals of science education. Some believe its purpose is to provide the common man with functional knowledge to understand science so far as it relates to his own life. Others feel, as an issue of equity, that creating in all students a scientific disposition empowers them to influence the world around them and their own position in it. Some argue that knowledge of
literacy skills should be taught in addition to subject-specific knowledge, while others suggest they are one in the same. However, most agree that for different reasons, our education system has an obligation to improve the science literacy learning of students.

Moreover, with an increased demand for science teachers—shortages in 43 states (Sutcher et al., 2019)—and with a rise in teachers certified through alternative education programs—up to 18% in public schools as of 2016 (The Condition of Education, 2018)—there is also an imperative to consider how prospective science teachers are trained and how their science instruction can be better supported. Although some strides have been made in the field of Content Area Literacy, with an ever-growing bank of generalizable strategies for teachers to exercise with students, DL theorists and researchers have been slow to consolidate their views or provide guidance on how to address those specialized literacy skills that distinguish the sciences from other disciplines. The field of DL is theoretically fragmented—torn between cognitive, linguistic, sociocultural, and critical orientations—and has yet to produce a practical framework for implementation.

However, through a Genre-Oriented Activity Theory lens, one can observe DL instruction as an activity system—a contextualized interaction among variables that align with each of the four major theoretical orientations toward DL. In this way, each orientation becomes consolidated and represented by one all-encompassing theory. For such a theory to inform classroom instruction, though, the teacher must be knowledgeable regarding all variables in the system, not just knowledge of content and pedagogy. Only with a deep knowledge of each component can purposeful responses to contradictions that arise in the activity system of DL teaching be made in pursuit of desired learning outcomes. This includes knowledge of the
subject (student), object (disciplinary norms, values, goals, purposes, processes, and
practices/activities), mediating artifacts (disciplinary tools and texts), and desired outcomes
(content-specific knowledge, texts or tools, and disciplinary skills) within their teaching context.
To date, there have been no studies examining DL instruction through a GOAT lens, and only 2
science teachers in one study (Saraceno, 2019) have been examined through a DLPCK lens. This
study aims to fill that gap in the literature by examining the contradictions teachers with
specialized disciplinary process knowledge and experience encounter within their own
instructional activity systems in pursuit of discipline-specific student learning outcomes and the
knowledges they employ to negotiate solutions to those challenges.
Chapter 3: Research Methodology

With a unified theory of DL, and an understanding of the knowledge teachers must have to enact DL instruction, this study seeks to explore the ways in which career-changing, non-traditional teachers integrate their knowledge bases to navigate teaching challenges in an attempt to support the literacy development of students in science—particularly teachers with previous experience with and knowledge of literate practices and processes within scientific communities of practice.

Underlying Assumptions About Research

My approach to this study of career-changing, non-traditional secondary science teachers was influenced by several underlying assumptions. First, it is my view that meaning is socially constructed through actions mediated by culturally and historically situated tools and artifacts (Vygotsky, 1978). I also believe that language is an integral mediating tool for meaning making, and that individuals construct their own reality through social interaction (Merriam, 1998). As a researcher and observer, I served as the primary interpretive instrument, and my goal was to understand each participant’s perspective on teaching DL in secondary science school contexts. Lastly, this study produced rich descriptions of how each teacher negotiated solutions to any challenges that arose in their attempts to enact DL instruction to support the literacy learning of adolescents in their secondary science classrooms.

Case Study Design

To better understand how career-changing, non-traditional secondary science teachers attempt to negotiate DL instruction, this investigation followed a holistic multiple case study design (Yin, 2014). The participants selected for this design type were three individual teachers
situated in three different secondary science classrooms at the same high school. As members of a specific group (career-changing, non-traditional secondary science teachers) and examples of the target phenomenon of teaching DL to secondary students, this collection of teacher cases constitutes the “quintain” of this study—the common characteristics that categorically bind cases together (Stake, 2006). In order to understand the quintain more thoroughly, I studied it by means of a multicase study because the collective whole exhibits the target phenomenon better than one individual case can.

Case study is more appropriate than other research designs for this investigation because it is “interested in insight, discovery, and interpretation rather than hypothesis testing” (Merriam, 1998, p. 29). As a methodology, it “is an empirical inquiry that investigates a contemporary phenomenon within its real-life context” (Yin, 2014). The investigated phenomenon, or each case in this study, was viewed as one among other systems (Stake, 1995) that were intrinsically bounded by that real-life context (Miles & Huberman, 1994). In this study, career-changing non-traditional secondary science teachers were a unit around which there were boundaries and was bound to secondary school contexts. This study did not seek to discover any causal relationships as in explanatory case studies—although the research base does lack studies that address the effectiveness of DL instruction— but instead aspired to generate rich descriptions and new theoretical understandings where an existing theory of DL instruction is incomplete or insufficient (Yin, 2014). This study explored specifically how each teacher attempted to enact DL instruction, how tensions complicated their efforts, and how each teacher negotiated those tensions in practice. Therefore, this focus on the how related to DL instruction among career-
changing, non-traditional secondary science teachers in their natural contexts made case study a logical methodological choice for this research study.

Using the multiple holistic case studies approach (Yin, 2014), I observed the practice of three career-changing, non-traditional secondary science teachers as they each attempted to support the scientific literacy development of their students over five weeks. Thus, I defined the case as the multi-week DL instruction of the participating teachers. It was the participants’ perspectives on their own instructional practices that was most important to this investigation. My goal was to understand the "immediate and local meanings of actions as defined from the actor's point of view" (Erickson, 1986, p. 119). Therefore, I employed methods that helped illuminate different perceptions and interpretations that constituted their “ecological circumstances” (Erickson, 1986, p. 121).

Case study inquiry acknowledges that there will be “many more variables of interest than data points” and that the researcher must “rely on multiple sources of evidence” (Yin, 2008, p. 18). Because I believe that learning occurs through interactive activity systems (Engeström, 1999), the phenomenon or process of DL education in secondary school contexts in action (three career-changing, non-traditional secondary science teachers’ instructional practices) served as my unit of analysis. Classroom observations of teachers’ instructional practices and the pedagogical tools they used, debriefing conversations, and semi structured interviews with the participants all provided opportunities to understand how DL instruction can and cannot be enacted in secondary science classrooms from the perspective of participants.

The phenomenon of teaching for DL was bound (Meriam, 1998) by three criteria. First, cases were bound by the domain of the participants’ subject-matter expertise as teachers
(science). Secondly, each case was bound to a minimum of one complete unit of instruction on a similar topic (two to five weeks) as the other participants. Lastly, in all three teaching cases in this study, an individual site classroom also bounded each case. Though each participant may have employed different instructional methods and approaches with different classes, the site classrooms and school schedule provided the physical, temporal, and spatial boundaries of each case—that is, the target phenomenon (DL instruction of each teacher) was observed with a single group of students during the same regular class period for each participant.

**Review of Purpose and Research Questions**

The aim of these three teaching case studies was to generate new knowledge about DL teaching efforts in secondary science. By using the words and actions of the participants to represent these cases, I focused on how a specific group of people navigated specific problems (Shaw, 1978). Because the cases and questions involved in this study were unique, the knowledge produced from it is concrete and contextual (Stake, 1981). Through rich descriptions of DL instruction efforts, I highlight the complexities of DL instruction in these specific contexts, and, in turn, complicate underlying assumptions about DL, teacher knowledge, and secondary science education. This study aimed to help readers question their currently held assumptions concerning DL teaching in their own contexts after reading these three cases.

The assumptions that undergird DL theory require further scrutiny because they do not always hold true. Existing theory and research, as described above, are grounded in an assumption that the classroom teacher is the disciplinary expert in an expert-novice relationship with students—teaching more than just the traditional academic content, but the discipline-specific critical, social, linguistic, and cognitive practices/processes that experts use to access
and critique knowledge produced by and valued within their field (Moje, 2007; Moje et al., 2004; Fang & Coatoam, 2013; Shanahan & Shanahan, 2008). Teachers are charged with apprenticing their students into the communities of practice (Wenger, 1999) that constitute the disciplines on which their content areas are based. Yet, it is not always the case that teachers have knowledge of, or experience engaging in discipline-specific practices and processes that DL theory calls for them to teach. There is a difference between having knowledge about science and knowing how to do science. Most science teachers are not actual scientists, and classrooms differ from non-academic disciplinary spaces in significant ways. Unlike professional scientists, teachers must blend pedagogical knowledge with subject-matter knowledge to make disciplinary information comprehensible to students (Shulman, 1986). Moreover, teachers’ and scientists’ subject-matter knowledge are often organized and used differently (Cochran, 1997). In other words, the dominant, expert-novice/apprenticeship view of DL assumes educators can teach practices and processes in which they themselves may not engage and enculture students into a community of practice to which they themselves may not belong.

Even more challenging is that the field of DL has remained highly theorized — that is, most publications continue to argue the need for a disciplinary perspective or describe how disciplines “differ in content, epistemology, language use, and habits of mind” (Fang & Coatoam, 2013, p. 629). Meanwhile, teachers have been left to find their own answers to the question: How do I actually put this theory into practice? Therefore, the purpose of this study is to explore the challenges former scientific experts, who have changed careers to secondary science education, face and how they leverage their real-world disciplinary experience and knowledge to support the DL of students. With a limited literature base on which teachers can
draw for examples of how DL theory can be translated to practice, a close examination of non-
traditional teachers who have professional disciplinary experience may present “the greatest
possibility of what we can learn” (Stake, 1995, p.4) about how to apprentice students into
disciplinary communities of practice.

I did not enter into this study with a complete view of DL instruction, but instead attempted to
pursue “deliberate lines of inquiry even though those lines could shift in response to events”
(Erickson, 1986, p. 121). I questioned and complicated my existing assumptions about DL
theory, the tensions involved in translating DL theory to practice, and the role teacher knowledge
plays in DL instruction for secondary students. For this investigation, my aim to understand the
complexities of DL instruction in secondary science, specifically, was guided by the following
research questions:

1. What are the subjects, objects, mediational tools, and outcomes that constitute the
disciplinary literacy teaching context of career-changing, non-traditional secondary
science teachers?
   o What do they themselves believe it means to be literate in their discipline?
   o What skills, practices, and knowledge do they value as members of scientific
     communities of practice?

2. What contradictions do career-changing, non-traditional secondary science teachers
   identify and experience within their disciplinary literacy teaching context?
   o How are these contradictions identified?
   o What factors contribute to these contradictions?
3. How do career-changing, non-traditional secondary science teachers negotiate solutions to contradictions and tensions within their disciplinary literacy teaching context?
   - What knowledge and experience informs their pedagogical choices?
   - What tools, resources, and environments do they use to support disciplinary learning?

By investigating these questions using case study methodology, I hope to shed light on the ways in which science teachers attempt to teach disciplinary literacy, what makes the planning and implementation of their instructional designs difficult, what they do to mitigate those challenges, and where/how they learned the skills and tools that enable their mitigation. The answers to these questions can inform future research in the field of disciplinary literacy theory and practice, training and professional development for science teachers, and policy decisions for administrators and other educational leaders.

**Research Methods**

My own work supporting faculty-led projects between the university and local school districts provided opportunities for me to meet teachers, literacy coaches, curriculum coordinators, and administrators in a variety of contexts. It is through this network of colleagues that I found district-level educators who cared deeply about improving literacy instruction for their students and were eager to introduce me to other educators from their district in support of my search for research participants.

**Personal Standpoint and Ethical Considerations.** During my investigation, I was mindful of how I positioned myself as well as how I was positioned by others (Dyson & Genishi, 2005) because those positionalities framed the understandings I constructed with participants.
They informed the questions I asked, the data on which I chose to focus, how I interacted with participants and others in the school contexts, and the assumptions I developed about how DL instruction was being negotiated. I approached this investigation with the acknowledgement that a subjective lens filtered my interpretation of the data collected from this study (Heider, 1988), but subjected those interpretations and resulting assumptions to critical scrutiny (Erickson, 1986). The following is a brief account of my subjectivity as I approached this study and how that may have influenced the roles that I occupied in this study.

**My Disciplinary Background.** The sole researcher in this study, I am a PhD candidate in Literacy, Language, & Culture and a former Horry County, SC high school English Language Arts teacher with a Master of Arts in Teaching (M.A.T.) and bachelor’s degree in English from Coastal Carolina University. I have a secondary education background in Engineering Sciences (www.pltw.org), and a professional background in Engineering and Health Sciences. I have never taught science content to secondary students in a school setting, nor have I worked in the same scientific fields as the participants. As a certified personal trainer, fitness instructor, and private athletic coach, I did gain experience teaching scientific content to clients in gym settings. And, as a product of a high school engineering academy and former junior draftsman for a manufacturing company, I have participated in advanced scientific coursework, including subjects such as Principles of Engineering and Design, Computer Aided Drafting, Digital Electronics, Software Applications, Computer Integrated Manufacturing Sciences, as well as Honors, Advanced Placement, and college-level Physics, Chemistry, and Biology. In these spaces, I learned primarily through guided practice and hands-on experience as I was constantly traversing across scientific activity systems—actively participating in scientific communities of
practice. Through observing other trainers in the gym interact with clients, and consciously taking opportunities to practice interacting with them myself, I was able to build and educate a client base so that they could achieve their fitness goals. Through apprenticeships, formative design processes, and guided inquiry, I developed problem solving skills and a deep value for participation-based learning/instruction. In was in these contexts that I learned how to do science.

Local History. In my third year as a doctoral student of Literacy, Language, & Culture at Clemson University (2018), I had my first opportunity to interact with secondary schools in the local Glenwood County, South Carolina school district. I was asked to assist with a research study into the impact of vocabulary interventions on student performance in reading at a local middle school. Leading up to the study, I spent several weeks visiting the school, meeting teachers, growing familiar with administrators, and making myself familiar to students. Then, I helped support the vocabulary instruction of a group of ELA teachers for one semester, administered pre and post assessments, and discussed recommendations for vocabulary-specific resource allocation based on research findings. In this way, I was primarily positioned as an outside resource by the teachers during the study and by the administrators thereafter. This had been my only research-based experience with local schools and officials and gave me the impression that improving literacy education in this district was a priority.

My Researcher Role. My role in this study was limited to observer and interviewer. I did not maintain any relationships with participants outside of this investigation. My ontology, epistemology, and axiology as a researcher positioned me relative to the social contexts in which I was an observer (Schwandt et al., 2007). My own beliefs regarding literacy instruction shaped
the lenses used to observe teacher practices. I believe DL instruction should involve approximating disciplinary activity systems using disciplinary texts as mediating tools to achieve disciplinary goals that are purposeful, meaningful, and relevant to the lives of students. Moreover, such instruction should provide equitable access to disciplinary knowledge as well as promote equity by empowering students to become contributing members of disciplinary communities of practice (Moje, 2015). I believe that too many schools are attempting to standardize curriculum and instruction, which devalues the expertise of teachers. Moreover, I believe DL instruction necessitates context-specific approaches that are only possible when teachers utilize their full range of local, disciplinary, and pedagogical expertise. Because individual students’ literacy needs cannot be generalized, the onus falls on teachers to design instruction that reflects disciplinary activity systems as much as possible while remaining critically responsive to each pupil.

During this study, I did not act in any consulting capacities—that is, I did not offer any advice or pedagogical guidance to teacher participants. I did not participate in any of the activities engaged in by the teachers. In addition, the teachers and I negotiated seating location, time, and frequency of observations and interviews in order to reduce the impact my presence had on participants’ normal activity.

**Site and Participant Selection.** For this study, I used mixed purposeful sampling (Miles & Huberman, 1994) to select teacher participants. I relied on my relationships with local educators to access a convenience sample of secondary schools that would be interested in participating in this study. Then, criterion sampling was used to identify career-changing, non-traditional science teachers at those schools. Finally, opportunistic sampling was used to identify
teachers whose long-range instructional plan included at least one two-week unit on a topic that aligns with their disciplinary experience. Each of the three teachers in this study had some degree of exposure to DL theory in the past and sought to impact the literacy and learning of their students.

Situated around a large Southeastern city, Glenwood School district boasts 14 National Blue-Ribbon Schools, 9 Newsweek's Best High Schools, 21 Carolina First Palmetto's Finest Schools, 48 Red Carpet Schools, and 29 National PTA Schools of Excellence (Glennwood.k12.sc.us). The district has a designated Read to Succeed leadership team and an explicit strategic plan to improve student achievement, including an emphasis on literacy development. In addition, the district has established collaborative relationships with Clemson University faculty to provide ongoing professional development in literacy to secondary content area teachers. With a total of 75,000 students attending 106 schools, it is the largest school district in the state of South Carolina and the 44th largest in the country (nces.ed.gov).

Teachers in the participating school district are the product of a variety of teacher certification pathways. In addition to traditional college-based teacher certification programs, many Glenwood County teachers come through alternative routes. South Carolina recognizes the credentials of teachers who earned their license through the American Board, Program of Alternative Certification for Educators (PACE), Teach for America (TFA), and Teachers of Tomorrow (ToT). South Carolina also has at least two of its own state teacher certification programs. The Center for Educator Recruitment, Retention and Advancement (CERRA) at Winthrop University reported that South Carolina schools hired a total of 433 teachers through alternative certification programs such as these just in the fall of 2016. Such a high number may
be a consequence of teacher retention problems, as CERRA also reported 481 vacant teaching positions across the state around the same time. Researchers noted that teacher shortages are especially high in rural schools and for subject areas like science (cerra.org).

**Park Forest High School.** Located in rural upstate, South Carolina, Park Forest High is a large comprehensive high school with 98 teachers serving 1,784 students. It is one of nine total high schools in the district. According to the 2015 South Carolina State Board of Education School Report Card, Park Forest graduated 68% of all seniors at the conclusion of the 2014-2015 school year. Park Forest features an International Baccalaureate Diploma Program, Advanced Placement Program, Dual Credit Program with Glenwood Technical College and a local University, Dual Credit Teacher Cadet Program, and an Occupational Diploma Program. However, of 11th graders who took the ACT college readiness assessment in 2015, 47% met the benchmark score for English, 24% for math, 26% for reading, and just 17% for science. Consequently, Park Forest has failed to earn any state academic honors or awards since 2013.

**Park Forest Biology Department.** The biology department at Park Forest High school engaged in common assessment and common planning for their college prep and honors level biology courses. Teachers met at the start of each semester to review previous assessment data and determine instructional points of emphasis moving forward. During a department meeting, I observed the teachers discussing individual questions from unit-level and end of course exams and the rate at which students answered incorrectly. With the purpose of improving end of course exam scores, they modified their common assessments and determined how much time they all should dedicate to instruction on specific content. The biology teachers collectively planned the number and types of lab activities for each class and the approximate dates they would be
administered. These assignments were to be mid-level and major-level grades for students. Teachers were afforded flexibility with the types and number of minor-level assignments, and they were also allowed to create their own PowerPoints and design their own instruction as long as they were faithful to the pacing guide, agreed upon lab activities, and common assessments.

Data Collection

Because I believe that learning is socially constructed through active participation in communities of practice and that language is the primary tool through which students and teachers co-construct and negotiate meanings, practices, processes, goals, and identities, I used qualitative methods (interviews, field notes, observations, audio-recorded conversations, and artifacts) in effort to better understand the “immediate and local meanings of actions as defined from the actor’s point of view” (Erickson, 1986, p. 119). Between February and April 2020, I observed the instruction of the three different secondary science teachers over a period of five weeks, wherein a minimum of one full instructional unit was completed by each participating teacher. The observed classes were held during different schedule periods for a duration of fifty minutes each, which allowed me to avoid any overlap and equally observe all three participants’ instruction for the full five weeks.

To understand the local meanings and tensions in participants’ DL teaching practice, field notes, artifacts, observations, interviews, and analytic memos served as interpretive tools, guiding my documentation and analysis of the “slices of social life” (Saldana, 2010, p. 15) in a thorough and reflective manner. Therefore, I followed a multi-dimensional, layered approach to data collection focused on the design and implementation of DL instruction. Each subsequent
layer of teaching activities allowed me to understand the teacher’s practices and perspective on those practices. The initial interviews framed each person’s perspective on scientific literacy and science education. Classroom observations and artifacts provided a window into the enactment of DL instruction and the negotiation of tensions and contradictions that could have led to undesirable outcomes. Teacher debriefings provided opportunities to understand how teachers made sense of their instruction and how they negotiated tensions in their practice. Additionally, my own audio-recorded memos assisted in my synthesis of observations. They helped me identify new lines of inquiry throughout the study and to interrogate my own interpretive assumptions.

In preparation for this study, consent forms that included a description of the study (Yin, 2014) were provided to participants (non-traditional teachers and their students), signed, and stored in a locked, fireproof safe. I also created a supplemental data collection template (See Appendix A) for organizing notes taken during observations. This 4 x 4 cell table for analytic notes was used to help organize my observations of practices that reflect each of four major DL theoretical orientations (cognitive, linguistic, sociocultural, critical) and four elements of the GOAT framework (subject, objects, mediational tools, outcomes). Lastly, an interview protocol (Appendix B) was prepared (Stake, 1995), including the guiding questions for semi-structured interviews with the participating teachers regarding their previous disciplinary experiences and their in-class DL instruction. In total, the data collected in this study came from the following sources: personal analytic memos, artifacts in the form of lesson materials and assessments, observations of the teachers and their students during lessons, and recorded and transcribed interviews conducted with the teachers. Artifacts included any documents, photographs, videos,
digital resources, tests, quizzes, or manipulatives used to plan, enact, and evaluate disciplinary instruction.

**Initial Interviews.** Before my initial observations of each teacher in practice, I interviewed teachers about his or her disciplinary history, teaching history, views on DL, tensions within his or her teaching practice, and how they attempted to negotiate solutions to these tensions. The semi-structured interviews were audio-recorded and transcribed and lasted approximately one hour (See Appendix B for interview questions). Although the open-ended questions served to guide the interview, I focused on “understanding, in considerable detail, how people. . . think and how they came to develop the perspectives they hold” (Bogdan & Biklen, 2003, p. 3). It was also during this interview that the least invasive conditions for observation were negotiated.

**Classroom Observations.** The instructional practices of each teacher were my focus throughout the entire study. I observed their actions in the classroom while taking field notes on the classroom learning environment and the disciplinary texts, tasks, and purposes that constituted each lesson. Additionally, I documented student behavior, questions and misunderstandings that arose, and other irregular occurrences that might have impacted the outcomes of observed instructional activities.

**Teacher Debriefs.** At the conclusion of each week of instruction, I debriefed with teacher participants separately. During these interviews, I asked each to share his or her perspective on their own teaching and student learning, tensions or contradictions encountered during the week, and planned responses for future instruction. These debriefs provided a means of triangulating my observation data with teacher artifacts and were audio-recorded and
transcribed. I also manually recorded analytic memos during the interviews, which lasted approximately thirty to sixty minutes each.

**Analytic Memos.** According to Saldana (2010), analytic memos can help researchers flesh out all their thoughts “about the participants, phenomenon, or process under investigation by thinking and thus writing and thus thinking even more about them” (p. 32). They are a place where we can converse with ourselves about the data as it is being collected (Clarke, 2005). Because I believe that analysis in interpretive research is always ongoing, I recorded written and audio-based analytic memos both when I was on-site and off. These memos helped me reflect on how I personally related to participants and the evolving nature of my research questions; they also helped me identify emergent patterns and draw connections across the three teaching cases (Saldana, 2010).

**Data Analysis**

According to Stake (1995), analysis is how we attempt to “make sense of things in our own contexts” (p. 72). My analysis during this study was ongoing (Saldana, 2010), and Genre-Oriented Activity Theory (Fisher, 2019) along with Disciplinary Literacy Pedagogical Knowledge (Saraceno, 2019) provided an analytical frame for this study. I used the interviews with teachers to develop an understanding of how each individual viewed literacy in secondary science, what tensions arose when they recontextualized disciplinary activity systems into secondary science classrooms, and what knowledges supported their negotiation of those tensions and contradictions. Field notes and analytic memos helped me build a narrative for each observation (Bogdan & Biklen, 2003). In addition to the analytic memos taken during interviews, further notes were recorded during the transcription of those interviews. In this way, I organized
initial patterns into richer themes by allowing new relationships to “rise to the surface” through constant comparison (Saldana, 2010, p. 15).

Artifacts, interviews, and observation notes for each teacher were first coded using Theoretical coding methods (Saldana, 2010) based on the four base components of the GOAT framework. Here, I identified the cognitive, sociocultural, linguistic, and critical aspects of the DL instructional activity within each participant’s classroom that constituted his/her contextualized instructional activity system. Characteristics of each teacher (the subject), the mediational tools used in their instruction, the students and standards that constitute the purpose of instruction, and the produced outcomes of instruction were all identified and categorized.

The second round of coding utilized Focused coding methods (Saldana, 2010), where emergent patterns that spoke most directly to my research questions were identified. Here, I identified any instructional challenges described by teacher participants and from my own observations. In addition, I used this round of coding to identify negotiations that occurred in response to those challenges.

Thematic coding was used in the third round (Saldana, 2010), where previously coded “challenges” for each teacher were further sorted by emergent patterns into themes. From the initial code, Misconceptions, Language, Expectations, Assessment, Resources, Training and Experience, Content, Student Schema, Time, Support, and Authenticity were identified as specific challenges faced by one or more of the participating teachers.

The fourth and final round of individual case coding utilized theoretical coding methods again, identifying which knowledge bases from the DLPCK framework informed participants’ negotiation of contradictions within their respective activity systems. Data previously coded as
“negotiations” were identified and regrouped into new categories based on the components of DLPCK (content knowledge, pedagogical knowledge, knowledge of the curriculum, knowledge of students, knowledge of context, knowledge of educational goals, and/or disciplinary process knowledge). Finally, those themes from each data source were triangulated (Yin, 2014) to paint a detailed picture of each teacher’s DL teaching context, practices, instructional challenges, and how they negotiated solutions to those challenges.

After individual case coding was complete, cross-case analysis was conducted to compare and contrast all cases (Stake, 2006) via thematic coding (Saldana, 2010). This time, emergent patterns across all three cases were categorized into themes—specifically, to identify differences and similarities among the participants themselves, their contextualized activity systems, the types of challenges they faced in their instruction, and the ways they negotiated instructional challenges. Individual case codes for subject, object, mediational tools, outcomes, instructional challenges, and negotiations were each compared, and overlapping themes from each of those codes were consolidated into new categories to generalize and distinguish the participating alternative-certification teachers’ overall instructional context, the challenges they faced, and how they negotiated those challenges.

To support the internal validity of this study, multiple sources of data were triangulated to confirm emergent findings, and biases were clarified regarding my own “assumptions, worldview, and theoretical orientation at the outset of the study” (Merriam, 1998, p. 205). Here, I compared participating teachers’ statements in interviews with the artifacts they used in their instruction and my own observations of their instructional practices in order to establish consistency and ensure the reliability of each data source.
Although generalizability is a limitation of case study methodology, the external validity of this study is strengthened by the inclusion of multiple cases. Moreover, thick and rich descriptions of the cases should help readers determine how closely their situations align with the context and conditions of this study.

**Contributions of the Study**

Merriam (1998) argued that interpretive case study research involves gathering “as much information about the problem as possible with the intent of analyzing, interpreting, or theorizing about the phenomenon” (p. 38). By investigating the situated practices career-changing, non-traditional secondary science teachers use to negotiate tensions in DL teaching, this study seeks to understand how DL theory can be translated into practice. I hope to illustrate the vast domains of knowledge that secondary science teachers must command in order to teach for DL so that content area educators, literacy specialists, and administrators can think more purposefully about what DL instruction should look like in their schools. By highlighting how these teachers negotiated DL instruction for adolescents, it is my desire to prompt administrators, teachers, and literacy specialists to evaluate local school reform efforts and to question how instruction can be adapted to accommodate these ongoing attempts to affect positive change.

In addition, I hope that the findings of this study contribute local understandings about the complexities of DL instruction to a wider body of knowledge about secondary DL. Through investigations such as this one, “the field of disciplinary literacy can develop not only a better understanding of the center of disciplinary activity but also a broader appreciation for the complex interactions of disciplines with other systems” (Fisher, 2019, p. 248). Moreover, examining teacher practices with attention to how learning is mediated by disciplinary texts
within complex and overlapping activity systems may help illuminate the complexity of teacher efforts to promote advanced literacies.

Although my interpretive lens and methodological approach did not seek to generalize findings across all science classrooms in any secondary school, I have constructed reasonable and trustworthy assertions within these local contexts in hopes of transforming the reader’s own understanding of DL and how he or she might use that understanding to inform their own negotiation of tensions related to disciplinary knowledge, pedagogy, student needs, and curricular standards within their own complex teaching contexts.

Lastly, I hope that this study benefits the Glenwood school district by contributing to a deeper understanding of the complexity of teaching for DL to meet students’ needs in secondary science. As the standardization of curriculum and teaching practices continues to take hold, combined with new teacher evaluation policies and the pressure to shrink achievement gaps, teachers areshoulderinga greater load than ever before. The results of this study can provide local secondary science teachers with critical inquiry into disciplinary teaching which, in turn, can help them reconceptualize their students, their disciplinary knowledge, their practices, and how they can use their instruction to position themselves as advocates for social justice within the discipline. My goal was to highlight ways to adapt DL instruction in Glenwood County secondary schools before it is abandoned like so many other past reform efforts. Moreover, this study is an opportunity to give secondary science teachers a voice to help administrators and program developers make science teacher training and professional development more responsive to the needs of educators.
Chapter 4: Falling in Line

Just like any other day, I arrive at Ms. Alder’s classroom for second period Honors biology to find her in the hallway chatting with a neighboring colleague while she greets students passing by. Despite the heavy rain this morning, she is still smiling and colorfully dressed in business-professional attire. “Good morning, Mr. Silva! I have copies of today’s quiz and activity on my desk if you would like copies for yourself to keep,” she says. I thank her and continue into the room. After grabbing a copy of the quiz and activity, I make my way back to the lab area and set myself up to observe the lesson. As the last two to three minutes tick away before class begins, I watch each student enter the room, observe the objective, and immediately seat themselves to begin studying.

Ms. Alder’s classroom is extremely tidy. The floors and walls are clean with few decorations carefully placed in conspicuous locations. Her handwritten objectives and agenda on the whiteboard at the front of the room reflect careful penmanship, and the backdrop of her words are absent of the typical stained color streaks left behind by dirty dry erasers. Today is vocabulary quiz day, and Ms. Alder has a bell ringer question and quiz instructions (to study) projected at the front of the room. The students follow these instructions carefully. Some pair with a neighbor or two, others sit in solitude; however, all students fervently test their vocabulary knowledge using flash cards in preparation for the quiz. Students who are normally playful and chatty are eerily quiet and focused, and their anxiety is both visible and contagious.

As students finish their vocabulary quiz, the tension in the room dissipates as if a pressure valve has been released. Ms. Alder transitions by reading the bell ringer question aloud with the class, “Farmer John has a heard of cows. He wants to do a cross of his cows to see what
genotypes are carried. Determine which bull should be the control to eliminate heterozygous genotypes.” She engages the whole class in guided practice using the question, collaboratively talking through each step of the process with handwritten Punnett Squares on the board. She verifies with the class that everyone agrees which bull should be the control and then transitions to content recap to prepare them for the next activity. She rapid-fire throws verbal prompts at the students: “What’s the difference between Mendelian vs non-Mendelian genetics? What’s the ‘law of dominance’? What’s going on with ‘incomplete dominance’?” Different students voluntarily shout out correct responses. Most seem to understand this topic well.

Suddenly, a student who has not yet offered any responses to her prompts raises his hand to ask a question that reflects deeper thinking beyond the target objective. “Ms. Alder, what about race mixing and skin tone? Is it like flowers where red and white make pink petals?”

She responds with a grin, “That’s a little bit different, there is a bit more to it than just blending two colors. You’re not the first to ask that, but it’s different.” Sensing that the young man who looked like he could still be in sixth grade wasn’t satisfied with her response, she took a pause before continuing to explain further. “I’ll use myself as an example. I have parents from different races. One of my parents is black and one is white. You can see, my skin tone is a light-medium brown. But skin color is determined by the amount of melanin in your skin, and we all have different amounts. So, even though my skin looks like a red and white make pink scenario, I could also have siblings with the same parents and different shades of skin than me—some very dark and some very light. You can’t do ratios with skin color the way we do with eye or hair color. It’s just a little more complicated.” Ms. Alder quickly pivots and starts to spout directions
for the next activity (a fictional round of monster-character speed dating), not leaving any room for more questions or delays.

As the activity on genetic inheritance ends, and the last students return to their regular seats, the end-of-class bell sounds. “If you are finished, drop your work off on my desk on your way out. If you still need time to work, go ahead and finish the analysis questions for homework. Don’t worry about the drawings. I won’t be grading you on that.” Students reply with asynchronous versions of “Bye, Ms. Alder,” on their way out of the room, still enamored with the activity, laughing and talking about it all the way into the hallway.

This was an example of a typical lesson in Ms. Alder’s classroom. Not only typical of the classroom environment, student behavior, instructional methods, and forms of assessment, but also representative of the kinds of instructional challenges Ms. Alder encountered in her instructional activity and her negotiations of those challenges. In this one example lesson, Ms. Alder negotiated her way around several instructional challenges in order to achieve the desired outcome of her classroom activity system. The most notable of which was her response to a student’s question during class that was relevant to the topic of the lesson; however, a full explanation would have had to include disciplinary information that was extracurricular and potentially too rigorous for students to understand with their limited schema. So, rather than dismiss the question, she drew on her own personal life as a relevant example to provide a simplified answer, allowing her to satisfy the student’s curiosity without sacrificing a significant amount of instructional time.

This was just one example of the many challenges negotiated by Ms. Alder that stemmed from contradictions between interactive components of her classroom activity system. In this
instance, the contradiction between a student’s interests (object) and mediating tools that lacked the information he was seeking manifested into a formidable query for which Ms. Alder was not particularly prepared. Her negotiation of this challenge was twofold. First, instead of explaining that such a question would not likely be on their EOC and moving on, she modified the object of her instruction to include that extracurricular content. Second, she modified her meditational tools by infusing a personal anecdote into her instructional activity to enhance student learning while maintaining relevance. In this way, Ms. Alder successfully navigated a solution to this instructional challenge. She engaged in similar negotiations regularly throughout the unit. In most situations, she was able to find a solution; however, some challenges to her instruction were either persistent or ongoing, resulting in failed negotiations or regular renegotiations of those challenges.

Deconstructing Ms. Alder’s Classroom Activity System

Using Fisher’s (2019) GOAT framework, the following sections identify characteristics of each component of Ms. Alder’s typical situated activity, which defined her instructional context—the subject (actor), object (shared goal or purpose), mediating tools (teaching modes and materials), and the produced outcomes of her instruction. Although some aspects of each component shifted and changed over the course of the observed unit, those qualities that were consistent or typical of each component helped to create a representative description of Ms. Alder’s classroom activity system.

Subject. The first component of Ms. Alder’s contextualized DL instructional activity system was the subject, Ms. Alder herself and all the knowledge, experience, values, etc. that she brought into the activity Ms. Alder, the actor in all observed instructional activity, taught Honors
and College Prep (CP) levels freshman biology. She was in her third year of teaching and final year of teacher induction at the time of this study. She earned an undergraduate degree in biology and subsequently worked as an intern conducting research on turtle populations. Thereafter, she earned a communications degree and later worked in marketing and advertising for seven years before entering the PACE program and earning a certification in secondary science education.

**Background.** Ms. Alder’s undergraduate coursework allowed her to engage with a wide range of scientific communities of practice:

“I thought I was going to go into marine biology and had some internships in that route, so I kind of stuck more to that field, but definitely I had to sample all of it, chemistry, microbiology, anatomy and physiology, took some astronomy, so I kind of had a sample of all the sciences with that particular degree.”

Here, she was regularly exposed to different research methodologies across multiple disciplines in the domain of science, which she sees as an asset to her teaching and believes helps compensate for her lack of pedagogical experience. She was especially interested in marine biology and worked multiple marine-based internships during this time. However, while serving as an intern at a marine center in Florida, Ms. Alder discovered that funding procurement is a critical value among research-based communities of practice and felt that, as a marine biologist, she would spend “more time writing grants, asking for money to do research, than . . . actually getting to do the research.” This did not align with her personal interests, goals, or values.

Unhappy with such aspects of the culture of scientific research communities, she decided to build upon previous experience with her university programming board by earning a degree in communications. She was then hired as an account executive with an advertising firm, where
Ms. Alder was responsible for pitching commercial ideas and managing marketing campaigns. There, she often utilized scientific methods of data collection and analysis to inform her promotion strategies. For example, she compared beta testing of advertisements to see how consumers respond to AB testing in scientific experiments. Leveraging similar control group experiments as those used in scientific labs, social media campaigns were redesigned until they consistently elicited the desired response from the target population. However, despite the scientific nature of these practices, Ms. Alder’s persistent passion for scientific content and a family full of educators eventually convinced her to enroll in the PACE program and pursue a different career in teaching secondary science where she could engage with scientific practices as well as scientific topics.

**Pedagogical Values.** As a freshman Honors biology teacher, Ms. Alder valued her in-class instructional time. She did not assign homework but allowed students to finish incomplete classwork at home if necessary. She preferred to begin her units and individual lessons with strategies to activate students’ interests and relevant schema, followed by “as many labs or small little activities . . . as possible.” She believed her instructional methods should be responsive to student needs and described having different approaches to instruction for different classes. For example, Ms. Alder explained that she used fewer scaffolding tools, such as guided notes, with her honors students than with those in her college prep-level biology students, and she sometimes provided them with different reading prompts based on their ability levels. She hoped to improve her differentiation by offering the more advanced honors students opportunities for enrichment but would not do so unless the work was authentic, relevant, and meaningful.
Ms. Alder believed it was important to build personal relationships with and have reasonable expectations of her students: “I just want everybody to at least put in some effort. You don’t have to be an expert or be 100% in what we’re talking about, but at least showing me some effort that you’re trying.” If their effort is not enough and they still struggled, her first response was to reevaluate her own instruction. If she herself struggled to find a solution, she was always willing to seek help from the instructional coach or to flip classrooms with another biology teacher in order to present information differently: “I have different ways of relating information to my students than my colleagues . . . some strategies that I’ve learned don’t work for some classes . . . There is a little bit of variety between the four of us.” She admitted that she herself struggled to learn from lectures or explanations and was more of a hands-on learner, so she tried to consider such individual preferences/affinities among her students when teaching. To that end, she tried to utilize groupwork and collaboration in her teaching: “I do like collaboration. I like for the students to feel like they can speak up, offer points of view.”

Over the course of a lesson, Ms. Alder favored discussion over lecture. She believed manipulatives were especially valuable learning tools, and strived to make content as personally relevant as possible: “If you ask my kids, I’m big on analogies . . . I always try to relate to what’s going on in their lives. Pop culture I’ll use to kind of drive the point home, whatever works.” She described the overall learning environment she tried to foster as relaxed and welcoming— “a chill place where we can talk about whatever the topic is that day.” She believed every student question was worth exploring, and she was comfortable stopping or extending a lesson in order to address student queries.
Ms. Alder also valued technology as an instructional tool. She believed it provided additional options for activities and lessons, and she especially appreciated that students all had their own Chromebooks. Previously, teachers at her school had to schedule and share Chromebook carts, making it difficult to plan regular activities supplemented by digital resources. Switching to one-to-one devices made such planning easier for her, and she tried to leverage that resource to enhance her instruction.

**Views on Scientific Literacy.** Regarding scientific literacy, Ms. Alder believed that being literate in biology is “being able to be presented with various scientific scenarios, data, research articles, and being able to . . . sift through that information and come to . . . your own understanding of . . . those scientific processes.” She wanted her students to be able to understand and respond to scenario-based questions that required analysis and interpretation of data. She did not particularly value the teaching or regular use of formal scientific language beyond specialized vocabulary found on the End of Course Exam (EOC). It was more important to her that students “are able to get their point across as best they can.” Generally, she expected students to use language they would in any other class. She admitted that her understanding of DL theory was limited, but believed decoding scientific texts, engaging in scientific activity, and thinking like scientists were key components of scientific literacy. In short, her ultimate goal was for students to be able to effectively “process scientific information for understanding.”

**Object.** The second component of Ms. Alder’s contextualized DL instructional activity system was the object or purpose of the activity, which was student learning. Ms. Alder taught the observed Honors biology class to a group of high achieving students who were predominantly white (one African American student). She described the students in this class as “very structured.”
They preferred more explicit teaching methods, note taking, and practice. Some of her students had difficulty sitting quiet and still for extended periods of time, so she felt it was important to occasionally get them up and moving around. The students also congregated into what she described as “cliques,” which she tried to break up using activities that involve movement and mixed grouping.

In my observations of the students, they rarely asked questions for clarification or to extend their thinking on the topic. This contradicted Ms. Alder’s expressed value of a classroom where topics could be discussed openly and freely. Most often, their questions were for confirmation that they were following directions accurately or that their findings were accurate. She said that the students in this class rarely attend tutoring sessions or took advantage of opportunities to resubmit assessments with corrections early in the year, but more frequently starting around May and leading up to the biology EOC. They appeared to be very invested in their grades and doing well on assessments.

The target content for student learning in this course was largely determined by the biology End Of Course Exam (EOC). While the department follows state biology standards outlined for the course (ed.sc.gov), department-level pacing guides, common assessments, labs and activities, and topics of emphasis were collaboratively designed by the biology teachers and primarily informed by the topics and questions found on the EOC. I was able to observe a department meeting in which such collaborative planning took place. In this meeting assessments and target concepts for the observed genetics unit were evaluated and selected. Details, such as the language of questions, were modified based on student responses from previous years using a software program to analyze student responses (frequencies of incorrect answers). The biology teachers and
instructional coach examined each question meticulously, checking historical data, the previous year’s data, evaluating the question itself, and evaluating answer choices. They discussed sequence and scope of unit materials and came to a consensus that vocabulary, test practice, and the topics from EOC questions students most frequently answered incorrectly would be points of emphasis for this year’s genetics unit, including mendelian traits, incomplete and codominance, dihybrid crosses, and pedigree. For her class, specifically, she described the object of her instructional unit on genetics as follows:

“I think with this genetics unit overall, just the most important thing I want them to know is just inheritance patterns, just, you know, we’re all not cookie-cutter. There are multiple ways that traits can be inherited and just being able to recognize them. At the end of the day that’s just kind of the biggest takeaway I want them to get from it.”

Here, Ms. Alder described more utilitarian outcomes—that is, she did not list specific vocabulary, tools, or disciplinary processes as the most important learning goals. Instead, her hope was that her students acquired a general conceptual understanding of how physical traits are passed down along generations—practical knowledge. Such pedagogical goals suggest Ms. Alder privileged content that was relevant to student lives over that which is most valued by the department. However, this contradicted my observations of her instruction, where she sometimes passed opportunities to extend discussion in order to save time and prioritize EOC content.

**Mediating Tools.** The third component of Ms. Alder’s instructional activity system context was the mediational tools used to facilitate disciplinary activity in her classroom. One of the tools embedded in the system permanently was the environment itself. The classroom was arranged in a traditional fashion—with desks aligned neatly into rows and columns. She situated
her desk in the front corner of the room opposite the entranceway. The back of the classroom was clearly defined with lab stations and sinks, along with a safety station for responding to experiment-related emergencies. There were scientific processes and vocabulary on the walls, class rules, etc. Her daily agenda was easy to locate on the board as well. One especially notable feature in her classroom was the “#squadgoals” wall, which had pictures of famous historical scientists beneath the playful hashtag, reflective of the relaxed nature of her classroom environment where the background knowledge and interests of her students were welcome and valued.

Every lesson in Ms. Alder’s class began with a projected question at the front of the class to which students were to write a response. Sometimes the question was accompanied by an image or video. Oral discussion typically followed before transitioning into a mini lesson, often in the form of a PowerPoint presentation with guided notes. Then, students usually engaged in paper-based activities or labs requiring some sort of application of newly acquired knowledge. Students rarely created or read authentic scientific texts or interacted with discipline-specific artifacts. More often, mediational tools reflected an emphasis on scaffolding and relevance to students’ interests rather than authentic disciplinary norms, such as the SpongeBob worksheet and fictional monsters activity. She also utilized the school-provided tablets to access web-based resources such as the Google Suite, MasteryConnect, Edpuzzle, Quizlet, and USAtestprep.com.

**Outcomes.** Finally, the last component of Ms. Alder’s instructional context was the produced outcomes of the activity. From her perspective, based on formative and summative data from the observed unit, the object and outcome of the instructional activity systems were usually in close alignment: “I’m seeing with the data is that we’re understanding some of it…”
However, as the unit drew to a close, formative data suggested that a lack of proficiency related to earlier topics of the unit, such as the application of the 3 laws of Mendelian inheritance, led to outcomes that were increasingly diverging from the objects of subsequent activity systems, such as determining pedigree: “Right now, the data is telling me with our check-ins that we need to go back to the beginning of this unit and focus on those three basic laws. . . . I think I took the training wheels off too soon.” From her perspective, these were the topics on which her instructional activity did not produce the desired outcomes. In some of those cases, she was able to adjust her instruction before the end of the unit. In other instances, she was unable to negotiate solutions to challenges that contributed to undesirable outcomes. Regarding the unit overall, she described it as “still a dicey unit.”

**Emergent Challenges and Negotiated Solutions**

The curricular objectives of the observed units on genetics and evolution in Ms. Alder’s Honors biology class were a) explain how genetic information (DNA) is copied for transmission to subsequent generations of cells (mitosis); b) explain how meiosis followed by fertilization ensures genetic variation diversity; and c) demonstrate an understanding of biological evolution and the diversity of life (ed.sc.gov). However, persistent contextual challenges complicated her efforts to achieve those outcomes with her students. Those challenges were a product of contradictions and tensions experienced within Ms. Alder’s DL instructional activity system. After documenting her perspective on those challenges and observing and discussing how they were negotiated, subsequent coding and analysis yielded the following five themes: *Scientific Misconceptions, Language, Expectations, Assessment, and Resources.*
Scientific Misconceptions. The first challenge to Ms. Alder’s DL instruction was her students’ previously held misconceptions about scientific concepts. Having developed strong relationships with students at Park Forest High, and after more than a semester of learning and building upon her own students’ background knowledge, Ms. Alder became acutely aware that many of her students had misguided or ill-informed understandings of certain curricular topics. For this reason, Mrs. Alder perceived the unit on evolution, for example, which immediately followed the genetics unit, as one particularly challenging subject around which to design her DL instruction. From her perspective:

“Evolution just kind of has this negative view, people just view it negatively and there are a lot of misconceptions around evolution . . . . I think we get so caught up in this idea of man and monkey, that we don’t really realize that we’re just talking about change over time.”

Following the GOAT model, this tension marked a contradiction between the knowledge, values, and beliefs of Mrs. Alder (the subject of the activity system) and those of the students, whose disciplinary learning related to the topic of evolution was the object. Though not every topic in Honors biology held the potential for such tension, the local history of public controversy and misrepresentations of Darwin’s theory of Natural Selection was a contextual factor that was ever-present and had to be considered by the subject (Ms. Alder) when planning and enacting instructional activity for that unit. In fact, as recently as 2009, members of the State Board of Education disputed teacher-selected state biology textbooks, arguing that evolution was still an unproven theory, life’s origins had yet to be fully understood, and that the chosen textbooks presented evolution as a factual explanation rather than as a theory subject to scrutiny alongside
Intelligent Design and Creationism (Bindewald & Spearman, 2012). This challenge to teaching students topics on which they may have already developed scientific misconceptions stemmed from the object of the activity system (the students’ schema and beliefs and the target content), which suggest the challenge was sociocultural in nature.

In attempt to negotiate tensions between the content Ms. Alder values teaching as a disciplinary expert, such as the topic of evolution, and the values of her students, whose learning of that content was the object of her instructional activity, she attended to the specific knowledge of her students in this disciplinary community of practice:

“I wanted to start yesterday with the telephone activity. I think we get so caught up in this idea of man and monkey, that we don’t really realize that we’re just talking about change over time. I think the telephone activity was a great way for them to just kind of visually see what I’m trying to get across to them. Yes, organisms have changed over time.”

The telephone activity described above served as an analogy for students—where the message that was passed along from person to person changed in the same way species change from generation to generation. She directly addressed students’ values and schema by openly challenging common ideas about evolution and steering the discussion away from scientifically irrelevant topics like creationism. Moreover, she did so using a game that was entertaining and engaging to students and appealed to their need for movement and peer-interaction. At the end of the lesson, there were audible “Ahh’s” and “I get it now’s” as students realized that apes did not turn into humans any more than the original message of the telephone activity turned into a sculpture. The end result was still a message, just a little bit different than when it started. In negotiating this solution, Ms. Alder was most informed by her knowledge of students and context. An acute awareness of the
local culture and most prevalent religious ideologies among her students allowed her to circumvent contradictions during her planning activity and before they could manifest as bigger challenges during her instructional activity thereafter.

Language. The second challenge to Ms. Alder’s DL instruction was subject-matter vocabulary. As she explained:

“Vocabulary was something that I scrapped this year because I was kind of teaching it out of context and I totally get why that was something I needed to stop doing, but I notice that even though they already have some experience with doing Punnett squares, the vocab isn’t there . . . . Finding ways to get them to understand those terms, I think, was a struggle for some of the students and had me kind of reevaluate how I was going to make sure they got to where they needed to be.”

Ms. Alder recognized that her students were unable to apply their knowledge of discipline-specific vocabulary when engaging in relevant scientific processes. She believed she was targeting the appropriate words; therefore, her students’ inability to apply learning from previous vocabulary-based instruction in new contexts suggested her initial strategies were insufficient for achieving the desired outcomes. Here, the contradiction in the activity system that led to this instructional challenge was between the mediating tools used in the activity (decontextualized definitions) and the object (the expansion of students’ disciplinary language registers) — linguistic in nature.

In response to instructional challenges related to language, Ms. Alder took a combination of cognitive and linguistic approaches to finding a solution. She espoused a linguistic perspective by explicitly focusing on subject-specific vocabulary—discipline-specific mediational tools—as
part of the object of her teaching activity. Then, she modified her instructional system to reflect linguistic and sociocultural orientations toward disciplinary language instruction:

“The biggest one [modification] was actually holding them accountable for vocab. We had the vocab quiz today and that just kind of put the ball back in their court. I think stem words are big in science, so every chance that I get, you know, mono, hybrid, cross, ‘Alright guys, what does that stem word ‘mono’ mean?’. Just trying to introduce them to it as often as I could, almost like drill and practice over and over. I do think it helped a lot.”

Here, she changed her mediational tools and strategies to improve student’s individual motivation and memory through contextualized exposure, repeated practice, and accountability/reinforcement via regular quizzes and grades (linguistic). Moreover, she emphasized disciplinary language in her classroom discourse while highlighting linguistic patterns germane to scientific registers. This shift in teacher practices that included assigning more quizzes and using more discipline specific language in her own classroom speech (e.g., saying “hemorrhage” instead of the more colloquial “bleed-out” in an observed lesson on DNA fingerprinting) undermined some of her previously expressed values (cognitive), such as a relaxed, informal learning environment. However, I did not observe any changes in overall student behavior as a consequence, and she felt that the shift ultimately led to better outcomes.

Several of her knowledge bases contributed to the negotiation of this solution. First, her knowledge of students based on formative assessment along with knowledge of educational goals helped inform modified purposes (objects) for instructional activities. Second, she utilized
pedagogical knowledge related to vocabulary instruction that included different, more contextualized methods of disciplinary language pedagogy she could employ.

**Expectations.** The third challenge stemmed from external standards, norms, and expectations. For example, she did not always have access to the range of pre-assessment data needed to accommodate students’ individual learning needs because the methods and timing of such data collection were prescribed by the district. In her words:

“For us, and this is something that we are kind of struggling with right now, we are required by the district to use MasteryConnect Benchmarks, so they actually make our benchmark for us and we’re required to use that as our data. The issue is our first benchmark didn’t happen until October, when we are well into the year, so it’s a little late, so we struggle right now with having baseline data.”

Therefore, during her instructional planning, contradictions persisted between her own thinking about how to design future instructional activities and the available tools that mediated her planning activity. The fact that she had to rely on tools she would not otherwise use in order to comply with the rules, norms, and expectations of her biology department’s community of practice reflects another sociocultural challenge.

Additionally, some of Ms. Alder’s students habitually completed work early, demonstrating a need for more rigorous instruction. However, she found it difficult to design enrichment activities for those students that would align with department grading norms:

“I have two that just kind of get it and they’re ahead, and that’s kind of something that I’ve been trying to work on. . . I want to definitely give them enrichment materials. . . . If I take it as a grade, I now have two students that have an extra grade that other students
haven’t had a chance for, and then if I give extra credit for it, they had an opportunity for extra credit the other students haven’t, so that’s kind of what I’ve been going back and forth on . . . I just personally have been struggling on how to motivate them to do it without the other kids feeling like they’re at a disadvantage.”

This was another example of a sociocultural contradiction between the object of her contextualized instruction and her values as acting subject, who believed students who could, should learn more than the minimum content outlined by the state curriculum and EOC. Yet, a grading culture among her department and students seemed to privilege standardization in the name of fairness over differentiation for the sake of student growth.

Although access to useable baseline data early in the year was a challenge for Ms. Alder when planning for this unit, by the end of the observation period for this study, cumulative formative data along with delayed benchmark data from the MasteryConnect assessment had become available and been used to inform modifications to subsequent planned instructional activities for this unit. In this way, she negotiated the tensions between her own belief in the value of current and readily available baseline data by leveraging formative data to inform instructional modifications for the topic of DNA fingerprinting, wherein she deduced that students needed more support to understand the relevance of the topic and its real-world application. She used this navigational approach for other topics as well, including biotechnology: “Right now, with biotech, they took a pre-quiz for me on Tuesday and then took their quiz on Wednesday, and I think it’s still a dicey unit.” Once again, rather than limiting herself to the baseline data from the department-mandated assessment, she leveraged more focused, topic-specific pre and formative assessments to inform her instructional design. This
creation/appropriation of alternative/supplementary tools for mediating her planning activity constituted a linguistic negotiation. The data (language) of the department-mandated benchmark assessment was an insufficient tool for planning the kind of differentiated instructional activity she values, so she infused the system with more appropriate tools and data. To do this, Ms. Alder had to draw on her knowledge of context by first ensuring that she abided by district policy in making her students take the mandated benchmark, pedagogical knowledge to determine the most effective assessment methods to supplement district resources, and knowledge of educational goals to determine what schema or skills to pre-assess.

How to provide meaningful enrichment for advanced students while adhering to department grading guidelines was another challenge characterized by contextual norms and expectations. However, this was one challenge that went un-negotiated. That is, Ms. Alder discussed her efforts to find a solution, but did not make any attempts at an enrichment solution during the observation period. She shared an idea with me, “I was thinking, with those students, while we’re still working on some pedigree and going over that, maybe they apply a pedigree to like blood types and figure out, kind of combine the two topics that we’ve been talking about to more of a real world scenario.” Such an idea was informed by Ms. Alder’s knowledge of students (who among them would be capable of extending their thinking on this topic) with content knowledge (sequence and scope) and disciplinary knowledge (real-world application of disciplinary processes like determining blood types). However, this idea never made it into any of the lessons I observed, nor did I see any materials prepared for such an extension activity. She cited timing as a personal weakness that may have limited her opportunity to enact such planned modifications.
Assessment. On several occasions, Ms. Alder described specific pedagogical challenges that she had encountered when designing disciplinary instruction for the observed unit that were influenced by sociocultural contradictions between her own thinking about teaching this topic—particularly in regard to valued learning outcomes—and the object of her contextualized teaching activities as determined by the EOC. Regarding the topic of pedigree, for example, she said:

“In the past, I have not spent a whole lot of time on pedigrees . . . . I’ve just done bare minimum in the past because I thought that’s all they needed to worry about and when I saw that on the EOC I knew I had to pump the brakes. . . .”

She went on to explain another challenge to teaching this topic, and that is her own DLPCK, particularly knowledge of disciplinary processes and content knowledge:

“You cannot fake it till you make it with pedigrees, so I think it’s good because it kind of keeps me on my toes, and I’ve got to make sure I know what I’m talking about.

Especially when we start going through it up on the board together, I’ve got to be right there with them. I just can’t have them shout out an answer and just take it. I’ve got to sit there and think about it with them as we’re filling it out. So, I think making sure that I was presenting the correct information to them in the most just kind of synced, easiest way for them to understand was kind of my challenge.”

Not that she lacked such disciplinary knowledge entirely but applying it may not have come to her as easily as it would to disciplinary experts, such as geneticists or animal breeders. She expressed similar views of her pedagogical content knowledge related to the topic of ratios:

“I previously was not teaching ratios. It was actually in our planning day that we’d had previously that week on needing to teach ratios because sometimes they do show up on
that end of course exam. . . . I think we’ve gotten a little bit better at it, but I do think that I probably could’ve found a different way to possibly introduce that than what I did.”

This statement suggests two challenges related to assessment: first, teaching certain topics was not especially important to her until she discovered it was on the EOC—another subject-object contradiction of values. Secondly, in her opinion, undesirable outcomes produced by newly created activity systems for instruction on ratios were linked to either misguided or under-informed thinking on her part as the subject while designing and implementing the lessons. In other words, she didn’t believe it was important content nor did she know the most effective way to teach it. Consequently, contradictions arose between the mediational tools she chose (in this case, lecture) and the students whose learning of ratios was the object while enacting lessons. This marks a challenge that is cognitive in nature. During planning, the contradiction stemmed from the thoughts, beliefs, and values Ms. Alder brought into the activity. During implementation, it manifested again during the students’ meaning-making process with the texts/tools chosen by the instructor, leading to undesirable outcomes. As evidenced by these two examples, Ms. Alders’ DLPCK—first, her lack of knowledge of educational goals and secondly, her pedagogical content knowledge—related to specific topics found on the EOC assessment contributed to contradictions in her DL teaching activity.

In her negotiations of challenges to her desire to design activities where students could “play around” with subject-specific content and disciplinary processes (that subject-object, sociocultural contradiction of values), the formidable amount of EOC material to be covered proved to be a tough haggle. As described in the previous example, Ms. Alder had ideas for broadening the object of her instructional activity to include disciplinary processes that do not
align with the EOC. However, she weighed the cost of time against the cost of suspending her values, and the changes she had considered gave way to community norms. In this case, the results of the negotiation were one-sided, and in favor of department prescribed object of Ms. Alder’s activity. Her knowledge of context (including the norms and values of the department in which she was situated), knowledge of educational goals, and pedagogical content knowledge (awareness of the time investment required for various instructional approaches to different subject-specific topics) were all significant contributors to these pedagogical choices.

With regard to the contradiction between her DLPCK (subject) and the object of student learning on the topic of genetic inheritance (pedigree), which stemmed from a lack of disciplinary process knowledge and experience, her first response was to allot more instructional time for that topic:

“I definitely planned for it to run over into the next day and I was upfront with the kids, I, in the past, have not spent a whole lot of time on pedigrees and I kind of eluded to the fact during second period that day that I may or may not have seen a pedigree during the EOC last year, so I knew I needed to spend more time on it, so I knew that we were definitely going to need two days for practice.”

This extension of instructional activity time involved apprentice-novice style guided practice, where Ms. Alder modeled her own thinking through this particular disciplinary process:

“I tried to scaffold, just let’s work on the bare basics first. Let’s be able to identify male and female, if they’re affected, if they’re unaffected; let’s work on identifying that first and just kind of going through those practice problems, and then kind of putting up more of a less aggressive pedigree. Alright, let’s work on genotype now, and kind of working
through those understandings they already have from the unit on genotypes and how inheritance works and then kind of adding to it each time.”

Similar to her response to linguistic challenges in her vocabulary instruction, this negotiation involved changes to the mediational tools and strategies of her instruction, leveraging practice (in the form of guided practice and scaffolded graphic organizers) and repeated exposure to content to improve students’ memory of disciplinary concepts. Again, knowledge of educational goals and awareness of the time investment required to teach various subject-specific topics using different methods (pedagogical content knowledge) were significant contributors to these negotiations. By the end of the unit, she was calling on random students to fill in pedigrees on the whiteboard, and I observed them all do so correctly with relative ease.

A similar approach (directly explaining subject-specific information and processes followed by practice in the form of graphic organizers) to negotiating challenges to her instruction on genetic probability, specifically ratios, proved less effective: “They had previously already done the SpongeBob genetics worksheet and they’d kind of done the percentage probability, so I just tried to introduce it that way, like ‘okay, well if we think about it in terms of ratios, what’s that going to look like?’” Her characterization of the outcomes produced by this approach with ratios, specifically, were underwhelming: “I think we’ve gotten a little bit better at it.”—suggesting she has not yet found a solution. However, despite seeing only minor improvements in student performance, the topic of ratios passed as an instructional focus and new topics were subsequently introduced.
Resources. More often than a lack of knowledge, Ms. Alder cited a lack of available resources as a barrier to what she believes would be the most effective DL instruction in biology. After enacting a lesson on DNA, she explained:

“What I’m seeing with the data is that we’re understanding some of it, but the context, because it’s presented kind of in this random ‘alright, let’s talk about DNA fingerprinting’, I think the reasons for all of those are getting lost on the students. . . . having to teach somebody how crime labs process DNA without actually having the access to it has been very difficult.”

Ms. Alder values authentic disciplinary activity that is meaningful to students’ lives. However, she felt that not having access to authentic disciplinary tools and data caused her to have difficulty making material relevant to her students. Moreover, the materials she might have access to can no longer be considered authentic by her own disciplinary standards:

“I also think a big issue is: the technology we’re having them learn about, scientists aren’t really using anymore, so the standard is a little outdated and we don’t have access to the machines to actually do it; so it just kind of seems, I don’t want to say pointless, but if there’s not a way for us to make some sort of real world connection if the real world isn’t using this stuff, there isn’t any relevance there for them to grasp. . . . I can only do so much with what I’ve been given, and some schools have DNA machines, some don’t. . . .

To have been such a short unit, it was very challenging.”

Furthermore, manual processes of DNA electrolysis that don’t require expensive machinery and could be replicated in a classroom environment involve the handling of cancer-causing chemicals, which she explained to students. In these examples, the contradictions that arise in
both planning and teaching activities stem from the mediational tools available to and chosen by
the subject. Either the tools Ms. Alder values as a disciplinary expert weren’t available to her, or
the ones that were didn’t align with what she, the subject, believed to be practical or authentic.
These contradictions stemming from the mediational tools of the activity system led to
undesirable outcomes:

“I think because they don’t know why this is important, they’re just not making the
connections that we expected. . . . The issue is biology is kind of like kitchen science, so
we don’t dissect anything, they’re not preparing their own wet slides and using
microscopes, so that sometimes is a challenge, just to find ways for them to collaborate
and feel like they’re in a lab. . . . I can’t just have them go back and dissect something
because we don’t learn any of that in the state standards, and if it’s not in the standards,
I’m not going to get funding for it, which is kind of what it boils down to.”

Since mediational tools of all forms constitute disciplinary “texts,” emergent contradictions
within instructional activity systems that produced undesirable outcomes can be considered
linguistic in nature, and the lack of funding for more appropriate disciplinary resources was a
sociocultural challenge that stemmed from a contradiction between the target standards that
constitute the object of the activity and the subject’s DLPCK and values.

Without funding to support the purchase of the materials she believed could facilitate
authentic and relevant disciplinary activity to enhance student learning, Ms. Alder first drew on
pedagogical knowledge and knowledge of students to design a linguistic responsive approach to
engaging their interest in the topic by changing her instructional tools and strategies:
“It’s just trying to hold their interest and keeping it exciting for them so they’re not just getting burnt out on doing, you know, tons of crosses. That’s why I’ve tried to, as much as I can, have them doing some sort of moving around, or like today we did the coin flip activity, so just trying to somehow add some excitement to it.”

She also discovered a digital resource: “. . .an online simulator, where they can, online, run the DNA fingerprinting. . . . where they can at least click and drag as if they had the real equipment in front of them, at least let them see the process...” However, like other ideas she shared with me about potential modifications to her instruction, I did not observe her utilizing this resource during her instruction.

Summary

For the most part, Ms. Alder was a student’s teacher—that is, she seemed to care more that her students performed well on the EOC and that they enjoyed lessons than that her instruction authentically reflected disciplinary practices and processes. She was a new teacher at the time of this study, and she leveraged her department support system to its fullest. Although what she believed students should learn and do in biology did not always align with the EOC or department standards, she most often deferred to institutional expectations when presented with an instructional challenge. She expressed dissatisfaction with departmental emphasis on EOC content, yet she regularly chose to modify her instruction to further align with that assessment. Ms. Alder clearly put thought and effort into how she could design instruction that better reflect her values as a disciplinary expert and would be more responsive to individual student needs; however, she was reluctant to implement those plans without explicit permission from
administrators. Overall, her instructional activity can be characterized as an exercise in reluctant standardization of teaching practices—falling in line.
Chapter 5: Quiet Rebellion

On a warm and stormy morning, Dr. Elm’s first period College Prep-level biology classroom feels especially stuffy. The students trickle into the building after trekking through steaming rain. Their damp hoodies and squeaking shoes spread wet onto everything they touch. It’s not unusual for this group to be tame early in the period, listening to music on their phones or playing games on their tablets. However, this morning, it seems half of them are not even awake. “…and baseball practice will be held in the auxiliary gym this afternoon on account of bad weather. That’s all for the morning announcements. Have a wonderful day!” Principal Willow’s sign-off signals the start of class.

“All right everyone, today you’re working on the penny flipping lab. This will help give you an idea of how genetic randomization works. Make sure you space yourselves out and work at a table with your lab partners,” Dr. Elm is brief in his instructions, expecting students to access and follow the lab instructions on their activity worksheet. They are immediately cut loose to begin working, and several students head in his direction rather than to a lab table. They line up waiting their turn to ask about makeup work. As he deals with previously absent students, others who are already beginning the lab have started to raise their hands with questions. It takes some time for him to finish, but most students wait patiently for his assistance. Some work on other things while they wait, a couple others entertain themselves by bouncing and throwing coins at their lab stations. The combination of student laughter, low-playing music from various cell phones and tablets, combined with the steady “pings” and “clanks” of copper discs upon granite tabletops are like an audio sample from a boardwalk arcade.
Amid the ruckus of working students, Dr. Elm finally starts to make his way around the classroom, addressing student behavior between trips from group to group to provide individualized instruction. What was a slow starting class now feels like a race as Dr. Elm darts around the classroom in an attempt to address each student with an upstretched hand. More continue to rise as he works with each group.

One girl, who had not yet raised her hand or been visited by Dr. Elm suddenly shouts out a question loud enough for him to hear from across the room, “Does the little b mean color blind?”

Having already answered that question for several other students, he directs his response to the entire class, “That’s called an allele, the little b, and if it’s a girl there needs to be 2 recessive alleles to get colorblindness. . . . big b little b on a girl means that she is a carrier, but not colorblind.”

Another student shouts a question in response to his answer, “But I thought the dominant trait always showed when it’s a big letter little letter? How come men are colorblind with only one little r?”

Dr. Elm crosses the entire room to sit with her group, “Good question, that’s because it’s sex-linked. That’s what we’re doing. Remember, boys only have one x chromosome, so their colorblindness is determined by that one r. Girls have two, so they can be heterozygous and have normal vision.”

“Wait, so it’s like the recessive trait is actually dominant for men?” the student retorts.

Dr. Elm glances up in thought for a brief moment before giving an example, “Sort of, it’s just more common in men. But there are other cases where a dominant trait is expressed less
often than the recessive version of the same trait. Technically, having six fingers is a dominant trait, but we all have five. Maybe the people with six couldn’t get married and pass on that trait.”

A different student and her partners in the adjacent group are dumbfounded overhearing this revelation, “What!? Nuh-uh! Six fingers? Does that mean we supposed to have six fingers?” she asks.

Dr. Elm snickers and weaves through an obstacle course of backpacks over to their table, “I don’t know. I guess your ancestors didn’t think so because they clearly chose not to have children with anyone with six fingers. Would you marry a guy with six fingers?” Her face twists in disapproval while her groupmates chuckle, and Dr. Elm notices that the period will be ending soon. He addresses the entire class, “You have everything assigned for this week available to you, so let’s get that done. Some will be due Thursday and some on Friday. Okay let’s do a quick review…(bell rings)…okay maybe not.” The students hastily gather their belongings and stampede out of the classroom.

This was an example of a typical lesson in Dr. Elm’s classroom. Not only typical of his classroom environment, student behavior, instructional methods, and forms of assessment, but also representative of the kinds of instructional challenges he encountered in his instructional activity and his negotiations of those challenges. In this particular example lesson, Dr. Elm negotiated his way around several instructional challenges in order to achieve the desired outcome of his classroom activity system. Specifically, differentiation was an ever-present challenge that required constant negotiation. Not only did Dr. Elm have students with diverse learning needs to attend to, but he had several students who were also behind on the unit due to
absences. Guiding all of his students toward the day’s learning objective would require a variety of methods and scaffolds dependent on their current schema. So, rather than lecturing or frontloading material that might benefit some students but not others, he physically met with as many individual students and groups as time would allow in order to personalize their instruction.

This was just one example of the many challenges negotiated by Dr. Elm that stemmed from contradictions between interactive components of his classroom activity system. In this instance, contradictions between some students’ schema and the mediational tools that were insufficient for facilitating student learning of the target objective lead to a nearly unmanageable number of student questions throughout the lesson. His negotiation of this challenge was threefold. First, he met with those students who would need the most support, those who had been absent for previous lessons. Then, he arranged students into groups so that they could support each other while he moved around the room, and so that he could teach two to four students at a time. Finally, he identified common misunderstandings and directed his instruction toward the entire class, saving time to address more specific questions with individual students. In this way, Dr. Elm successfully navigated a solution to this instructional challenge, though at the cost of instructional time and a great deal of physical energy. He engaged in similar negotiations regularly throughout the unit. In most situations, he was able to create a solution; however, some challenges to his instruction were either persistent or ongoing through the unit, resulting in failed negotiations or regular renegotiations of those challenges.

Deconstructing Dr. Elm’s Classroom Activity System
In accordance with Fisher’s (2019) GOAT framework, the following sections identify features of each component of Dr. Elm’s typical situated instructional activity, which defined his instructional context—the subject (actor), object (shared goal or purpose), mediating tools (teaching modes and materials), and the produced outcomes of his instruction. Even though facets of each component shifted and changed over the course of the observed unit, those qualities that were consistent or typical of each component helped to create a representative description of Dr. Elm’s classroom activity system.

Subject. The first component of Dr. Elm’s contextualized DL instructional activity system is the subject, Dr. Elm himself and all the knowledge, experience, values, etc. that he brings into the activity. Dr. Elm, the actor in all observed instructional activity, taught College Prep (CP) level freshman biology. He was in his twelfth year of teaching and third year as a teacher at Park Forest High School at the time of this study. Dr. Elm has an undergraduate degree in biology—which included coursework in ecology, marine ecology, and wetland ecology— and a research assistantship “working with plants and trying to move DNA.” Dr. Elm later earned a PhD in molecular and cellular biology while working as a researcher in the university DNA lab. After picking up some substitute teaching gigs, Dr. Elm developed a taste for teaching, and decided to earn his teaching certificate in secondary science through the PACE program.

Background. Dr. Elm’s undergraduate experience exposed him to a wide array of disciplinary processes:

“...we did things like biochemical psychology, physics of a membrane, biochemistry, biophysics, a lot of that type of work and a lot of molecular because that’s what I was
doing was molecular, so I had to do the molecular and cellular, so I had classes in cellular biology, I had classes in molecular biology, and I also took transmission electron microscopy, and microscopy work, doing immunofluorescent microscopy and just about every microscopy I can get my hands on actually.”

He also had the opportunity to work with a wide variety of disciplinary tools: “I was really good at repairing equipment, so I got to work in a bunch of labs because I would fix things while I was in there, so that worked out really well. I learned how to use a lot of pieces of equipment that I would never use. . . . I’ve had a lot of background in working in a lab.”

Dr. Elm spent several years after graduation managing movie theaters in California before enrolling in graduate studies at Arizona State University, where he eventually earned his PhD in molecular and cellular biology. During his time at ASU, Dr. Elm worked as a teaching assistant and research assistant in the university’s DNA lab. There he continued working on plant DNA research:

“. . . we were actually trying to find mutations around reaction centers and how that was affecting plants, but . . . . I moved to doing human research. Actually, doing stuff on Alzheimer’s and arthritis, and a bunch on Parkinson’s disease, basically problems with the brain. All geriatric problems of the brain mostly.”

Eventually, he was hired by the lab as a research scientist and served as a member of their “tissue collection team” for donor organs.

Near the end of his doctoral studies, one of Dr. Elm’s close relatives had a serious accident, so he postponed his search for a post-doctoral position and relocated to South Carolina to support their recovery. As their condition improved, he started working part-time as substitute
teacher and eventually accepted a long-term substitute position. During that time, Dr. Elm discovered that teaching was something he always had an affinity for and quite enjoyed, so he decided to enroll in the PACE program to earn a teaching certificate for secondary science education: “I ended up in education and I really enjoy it. I really like teaching.”

However, Dr. Elm characterized his PACE training as mostly “useless.” He felt that he had already learned most of the material from his previous experience substitute teaching and teaching at the university level: “They made you do a lesson plan and they made you make a test and things like that, but I’d already been doing that. By the time they got to that, I’d already been teaching for a year and half, so if I hadn’t figured that out by then, I was in trouble.”

He spent the first three years of induction at a small rural high school (approximately 250 students) in the Oconee County School District of South Carolina, followed by five years at a larger secondary school in the same Glenwood County School District as Park Forest High School. Over the course of his teaching career, he has taught general biology, anatomy and physiology, IB biology, and AP biology.

**Pedagogical Values.** As a freshman College Prep biology teacher, Dr. Elm valued differentiated instruction that was responsive to individual student needs. Specifically, he favored what he described as a Montessori method:

> “Usually it’s sit down with the individual students and go over, which is pretty much the way I teach anyway. I like to . . . present it, sit down work with them, have them work with it on their own, check and see how they do.”

This low monitoring approach gave him the freedom to adjust his instruction for each student receiving individual support. In addition to responding to student needs, he felt that making
material personally relevant, or at least drawing connections between their individual background knowledge and target content were valuable tools for engaging students with content material and motivating them to complete assigned tasks:

“I sit down with individual students . . . and modify curriculum for that one student, give them a specific explanation that works for them; if they’re a basketball player, use basketball, if they’re a fisherman, use fishermen, right? I try to do it so it’s centralized to their interests and why this is important to them.”

In this way, Dr. Elm felt he could make content that students might not normally be interested in personally relevant to their own lives. He viewed content relevance as a tool for motivation. For these reasons, Dr. Elm believed it was important to establish and maintain personal relationships with his students:

“You know what their strengths are, you know what their weaknesses are, you get to work with them on them. . . . You’ve got to build that relationship and get those students to buy in. . . . Then they’ll find things you’re interested in and they’ll bring them to you. . . . or things that they’re interested in, they’ll bring to you. If they’re not comfortable with you, they won’t do that. . . .”

Because he valued personal relationships with his students and instruction that is responsive to the needs of the students, he also expressed a strong dislike for standardization: “I don’t like being told how to teach my class and what to teach in my class. . . . Cookie cutter, I don’t like cookie cutter.” What he described as “cookie cutter” instruction does not allow the freedom or time to explore student interests outside of the curricular pacing guide. From Dr. Elm’s
perspective, following a cookie cutter approach would force him to compromise his personal relationships with students.

In fact, at the time of this study, Dr. Elm was actually in the process of modifying his class structure to allow for more one-on-one time with his students:

“I’m kind of flipping back and forth right now between a flipped classroom and a standard classroom. I like the flipped framework, especially in the material we’re doing right now, because once you get it, you’ve got it, you don’t need to continually be hammered on it and I don’t need to sit in front of them and talk about it over and over again.”

The instruction I observed consistently reflected this approach. Most lessons began with a ten to fifteen-minute mini-lesson, then students were left to work on any labs or assignments in groups or individually at their own pace while Dr. Elm rotated around the classroom providing individualized instruction: “You just have to know the student and sit down with them individually . . . that’s probably the best way to do it.” They were given access to all assignments for the week on Monday, and the products of their learning for each day were not due until Friday. This gave students who worked more slowly the chance to finish assignments after or outside of school while also allowing those who finished assignments early to move ahead. All of the assignments and materials were accessible and submitted (in the form of pictures of completed work taken with cell phones) using Google Suite applications.

**Views on Scientific literacy.** With regard to scientific literacy, Dr. Elm believes that it involves a “higher understanding” comparable to that of a biology major. He explained scientific literacy included “knowing your subject and having actually applied your subject to real world
situations.” However, he did not believe that this should necessarily be the goal of secondary science education for all students:

“We teach them stuff they’re never going to use and they’re forcing them to learn it, like ‘how do you produce a protein from a piece of DNA?’ Maybe half a percent of them will ever do anything with that and why are you forcing all that on them? . . . This is your biology EOC class and it’s not even biology anymore, and they’re teaching them stuff they don’t need to know. Most of the stuff in the biology class, it’s not useful for them. They don’t need to know things about a cell. When are they going to need that? When are they going to use it? It’d be much better to do some more of the environmental, and ecology, and body stuff. We don’t do anything in the human body, nothing, so it’s like why are you teaching this?”

Dr. Elm felt that many of his students were being taught content that was not important or beneficial to them in his class. He did not agree that all students should learn the same biology content. Instead, he believed science education should serve a more utilitarian role and, at most, lay a foundation for more advanced disciplinary learning at the college level:

“I used to teach in college, and . . . they wouldn’t even know what the equipment was. . . So, when they get into their first mandatory . . . lab science class, and a quarter of their grade’s based on lab stuff and they’ve never seen the equipment, it’s really hard for them to be successful in those classes. . . We’re supposed to be preparing them for the next step.”

Dr. Elm believed that lab equipment and processes were important for students to learn if they were to be successful in college; however, he still committed himself to biology standards and
objectives that limited his ability to teach those disciplinary skills, explaining that “you can’t change what the states teach … No matter how much you scream at them.”

To that end, he felt it was important for his disciplinary instruction to focus on teaching students how to understand “diagrams, graphs, all different types of graphs, tables, and some statistical analysis.” He said identifying patterns is especially important in the field of genetics (the topic of the observed instructional unit from this study) and added subject-specific vocabulary and processes of inquiry to the list of learning outcomes he values: “I try to put those two together, laboratory and inquiry investigations with the necessary language, and merge those two together, that’s pretty much my style.” Ultimately, Dr. Elm believes that if his students can learn “how to get to information, how to cipher through information, how to analyze that information, and then be able to reproduce that information, it doesn’t matter what subject they’re in, they’re going to be successful if they can do that.”

Object. The second component of Dr. Elm’s contextualized DL instruction is the object or purpose of the activity, which is student learning. Dr. Elm taught the observed College Prep biology class to a diverse group of students. In addition to being a racially and ethnically mixed class, they were also from different cohorts (approximately half freshman and half sophomore). The following is his characterization of the students in the observed class:

“A lot of the sophomores didn’t take ninth grade biology because they needed a little more time and little more help. . . Then, the ninth graders are in there. . . A large chunk of my ninth graders in the classes are socially promoted, not grades promoted, so they come up with a 400 reading score. But, I’ve had really good discussions in that class. They’re
not a behavioral problem in class. . . but I’ve had to fight with five or six people to keep them working all the time.”

In addition to students who may not have been adequately prepared to take his biology course, he also shared with me that, among this group of students, “a bunch of kids . . . have IEP’s and 504’s, some are lower-functioning.” Furthermore, three students in this group had not been there earlier in the year but instead were transferred into his class from alternative school. Still, he described the observed class as either a “good class” or “good students” multiple times in our interviews.

In my own observations, the students in Dr. Elm’s class responded to his instructional approach in different ways. Some students did little work until the end of the week, others worked quickly and finished a week’s worth of assignments in a few days. There were some students who did not ask a single question during any of my observations and others who sought Dr. Elm’s assistance daily. Few students worked in groups. Most worked independently and sought help from nearby classmates or Dr. Elm himself when they had questions or difficulties. Indeed, they were a mild-mannered group—not particularly talkative or energetic. No doubt early morning fatigue contributed to their docile nature, which seemed to fade in the last ten to fifteen minutes of each class period.

Like Ms. Alder’s class, the target content for student learning in this course was largely determined by the biology End Of Course Exam (EOC). While the department follows state biology standards outlined for the course (ed.sc.gov), department-level pacing guides, common assessments, labs and activities, and topics of emphasis were collaboratively designed by the biology teachers and primarily informed by the topics and questions found on the EOC. Being a
College Prep course, the department expectation is that these students participate in fewer lab activities and practice with less rigorous examples than those in Ms. Alder’s Honors class; however, they are both accountable to the same EOC exam. As agreed upon by the department, vocabulary, test practice, and the topics from EOC questions students most frequently answered incorrectly were target points of emphasis for his genetics unit, including mendelian traits, incomplete and codominance, dihybrid crosses, and pedigree.

**Mediating Tools.** The third component of Dr. Elm’s instructional activity system context was the mediational tools used to facilitate disciplinary activity in his classroom. One of the tools embedded in the system permanently was the environment itself. Dr. Elm’s classroom was arranged in a similar fashion to Ms. Alder’s. The back of the room was a clearly defined lab area with safety station and sinks. However, there were fewer visible disciplinary tools and texts in his classroom. In the beginning of the observation period, his desk was situated at the front of the room. Midway through the study, he moved it to the side of the room. Students’ desks were arranged so that students sat in groups of four, and there was a couch to the side of the room on which students who completed work early often sat.

Other mediational tools utilized in the observed biology unit included guided notes, worksheets, and paper labs—all of which were collaboratively chosen or designed by the biology department. Dr. Elm encouraged students to utilize their tablet devices to leverage the internet in support of their independent work and to access digitalized course content and materials. He also used digital platforms as tools to disseminate course-relevant information to students and collect evidence of learning. Whole-class lecture was rare, but one-on-one small group direct instruction occurred daily. In addition, he performed one lab demonstration during the observed unit in
which DNA extraction equipment and chemicals were used to help demonstrate specific disciplinary processes.

**Outcomes.** Finally, the last component of Dr. Elm’s instructional context was the produced outcomes of the activity system. From Dr. Elm’s perspective, formative assessment reflected a range of outcomes for students, to which he responded to individually. Overall, he cited miosis, hybrids, proteins, and alleles as topics around which his instructional activity produced less than desirable outcomes. However, lessons on topics related to genetics, such as Punnett squares and sex-linked traits, produced outcomes more closely aligned with the objectives of activity. In other words, most students struggled with content related to what he called the “micro and the cell stuff,” but seemed to more easily grasp broader concepts like genetic inheritance. At the conclusion of the observed unit, he commented on their long-term progress, asserting that “they did really well on this test,” and “they’re basically jumping, at an average, ten points on each test right now.”

**Emergent Challenges and Negotiated Solutions**

The curricular objectives of the observed units on genetics and biotechnology in Dr. Elm’s CP biology class were a) explain how genetic information (DNA) is copied for transmission to subsequent generations of cells (mitosis); b) explain how meiosis followed by fertilization ensures genetic variation diversity; and c) understand how biotechnology can manipulate DNA to solve human problems (ed.sc.gov). However, persistent contextual challenges complicated his efforts to achieve those outcomes with his students. Those challenges were a product of contradictions and tensions experienced within Dr. Elm’s DL instructional activity system. After documenting his perspective on those challenges, subsequent coding and
analysis for emergent patterns yielded the following six themes: Training and Experience, Expectations, Assessment, Content, Student Schema, and Time.

**Training and Experience.** The first challenge to Dr. Elm’s DL instruction was classroom management. In his own words:

“Classroom management’s probably my weakest point because I never took any classes in classroom management... Then I went from being in very small classes in a small school, where it was really easy to develop relationships with the students, to being in a big school where it becomes harder because the first half the year you’re trying to develop those relationships and you’re basically fighting with them for the first half the year to get everything done.”

Here, Dr. Elm explained a challenge both cognitive and linguistic in nature. First, admitting his weaknesses regarding classroom management and attributing them to a lack of education on the topic suggests the contradiction in his activity system stems from his own lack of pedagogical knowledge—a cognitive problem. However, his belief that personal relationships can be leveraged for both motivating students and making content relevant to their individual lives and interests suggests that he views such relationships as mediational tools that support his classroom management. The inability to develop and leverage those relationships (tools) that he values constitutes a linguistic tension in his teaching activity.

In attempt to negotiate the challenge of classroom management, which stemmed from tensions between his own pedagogical knowledge (the cognitive component of his instructional activity) and the tools, strategies, and language (mediational tools) he was using or could not use to regulate student behavior, Dr. Elm instituted a linguistic change to his activity system informed
by his knowledge of context—specifically the immediate context of his own classroom and how
g o i, arrangement impacted instruction. He believed that one of the ways he could more effectively
keep students on task was to more clearly define his role and students’ roles throughout a lesson
by:

“Change[ing] . . . instruction from being up front to me not being up front the entire time,
but moving to the side/back of the room to allow them to know when I’m up front, they
need to be paying attention, I’m actually directly teaching, and when I’m not, I’m
 accessible and they can come ask me questions, or I’m up asking them questions.”
The physical relocation of his desk—modifying the environment, which is a mediating tool itself—
 changed the message and what it meant to students when he moved around the room:

“ I think I seem more ‘I’m going to get you’ walking around rather than me trying to help,
and I think me sitting down and them coming to me allowed them to set that time and come
over and not feel like I’m trying to get them, I’m trying to catch them not working. This is
what I’ve been doing the whole week before and it was miserable.”

In my earlier observations, I noted that Dr. Elm appeared to be “stretched thin” trying to help so
many students individually while monitoring the rest. Sometimes students waited for long stretches
of time with their hands raised before he made his way around to finally help them. He also had
difficulties getting the entire class’s attention from the front of the room. However, students knew
 after this change that the only reason he would be at the front of the class is if he had something
important to share with the whole group. They also knew, because he was no longer wandering
the room switching roles wherever he stood, that him sitting at his desk to the side of the room
indicated that they could come to him with questions and seek one-on-one support. In his
estimation, the outcome of this negotiation “works out that they get more individualized attention.”

He added, “Now they’re turning everything in. . . and I think I’ve found the balance now.”

**Expectations.** The second challenge to Dr. Elm’s DL instruction was the department norms, standards, and expectations to which he was accountable. From his perspective, they were often restrictive and sometimes directly contradicted his own personal pedagogical and disciplinary values and experience. There was one week in particular that he experienced difficulties because of the materials he was required to use by the department:

“This week for me pedagogically, the problem is that I’m not a worksheet kind of teacher, right? I want to do more conceptual stuff, work in a lab, get into it and then move to that material, and that’s not how this school operates. For me, it’s been hard because I’m basically handing out a worksheet every day and we’re working through it.”

Similar to his management problems, this is another example of a contradiction that arose between Dr. Elm’s values (subject) and the learning materials (mediational tools) he was expected to utilize in his teaching activity. He admitted in one of our interviews,

“I hate it and the reason I hate it is … Are we doing all this nice common planning? Yes. Everything’s lined up, you know exactly what you need to be doing, but I get inspiration for things and I find things, or somebody mentions something, and I can’t change what I’m doing to incorporate these new things that would work really well.”

This was a linguistic challenge, as the communicative tools for mediating disciplinary activity (in Dr. Elm’s opinion) were what contributed to undesirable outcomes for his students. Moreover, he felt that it limited his ability to differentiate his instruction to make material relevant to student interests, a sociocultural contradiction between his values and the those of the department (object):
“You’re trying to convince several other people to do the same things that you want to do and if that’s not something they’re comfortable with, they’re never going to do it. Like I said, I’m very lab-based, the other teachers here are not, so it ends up being more towards paper, rather than actual lab experience. That’s why I don’t like it.”

Dr. Elm felt that the tools agreed upon by the department were insufficient for teaching his students the kind of authentic disciplinary practices he values—a linguistic challenge. Moreover, department norms basically prohibited him from employing different tools or altering the pace of his progression through curricular objectives to accommodate individual students without imposing those tools on every student and teacher in the department—a sociocultural challenge. From his perspective, these expectations were significant obstacles to his DL instructional efforts:

“Common assessment’s fine, but absolutely common everything and keeping each class at the exact same point, where you can’t slowdown in some classes or speed up in some classes, you’re supposed to be all at the same point, taking tests at the same time, that’s a daunting task and it doesn’t serve the students.”

Dr. Elm found value in holding students to similar standards across the department; however, other department standards that bound him to a fixed pace and schedule made it more difficult for him to meet those assessment standards, and it made him feel overwhelmed.

In response to instructional challenges related to the biology department standards, norms, and expectations, Dr. Elm sometimes circumvented them using linguistic and sociocultural approaches. For example, he conducted a lab demonstration with the observed College Prep class that was not only outside of the curriculum for his course but went beyond the scope of what the department had agreed upon even for the Honors students. He had made it very clear in our
interviews that he felt the tools chosen by the department were insufficient for authentic DL instruction, and he had very strong feelings about the expectation that he limit himself to those resources. Therefore, his best solution to this contradiction between his values and the department’s over instructional tools was to introduce unapproved materials to his classroom activity system:

“I went more from the lab approach to get those in, some of the other teachers didn’t do that, so I’ve kind of diverged a little bit, which we can in the minor stuff, it’s kind of frowned upon, but I have all the equipment and stuff. The reason it’s frowned upon is, [administration] . . . wants everything to be pretty uniform.”

Here, Dr. Elm leveraged his knowledge of disciplinary processes by choosing more authentic tools for instruction, as well as knowledge of context, curriculum, and educational goals by ensuring the new tools still aligned with prescribed department standard objectives (and more) without violating any explicit department policies. That is, minor grades were the only assignments teachers had the liberty of adding or changing. Therefore, Dr. Elm simply chose to change the students’ evidence of learning from what would normally be a major or mid-level grade for a lab to a minor one. The following is his description of the demonstration and how he used it as a tool to negotiate this challenge to his disciplinary instruction:

“The standard is that students understand that DNA controls the cell and that the DNA is located in the nucleus, and then how we can manipulate that DNA, which is what we were doing. We did a DNA extraction, right, so there’s DNA that comes out of here. It also gave good information on structure because of how you get the DNA out, I got to explain that
to give them another backup for their structure rather than just looking at diagrams and talking about it, they can pull it out.”

Not only did he expose students to extracurricular disciplinary tools and processes that were not required or approved by the department, but he chose a lab demonstration that would also reinforce target content learning by presenting the same information using multiple modalities. He elaborated more on the disciplinary processes involved in the demonstration:

“That we ran it in the gel electrophoresis. . . We spin it down. We extract it, pour off alcohol. We resuspend it in a buffer so they learn, well the alcohol’s not going to work to put in the gel, we need to have an aqueous solution with water in it, so we use this buffer.”

Here, students were able to see the chemical and physical reactions described in their course texts. They might learn that buffers are used in DNA extraction from department prescribed resources but seeing how buffers are used and having the extraction process explained as the reactions happened exposed students to a wider range of disciplinary tools and processes. Even though the students didn’t participate themselves, and the demonstration was not 100% authentic to modern DNA extraction methods, it still exposed students to lab materials and processes that supplemented their learning goals and could be applied beyond the biology EOC and across the domain of science:

“I actually have a [polymerase chain reaction] PCR machine. We don’t have the enzymes and stuff you need to do PCR [thermal cycling] and all that stuff, it’s really expensive, but I ran through the process with them. You can’t see it anyway, so you can dummy it up because you don’t see DNA, it’s actually clear. You amplify the DNA. I can just fake it
and put suspended DNA in . . . So, even without the supplies, I can mock it up so they don’t even know we really don’t have the supplies and they can do the whole process.”

This modification to his instructional activity constitutes a linguistic approach via the introduction of authentic disciplinary tools into the activity system. The standards do not require students to engage in hands-on practice with DNA extraction. They are not required to know the tools used in the process or how they function. Yet, Dr. Elm was able to make his instruction more authentic to disciplinary practices and processes without violating explicit department policies for content instruction and grading.

**Assessment.** Although Dr. Elm referred to common assessment as “fine”—especially in comparison to the impact of other mandated common practices on his instruction—he did suggest that tensions still arose as a consequence of the biology EOC, specifically. For example, target content as determined by the EOC rarely included the kind of disciplinary process knowledge or application that Dr. Elm values as a teacher and disciplinary expert:

“I’m not the biggest fan of the EOC. I just think it’s something that we . . . It’s not going anywhere. It’s just something we have to do. . . . That’s kind of what’s missing in this direct instruction, drive it down their throat, information style, that you kind of have to do with EOC’s because it’s a massive amount of material. . . there’s not a lot of lab stuff you can do with that.”

Asserting that instruction geared toward EOC content does not lend itself to the kind of hands-on disciplinary activity he prefers suggests a sociocultural misalignment between his own values related to disciplinary learning outcomes and that of the prescribed object (EOC content) of his instructional activity. He summarized his feelings by asserting that “what they’ve turned the
classes into for EOC’s is training to take an EOC. It’s not a biology class anymore, it’s an EOC class.”

Negotiations in response to contradictions between his own values related to disciplinary learning outcomes and that of the prescribed object (EOC content) of his instructional activities were evidenced in the previous observed activity as well. In addition to introducing new tools to his classroom activity system with the electrophoresis lab, he also added new objectives to the activity system. Because knowledge of certain chemicals and their functions in the DNA electrophoresis process is germane to the discipline, he designated that knowledge as an additional objective for the activity—knowledge such as “why we use a buffer, and what a buffer is, because that’s barely in our standards, but something that’s kind of important when you’re doing anything in a lab is understanding what a buffer it. It’ll be good for them for chemistry.” Instead of trying to negotiate away the EOC, Dr. Elm found a way infuse authentic disciplinary tools into his classroom that align with both the EOC standards and his own values, increasing both the breadth and depth of his disciplinary instruction. Here, he negotiated a linguistic and sociocultural solution informed by his disciplinary knowledge, knowledge of context, knowledge of curriculum, and educational goals.

Content. His fourth challenge stemmed from the target content itself—that is, Dr. Elm often felt that the prescribed objectives of his teaching activities were either irrelevant to students’ personal lives or poorly sequenced. Regarding relevance, he explained:

“Because for some of the kids, they’ll need the deeper understanding and some of them aren’t going to ever do anything in biology, they’re going to be a plumber, so I think we actually teach the wrong material. I think we should actually teach what we teach at the
end of the year a little bit, the ecology, evolution, and maybe something in the human body, because we do all cell stuff until the last like four or five weeks of school, that’s all we’re doing is cells.”

In essence, Dr. Elm does not believe that all students benefit from learning the content he is charged with teaching. Again, this tension over the object of his activity constitutes a sociocultural challenge. Like the linguistic challenge to differentiating his instructional tools, this conflict made it difficult for him to differentiate target content—something he values:

“They’re teaching them stuff they don’t need to know. Most of the stuff in the biology class, it’s not useful for them. They don’t need to know things about a cell. When are they going to need that? When are they going to use it? It’d be much better to do some more of the environmental, and ecology, and body stuff. We don’t do anything in the human body, nothing, so it’s like why are you teaching this?”

Moreover, he believes the order in which topics are arranged in the curriculum results additional tensions that make his instruction difficult. For example, the department pacing guides treat the law of segregation and dihybrid crosses as separate topics in the genetics unit. However, in order to understand dihybrid crosses, students have to apply the law of segregation. To understand the law of segregation, students have to understand the process of creating gametes from parental alleles—miosis. Sequencing topics such as sex-linked traits between Mendelian laws of inheritance and dihybrid crosses made them “seem like two separate entities, they’re actually one complete concept.” This opinion was informed by some of the questions students asked while working independently on dihybrid cross worksheets. I prompted Dr. Elm to describe how their confusion related to content sequencing, and he explained in more detail:
“When we started doing the hybrids, we’d just been doing sex-linked, and we did two different sex-linked things, they immediately wanted to put the X and the Y in to make it sex-linked because they’d been doing that repetition through that. . . Or they want to just put, instead of having two alleles, they’re just using one allele.”

In other words, separating Mendelian laws from dihybrid crosses as learning objectives contradicted his disciplinary understandings and pedagogical values, and he believes it made it difficult for students to see that the topics were related, complicating his efforts to achieve the desired outcomes of his instructional activity.

In response to challenges related to content, specifically those sociocultural tensions between the department’s belief in standard objectives and Dr. Elm’s belief in relevant objectives, he leveraged current events in science to draw connections between course content and contemporary issues that can directly impact student lives. One clear example of this practice occurred during an observed lesson where a student asked Dr. Elm what he knew about the novel Coronavirus (COVID-19). Some had seen on the news or read online that the virus was dangerous and that there was no treatment or vaccine. The question sparked interest and others began searching the topic online. Soon several students were asking questions about their relatives’ health risks, the prospect of closing school, the symptoms, how to avoid catching it, etc. Dr. Elm used this as an opportunity to reinforce students’ understanding of microbiology concepts:

“You know, you bring that stuff in and you make it more relevant, make it interesting. You talk about viruses, this is what a virus does, this is how it invades. . . start talking about things that affect them. . . this is what it’s going to do to you, stop sharing drinks. . . stop sharing foods, you pass things around.”

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In this way, Dr. Elm combined his disciplinary and content knowledge with knowledge of context—in this case, an ensuing pandemic across global contexts—to negotiate the challenge of making biology relevant to individual students’ lives. Current events became a platform for extracurricular disciplinary learning.

His responses to sequencing challenges, however, were less nuanced and came at a cost. Regarding the difficulties in his instruction that stemmed from Mendelian laws and dihybrid crosses being positioned as separate topics in the curriculum, Dr. Elm dedicated most of an observed class period reteaching meiosis. However, this time, he used it to explain both dihybrid crosses and the law of segregation: “I was explaining to them, not just showing them ‘here’s the pattern, how it works,’ but why that is through meiosis and how that occurs so they could get the law of segregation to go along with the dihybrid crosses.” Meiosis was not one of the predetermined objectives for that particular lesson, but “to understand that dihybrid crosses bring in the miosis because that gives them a physical model, we did physical models on why it separates out the way it does, and it randomly segregates.” In this negotiation, he leveraged his disciplinary knowledge and his knowledge of students to inform changes to the object of his activity—a sociocultural solution.

Student Schema. In addition to the target objectives being irrelevant to students lives and poorly sequenced, they sometimes exceeded students’ zone of proximal development—that is, Dr. Elm felt that, based on his knowledge of students and their schema, some of the prescribed objects of activity were too advanced. He emphasized that, for example:

“Chemistry is really what they’re missing. They’ve done a lot of stuff in biology that’s environmental related or species related or organ systems, things like that. They do a lot of
that in middle school. . . but they’re missing chemistry stuff. Some of the kids come up, they don’t know it. . . They don’t know what an atom is. I write them up on the board, like I put sodium as Na, and they go ‘why is it Na?’ They have no idea. It’s really hard on them because you’re throwing them straight into chemistry without a chemical background.”

Because the learning objectives were fixed and determined by his department, the students’ lack of requisite background knowledge in chemistry made it more difficult to achieve desired outcomes related to molecular biology—a sociocultural challenge.

Activity surrounding other topics related to chemistry in the observed genetics unit produced contradictions between what Dr. Elm knew about his students’ schema and ability levels and the curricular objectives set forth by the department, which he believed to be outside the zone of proximal development for some of the students, and were negotiated by accelerating the gradual release of responsibility for his more advanced students while dedicating more time to individualized content review with students who struggled. He described his two-part solution as follows:

“The first things I do is, when we come into a unit, I try to give them two or three days ahead, so if they’re busy in their other classes, they’ve got a little bit of time, if they’re not busy in their other classes, they can pre-do stuff and be ready for it.

But also. . .I can walk around and find the students that need the help. The ones that have got it, they’re good, I can let them work and it gives me time, rather than me just standing up in front and explaining everything, and all the students, the 60% of them that already knew it, I’m wasting their time, and the other 40% don’t understand what I’m doing so it’s not helping them. I get to break it and go to work with that 40%. “
By decommitting himself to the pacing guide enough to allow different students to pursue different objectives based on their own knowledge and abilities, and by changing the method by which he mediated his instructional activity, Dr. Elm negotiated a linguistic and sociocultural solution to this challenge informed by his pedagogical knowledge, knowledge of curriculum, educational goals, and knowledge of students.

**Time.** The last challenge Dr. Elm experienced in his DL teaching efforts was that of not having enough time to implement the amount of activities he felt was necessary to achieve all of the learning objectives for the observed unit of instruction. As described above, the quantity of EOC content already necessitates a rigid pacing guide be imposed on the department. As a consequence, Dr. Elm. felt the students in his class “don’t have time to play around with stuff”—a component of inquiry he values as a teacher and disciplinary expert. In addition, bridging gaps in students’ background knowledge would require using additional instructional time to review extracurricular content, time that can only be recovered by accelerating an already brisk pace of target content instruction or at the expense of target objectives. Not to mention the fact that he lost an entire day of instruction during this unit to tornado and flood warnings. Simply put, the object of his instruction may have been too broad in scope to begin with given the time constraints of his teaching context, that scope was further broadened by students lack of background knowledge, and the time constraints were further tightened by contextual anomalies (school-wide lockdown and extended tornado drill).

With such little time to cover all of the required course content, Dr. Elm was already expected to achieve more objectives than he believed possible in the time he was given with students, and that list of objectives grew even larger as a consequence of discovering students’
lack of background knowledge. In addition, a school-wide lockdown for an extended tornado drill consumed an entire day of would-be instruction for the observed unit. Although Dr. Elm was confident that his flipped classroom structure would allow him to differentiate his instruction and maximize learning time for each student, he admitted that under these circumstances there was “still not enough time—28-30 kids—it’s not enough time.” In attempt to negotiate this contradiction between Dr. Elm’s vision of how much content could reasonably be taught given the time constraints and the content required by his department, the flipped classroom was his best solution. However, he quickly realized that a solution had not been fully negotiated and the challenge would persist: “They’re just getting it now, which is a little late because we’re testing a week from today, so I would’ve liked them to have gotten that a little bit earlier.” His flipped classroom may have solved the problem of students’ lack of background knowledge, but it ultimately failed to solve his problem of limited time.

Summary

Like Ms. Alder, Dr. Elm often found his own values to be at odds with those of the department and EOC. Not only did he question the authenticity of the biology curriculum, but he questioned if the content itself was worth teaching. Dr. Elm doubted students benefited from learning certain biology content at all; however, of those topics he was expected to teach, he felt that they should be taught with authentic tools, tasks, and for authentic purposes. To this end, Dr. Elm frequently circumvented EOC standards and department expectations. He flipped his classroom to give himself more flexibility regarding the pacing guide. He demonstrated lab activities in which the department would not allow students to participate. And, he used the little bit of grading freedom afforded to him to hide unapproved major activities and assignments from
administration as minor grades. In many ways, Dr. Elm put his own values and the needs of his students ahead of those of the biology department. Overall, his instruction can be categorized as a slow, quiet rebellion against the standardization of biology instruction.
Chapter 6: Oppressive Autonomy

Walking into Ms. Hawthorne’s classroom feels like walking into a real laboratory for a real scientist. The walls are covered from floor to ceiling with periodic tables, anatomical diagrams, scientific quotes, and products from student lab activities. Various experimental equipment line the center of each lab station at the back of the room, and a terrarium housing a lizard sits beside her desk at the front of the room. Her students congregate in small groups, boisterously socializing before the bell rings. Her entry into the classroom is a signal for students to return to their seats. And they exchange small talk and banter with her as she opens a short PowerPoint presentation.

Today’s lesson is on forensic serology, and her PowerPoint introduces the topic using blood transfusion, organ transplant, or pregnancy to set up the importance of blood typing. “You mean like on Maury?” a student in the back of the room asks playfully.

“You are the father!” another shouts. The whole class laughs.

“That’s a perfect example, actually,” Ms. Hawthorne replies. She continues to emphasize the practical applications of DNA and blood spatter to forensic investigations, and students draw more connections with cable references. “Dexter can solve any case if there is blood spatter at the scene,” one girl says, as if she is bragging on behalf of the fictional TV character.

Ms. Hawthorne agrees, “Yes, Dexter is another good example. It’s actually a better example than some other shows because you see that Dexter really only focuses on one thing. He sometimes gets more involved in the putting together of evidence than real forensic serologists do, but you get a better idea of how specialized different types of forensic scientists are.” She finishes her lesson introduction and by showing students how to use Punnett squares to determine genotypes (allele combinations) of offspring based on parents’ blood types, she also uses
percents to show probabilities for each type before teaching students how to use a digital resource that will support their lab activity for the day. She refers to the activity as a bloody typing game, where students test blood types and interpret results based on the reactions that do or do not occur in the test tubes on the screen. Then, they administer blood transfusions to fictional patients.

After giving her instructions and modeling the activity, students are released to their independent lab work. Initially, the students delve into the assignment with focus. There is little talking, and most seem to be very concentrated on their work. Ms. Hawthorne makes rounds checking student progress in the game and helping any students who appear to be struggling. She reinforces previous learning, reviewing concepts to coax students toward the right steps in the game. As students begin to grasp the first phase of the game, the second phase begins to excite them. “Ahhh! I killed a guy!” one girl shouts as she pulls her hands away from the tablet screen and drops it on her desk. The audio signal that her fictional patient has been given the wrong blood type for his transfusion is a loud scream that startles her, and her neighbors laugh uncontrollably.

“Brie, you’re the worst nurse of all time!” a friend beside her jokes while elbowing her in the side.

Ms. Hawthorne addresses the whole-class, “Remember guys, you have to make sure you don’t make any mistakes when testing the blood types. If your patients are screaming it’s because you did something wrong before giving them the blood transfusion.”

“Ms. Hawthorne help me! I keep killing people over here and I don’t know why!” she pleads. Ms. Hawthorne squats beside her desk and reviews previous learning using Punnett squares to determine genotypes (allele combinations) of offspring based on parents’ blood types and using percentages to show probabilities for each type. She then guides the student again through the
entire game from the beginning until a successful transfusion is accomplished. Meanwhile, other
screams are heard throughout the room as some students struggle or make mistakes administering
their digital blood transfusions.

One small group of boys deliberately give their patients the wrong type to try and startle
each other. That side of the room sounds like the opening scene to a B-list slasher film. Ms.
Hawthorne recognizes their frolicking and addresses it indirectly, “It sounds like you gentlemen
REALLY need some help. Do you need me to come over there and help you?”

“Nope, we’re good. Sorry,” their faces turn shades of crimson as they try to stifle their own
hysterics, and they make busy not to draw any more attention to themselves. Ms. Hawthorne
continues to move from student to student ensuring that they complete the game successfully until
the end of the class period. As students pack up their things in anticipation of the bell, she squeezes
in her last instructions of the day, “If you did not finish your analysis questions from the activity
today, I will collect them tomorrow, so don’t forget to finish them.”

The bell rings and students slowly exit the class. “Ms. Hawthorne, we should watch an
episode of Maury tomorrow in class,” One of the boys from the slasher group says on his way out.

“I don’t think we have time for that,” she replies.

“What about Dexter?” he pleads while hanging on the door frame, head in the classroom
and both feet in the hall.

“Maybe at the end of the year we can watch some scenes or something,” she relents without
committing.

“Yes!” he shouts and darts out into the hallway.
This was an example of a typical lesson in Ms. Hawthorne’s forensics classroom. Not only typical of her classroom environment, student behavior, instructional methods, and forms of assessment, but also emblematic of the kinds of instructional challenges she encountered in her instructional activity and her negotiations of those challenges. In the above example lesson, Ms. Hawthorne negotiated her way around several instructional challenges in order to achieve the desired outcome of her classroom activity system. In her case, lack of resources was an ever-present challenge that required constant negotiation. She desires for her instruction to be authentic to the practices and processes of real forensic scientists, but she did not have access to the kids of tools and materials that professional investigators use in the field. For this lesson, she lacked the test tubes, blood samples, and chemicals necessary to actually determine blood types. So, rather than just explaining the process for students to remember and regurgitate on the exam, she found a free digital resource that simulates the process enough for students to understand how those tools would be used and to what ends.

This was just one example of the many challenges negotiated by Ms. Hawthorne that stemmed from contradictions between interactive components of her classroom activity system. In this one example, contradictions between her own valued learning outcomes and the mediational tools provided by the district caused her difficulty when designing her instruction. Her negotiation of this challenge first involved research and a willingness to vet and incorporate new tools that were neither fully hands-on, nor completely decontextualized. Then, she used the tool as an instructional aide as well as a form of guided practice. Finally, she allowed students to engage with the process independently while providing support when necessary and drawing parallels between the game and real lab procedures. In this way, Ms. Hawthorne successfully
navigated a solution to this instructional challenge. She engaged in similar negotiations regularly throughout the unit. In most situations, she was able to negotiate a solution; however, some challenges to her instruction were either persistent or ongoing through the unit, resulting in failed negotiations or regular renegotiations of those challenges.

**Deconstructing Ms. Hawthorne’s Classroom Activity System**

Using Fisher’s (2019) GOAT framework, the following sections identify features of each component of Ms. Hawthorne’s typical situated instructional activity, which defined her instructional context—the subject (actor), object (shared goal or purpose), mediating tools (teaching modes and materials), and the produced outcomes of her instruction. Even though features of each component shifted and changed over the course of the observed unit, those characteristics that were consistent or typical of each component helped to create a representative description of Ms. Hawthorne’s classroom activity system.

**Subject.** The first component of Ms. Hawthorne’s contextualized DL instructional activity system is the subject, Ms. Hawthorne herself and all the knowledge, experience, values, etc. that she brings into the activity. Ms. Hawthorne, the actor in all observed instructional activity, was in her sixth year as a teacher at Park Forest High School at the time of this study and taught CP forensic science. She has a bachelor’s degree in biology from the University of South Carolina Upstate and a master’s degree in biomedical forensic science from Boston University School of Medicine. After struggling to find employment in the field, Ms. Hawthorne enrolled in the PACE program to acquire a teaching certification in secondary science, where she plans to continue working until retirement. Thereafter, she hopes to return to lab-based employment.
Background. Her master’s coursework included forensic biology, forensic chemistry, and crime scene investigation, followed by more focused coursework in a more specialized discipline. Ms. Hawthorne chose to enroll in more advanced DNA courses before completing her thesis, which was a “lab-based, DNA-based thesis.” She said that her program involved a lot of lab work, and “since forensics is applying science to law, I also had to take two law classes that are focused on forensic scientists, testifying and how it all goes, but there was even practice activities in that as well.” In addition, she worked a “six-month internship with Glenwood County Forensics, the DNA lab, around fall of 2012 or maybe spring 2013.” Upon her appointment, “the very first thing they had me do was read through all the lab safety manuals and through all the protocols,” explaining to her that she was expected to learn them all. After passing her safety protocol quiz,

“They still weren’t allowed to allow me to work on any case-related things, but they would let me observe if they were working on something. They would put together different examples. They would make a fake thing for me to look at, kind of like I would for my students. I would see them working on case-related things and they would explain to me as they were working why they were doing different things.”

Her disciplinary experiences were not limited to lab activity, however. She explained that forensics is not just considered with science but also with law. Thus, she chose to “minor. . . in criminal justice, so I actually had to go and observe a lot of court cases also.” Here, she learned why the safety protocols were so important for her to commit to memory: “To make sure that you don’t contaminate or misplace or do anything with it because you could be held legally responsible for it.”
At the conclusion of her internship experience and after graduation, Ms. Hawthorne struggled to gain employment as a forensic scientist. While she continued her search, she worked part-time as a substitute teacher. As time passed, the prospects of finding a job directly related to her training experience seemed slim, so she built on her substitute teaching experience by enrolling in the PACE program to earn a professional teaching certificate for secondary science education. She admitted that teaching is not her true passion but hopes to do it long enough to collect retirement benefits and pay off student loan debt. Thereafter, she hopes her teaching experience will make her a more appealing candidate for jobs in the field of forensics.

**Pedagogical Values.** As a high school forensics teacher, Ms. Hawthorne values flexibility, authentic disciplinary activities, labs, and tools, and differentiated instruction. She made herself available for tutoring before school, during lunch, and after school every day of the week so that she could implement more responsive instructional activities for her struggling students. She did not assign homework but allowed students to finish in-class assignments at home or during tutoring hours if necessary. She was also always willing to accept late work from students. In fact, three students who did not complete a blood spatter lab the day before spent the duration of one of my lunch interviews with Ms. Hawthorne making up that assignment. Before they arrived, she had already arranged the necessary materials into stations.

**Views on Scientific literacy.** Regarding scientific literacy, Ms. Hawthorne defined it as “reading any text that has to do with science for content or being able to look at information that’s given to you and understand how it all applies to each other, but really reading for context.” When asked to elaborate on literacy in forensic sciences specifically, she said it involved being “able to use science to help solve any legal issues, whether they’re criminal or not, and being able to use
critical thinking and deductive reasoning to solve the problem at hand.” She went on to characterize the types of reading, writing, and speaking practices germane to the forensic disciplines:

“Reading is usually current work, current research, so articles published by other scientists. Writing would be publishing your current work and research. Speaking would be either presenting your research at conferences or testifying in court on cases that you’ve previously worked on.”

In addition, she described professionalism as an important disciplinary norm:

“There’s kind of a culture of you have to be very professional at all times because whatever you do and say could have a direct or an indirect impact on someone’s life, whether they go to jail or not, how long for. Now, even if they committed the crime, but the scientist makes a mistake or misspeaks, that could all come back onto the scientist. No matter what the scientist is saying or who they’re saying it to, you kind of almost always have to be cautious and realize what you’re saying and how you’re saying it.”

When asked what her vision for the course was regarding outcomes, she explained how they were distinctly less intense than those of her Honors students:

“Because this class isn’t as math-focused, especially for the CP level, I chose some of the topics and chose to leave out some things based on that. . . . For the CP level, we were able to substitute chemistry with another science. . . so they had to have taken biology, and they could have taken like earth science, or environmental. . . so that they at least get those skills, lab skills and scientific method, reasoning skills down. . . .This course is more content, more relevant, and students tend to understand it a little bit easier because they’re interested in it . . . I do get that average student that’s either not going to college or not
going to college for anything science-related and they just need a third science credit and they don’t want it to be too math-y.”

In short, Ms. Hawthorne wanted her instructional activity to reflect the disciplinary values of the field of forensics, be responsive to her students’ diverse needs, relevant to their lives and interests, and more focused on scientific processes and skills than mathematical.

I asked Ms. Hawthorne to share the one thing she believed was most important for students to learn in her CP forensics class. She answered,

“Attention to detail. . . . Really all year long they’re learning both deductive and inductive reasoning, but to me, in forensic science, because it’s all going through that legal system and you have to dot your I’s and cross your t’s on everything so that you, yourself, don’t end up being implicated in anything. Planted evidence or accidentally cross-contaminating something and DNA transfers so easily, but it’s all really, really tedious and it’s so not what you see on TV, so breaking that barrier of it’s not what you see on TV, and this is what it looks like, and just paying attention to those details. If you’re supposed to date something, if it’s not dated, it’s going to be sent back. If you don’t meet a deadline, then that guy that was on death row is going to be executed because you didn’t meet your deadline.”

Ms. Hawthorne revealed her specific disciplinary values that she has adopted herself and wanted to instill in her students. Not only to clarify misconceptions about forensic investigative processes, but she had practical reasons for emphasizing disciplinary values over informational content. “Attention to detail” may not be as important in other disciplines, such as retail, but in forensics, negligence can cost an innocent person their life or lead to the release of a dangerous criminal.
From her perspective, the weight of our justice system teeters on the diligence of forensic scientists.

**Object.** The second component of Ms. Hawthorne’s contextualized DL instructional activity system is the object or purpose of the activity, which is student learning. Ms. Hawthorne taught the observed CP forensics class to diverse group of students. In addition to being a racially and ethnically mixed class, like Ms. Hawthorne’s, they were also from different cohorts. Moreover, she had eight students with IEP’s, three language learners, and three students with temporary medical disabilities that require that she release them from class (with a helper) at least five minutes before the closing bell. Her class was the most energetic of the three observed in this study. They were also the most sociable. One student in particular went out of his way to make small talk with me before class almost every day I was there to observe. The students were also eager to show me their work during lab activities and comfortable explaining their processes.

Unlike Ms. Alder and Dr. Elm, Ms. Hawthorne had no standards at all for her course. There was no pacing guide, bank of approved resources, standard assessments, or other colleagues who taught forensics to whom she could turn for guidance. Ms. Hawthorne completely designed her own curriculum and was responsible for her own modifications based on data collected using her own assessment materials. She explained:

“Not only am I having to create the activities for the students to show me that they understand the content and to help them learn the content, but I have to decide on what that content is and what I want the students to learn, which then, in the broader picture of things, other schools that are also teaching forensic science wouldn’t necessarily be teaching the same thing. A student taking my class and a student taking forensic science at another
school could learn some of the same topics, core topics and concepts, but they could end up learning totally different things.”

However, even though forensics was not a required course, it was considered one of the laboratory sciences, of which students had to pass three to graduate. So, in the absence of an EOC or course curriculum, the only expected outcome that wasn’t determined by Ms. Hawthorne was that her students’ learning involved some lab-based education that was less rigorous than her Honors version of the course. For the observed unit, she chose to focus on a combination of DNA, fingerprinting, and blood spatter analysis as topical objectives around which to design her instructional activity.

**Mediating Tools.** The third component of Ms. Hawthorne’s instructional activity system was the mediational tools used to facilitate disciplinary activity in her classroom. Ms. Hawthorne used a wide variety of tools in her instruction, many of which I was able to observe myself. In addition to lecture, she frequently used PowerPoint presentations, scientific articles, and paper-based worksheets, references, guided notes, news stories, scenarios, and instructions. Visual aides were also used often, and included images, sketches, graphs, diagrams, and scales. In addition, lab activities and assessments required students to use manipulatives that included fake blood, droppers, magnifying glasses, calculators, dyes, fingerprinting powder and dusters, magnetic dusters, and various measuring devices.

**Outcomes.** Finally, the last component of Ms. Hawthorne’s instructional context was the produced outcomes of her teaching activity. When asked what formative data was telling her, she replied,
“We’re pretty much staying on track with where we need to be, which makes me feel pretty good and I’m kind of taking the opportunity at the end of the week to get some students caught up on some work from the previous unit because we are in a good place currently with the current unit.”

Her sentiments were confirmed at the conclusion of the assessment on fingerprinting, where I noticed all but two or three were visibly and vocally pleased with their grade. She used an app on her cell phone that functioned like a digital Scantron—taking pictures of student answer sheets and instantly grading them. I overheard one of the few students who did not perform well on the assessment respond to his grade, “Well, that’s higher than I thought I’d get.” This suggests that even low-performing students may have improved as a product of Ms. Hawthorne’s instructional activity.

**Emergent Challenges and Negotiated Solutions**

Ms. Hawthorne’s explanation of her objectives for this unit was as follows:

“So this unit is forensic serology and serology covers any and all bodily fluids, and I do touch on a variety of different fluids so that they’re familiar with what they are, how to test for them, but I spend more time focusing on blood because that is a common bodily fluid found and I can also talk about DNA at the same time and blood spatter, so that’s a good way to combine several different topics into one unit and relate them to each other as well.”

However, persistent contextual challenges complicated her efforts to design authentic disciplinary activities for her students. Those challenges were a product of contradictions and tensions experienced within Ms. Hawthorne’s DL instructional activity system. After
documenting her perspective on those challenges, subsequent coding and analysis for emergent patterns related to the contradictions and tensions experienced during her DL instruction activities yielded the following Five themes: *Time, Expectations, Training and Experience, Support,* and *Authenticity.*

**Time.** Though time is a challenge for most teachers of any subject at any grade level, Ms. Hawthorne had a unique circumstance exacerbate that challenge. Near the end of the observed unit, Ms. Hawthorne went on a two-week leave of absence. During this time, technology was inaccessible to her. Not only did that pose a challenge in that she would not be there to provide the most effective instruction, but it would be impossible for a substitute to implement any of the instructional activities she had already designed for her students:

“Because I had to be out for two weeks. . . the activities that I would normally do with the kids aren’t necessarily sub-compatible. . . I wasn’t able to post anything or show them any videos, so I had to look back at, well, what can we do that doesn’t require me using technology but the students would still learn the same content? . . . I feel like I just need to move on from this unit.”

Ms. Hawthorne was not bound to any pacing guides or standard assessment; however, an entire unit of instruction could have been completed in two weeks. The loss of such a significant amount of time after already starting a unit made her question if it would even be possible to resume instruction on the same topic. This reflects a conflict between the object and subject of her activity system. Because she controls the curriculum and determines the target objectives, this challenge is cognitive in nature—an internal struggle over values on the part of the actor (subject).
In attempt to negotiate this conflict between her own values and the target objectives of the unit, she completely shifted the objects of her instructional activities. Ms. Hawthorne chose other disciplinary practices around which instructional activity could be designed for and implemented by a substitute teacher until she could return to her classroom: “Because I knew I would be getting technology back soon, instead of just pausing and doing nothing, I chose to switch up the order and do those tasks that I could do without anything digital first.” This involved removing one lab activity from her long-range plan: “I’m not sure if I’m going to do the DNA extraction from strawberries lab with my CP kids or not and actually had a student mention that they did that lab in [another] biology class. . .but because of the time schedule and everything, I may skip that activity with CP.”

Ms. Hawthorne did skip that activity. During her time away, students focused primarily on vocabulary, guided notetaking, and paper-based scenarios. The artifacts themselves reflected a cognitive approach to DL instruction (e.g., highlighting vocabulary terms as they appeared in guided notes), but constituted a linguistic approach to the contradiction in her activity because she changed the mediational tools of the system. In addition she modified the objectives of her designed activity system to exclude disciplinary processes knowledge—a sociocultural approach. To do this, she had to utilize pedagogical knowledge to modify her methodology, curricular knowledge to modify the sequence of topics and objectives, and knowledge of context to design activity for students who would be learning from a substitute with limitations that would normally not be placed on her classroom activity

**Expectations.** The second challenge to Ms. Hawthorne’s DL instructional activity was the lack of standards for her content area. Despite the flexibility this allows, the lack of
expectations made it especially difficult for her to determine what content to teach even more than how to teach it:

“It’s harder more than it is easier because I have to come up with all of my own topics and all of my own essential questions and there is no guideline to follow. At the same time, students taking forensic science with me, versus students taking it at another high school in the same district could be learning totally different information based on what the teacher prefers.”

To Ms. Hawthorne, not having any expectations placed on her resulted in extra work on her part as a teacher. She had to become a curriculum designer as well. Not only did this push the limits of her ability as a teacher, but it caused her to question her curricular decisions because they were often misaligned with those of forensics teachers at other schools:

“I don’t know much about computers, so like digital fraud, anything to do with banks, I don’t know much about it, so I don’t teach it, but if that’s somebody’s specialty or strong suit then they’ll focus more on that than they would on fingerprints or blood or DNA because I know those really well.”

This is another cognitive challenge and is another result of a conflict between the subject and object of the instructional activity system.

In attempt to negotiate the cognitive challenge over designing instruction without any expectations—the conflict between the subject and object of her instructional activity system—Ms. Hawthorne relied heavily on her disciplinary knowledge and knowledge of students:

“I started with, well what do I want them to take away from this unit? . . . like the backwards by design model. Then once I know what they need to learn. . .I’ll make the
test at the same time as I’m making notes, so that I’m making sure that I do cover all the topics that I want them to know, I’m not . . . spending too much time on side things that they don’t need to know as much about, and then choosing activities. I constantly feel like I’m modifying activities year to year just to make sure that the activity really does fit the overall plan of what I want the students to take away.”

There are several pedagogical choices that contributed to the negotiation of this challenge. First, Ms. Hawthorne utilized a backwards design model to narrow her objectives surrounding a specific topic. She combined her disciplinary knowledge and knowledge of students to determine learning goals that were beneficial to them. Moreover, she practiced modified iterations of this process with each new group of students to ensure that the objectives she did choose would progressively facilitate more responsive instruction.

Another approach she used to negotiate this problem was to incorporate current events into her instruction. This gave her topical direction as well as a way to make material relevant to her students. She explained, “If I see something in the news or hear something that’s relevant, I’ll try to pull that in. The death row inmate that just got recently so close to being put to death, and he’s really innocent, and it fit perfectly with what we’re going over at the time.” Shifting learning objectives and tools to capitalize on relevant current events was both a sociocultural and linguistic negotiation of this instructional challenge informed by her knowledge of context (current events), pedagogical knowledge, and disciplinary knowledge. Students were always engaged and curious about the forensic details behind Ms. Hawthorne’s real-world examples, and she believed it helped them better understand target content.
Lastly, she sought out materials created and used by other forensics teachers online to help inform her planning activities:

“I found . . . Power Points that another school district in another state had posted online and . . . had our textbook as a reference, so I went through the Power Points, added any information that I thought they needed to know that their textbook pointed out as important. . . . Then over the years I’ve still been adding and modifying as I’m teaching.”

Here, pulling learning objectives and tools from other similar communities of practice was both a sociocultural and linguistic negotiation of this instructional challenge informed by her knowledge of students, knowledge of content, and disciplinary knowledge to determine which online resources and target objectives would be most appropriate for her students. This is another sociocultural and linguistic negotiation as it involved modifying the mediational tools and objects of her instructional activity.

**Training and Experience.** The third challenge experienced in Ms. Hawthorne’s efforts to enact DL instruction stemmed from a lack of training and experience. She cited classroom management issues and an inability to differentiate her instruction as manifestations of this challenge: “Even now, I’m still struggling with some classroom management and being able to keep track of everyone and differentiating. . . . the biggest challenge is getting everyone focused and on the same page.”

This was an ever-present challenge in her planning activities and instructional activities. She explained that “with the CP kids, you have your typical distracted kids, can’t focus, have different learning difficulties, hard time paying attention, want to chat with my friends, want to be on the phone. . . . the CP kids help distract each other.” Yet, she felt the root of this challenge
was that she was not equipped with the knowledge to inform more effective management and differentiation strategies: “I’m expected to know how. . . but no one has actually taught me how.” This challenge was both cognitive and linguistic in nature because the tools (linguistic) used in her activity were not sufficient for managing student behavior or individualizing instruction, and the subject (Ms. Hawthorne) lacked the knowledge to implement more appropriate instructional strategies.

Ms. Hawthorne’s response to the cognitive and linguistic challenge stemming from the tools (linguistic) used in her activity, which were not sufficient for managing student behavior or individualizing instruction, and the subject (Ms. Hawthorne) who lacked the knowledge to implement more appropriate instructional strategies, was first negotiated by creating more structure and providing more explicit direction to her students:

“I always have a weekly plan written for them on the board. I’ll give them a general announcement at the beginning ‘this is what our plan is’ or ‘this is where you should be. This is where we’re headed.’ I’ll try at the end of class to kind of also wrap with that.”

In my observations, Ms. Hawthorne would use this approach to check students who were off task. If someone appeared to be doing something other than participating in the instructional activity, she would reference the weekly plan and ask these students where they were with their work, redirecting their behavior:

“Every day I walk around, and I’ll ask them different types of questions, their review. I’ll check to see where they are in their notes and then all the different worksheets that we do, I’m trying to get those checked and graded quickly, and then while they’re working on
them, I’m also walking around spot-checking different places that I know students make mistakes, just to make sure that they’re on track.”

In this way, Ms. Hawthorne negotiated two solutions to contradictions in her activity system. First, she addressed management challenges with higher individual monitoring and more explicit directions, making it easier to keep her students on task. Second, she used this higher individual monitoring system to also individualize her instruction with more one-on-one support. Her knowledge of students’ values, habits, and behavior contributed most to this negotiation, which was linguistic in nature because the tools and strategies of her activity system were modified.

**Support.** Believing that her pedagogical knowledge was a weakness, Ms. Hawthorne expressed a desire to receive further training. In fact, she explicitly reached out to her district in order to enroll herself in extra professional development; however, she was not sure at the time of the study if her request would be approved:

“The next professional development opportunity that I’m actually seeking out is the gifted and talented classes, and I’ve been also trying to go to different things to do with English as a second language. . . . I haven’t been able to get into any of the gifted and talented classes that should actually teach me how to do it [management & differentiation]. . . . for the last two years and even this year I applied several times. . . . I feel like I’m in trouble about half the time about not doing it, but no one has taught me how to do it, but they expect me to just do it.”

Here, the tension surrounding the mediational tools and strategies (linguistic) used in Ms. Hawthorne’s activity extended to include the object. Previous feedback on her instruction suggested that she was failing to meet expectations (of which there were few) regarding the tools
and objectives of her instructional activity. Yet, there was no forensics department in her school, nor support documents or department mentors for her to turn to for guidance. In this way, her challenge also became a sociocultural one as she tried to meet school-wide expectations with each lesson and little to no support.

These challenges that stemmed from a lack of support as she tried to meet school-wide expectations with each lesson proved more difficult to navigate for Ms. Hawthorne. In fact, she had to bypass professional development options in her district and turn to a local university to receive any additional training in forensic science education:

“Furman University will hold a day of professional development science sessions and . . . Everyone goes to an opening session, everyone goes to the closing session, but you get to pick three classes in between you go to and they do have . . . enough variety in their sessions for me to have chosen all three of my sessions to be forensic-related. . . . But that’s the only professional development sessions that I so far have come across that had anything specific to forensic science.”

Ms. Hawthorne expressed that this was still not enough to fully solve her problem. Even after discovering this resource, she still felt that she needed more training and support, and continued to lobby her district for more coursework in pedagogy: “Actually, after you leave [the interview], my next task is to see if I can get [administration] to help me see if anything can be done at this point. . . I’ve been trying . . . for the last two years, and even this year I applied several times.”

For Ms. Hawthorne, the negotiation of this challenge continues. She took measures to relieve some of the tension in her activity system, but she is still in search of better solutions.
Authenticity. The last emergent challenge to Ms. Hawthorne’s DL was that the discipline itself was incredibly diverse, and some topics were impractical for designing classroom instructional activities that would be authentic to disciplinary practices. For example, Ms. Hawthorne believed that applying science to law was a central practice in the discipline of forensics. However, she had difficulty finding ways to incorporate lab-based authentic practices on the legal side with CP students in a public high school context. As she explained, “There’s not really a lab that you can do with the legal system and learning the amendments.”

In addition, mocking an actual full-scale crime scene was a practice that she had tried in the past, and considered for this unit. Once again however, the full-scale practice required the design of an activity system that was impractical for implementing in a high school setting. She explained that having such a large number of students—many more than there would be forensic scientists at an actual crime scene—made it difficult for students to adhere to standard procedures for evidence collection during such an activity:

“It was hard, and I even used one of the rooms in the media center so that it was set aside and only my classes came through and did their crime scene investigation, but with the class sizes being bigger, even breaking them down into groups and assigning each one a task, it’s still hard to keep your finger on every single group . . . as they’re walking into the room, someone should’ve already taken a picture of the entrance and exit. Then the second group . . . they’re going to have a harder time getting those pictures because there’s all these people in the room, and don’t touch the doorknobs and handles because fingerprints might be there, and you just ruined it, or ‘what are you stepping on? Where are you walking? Is it normal for all of this to be on the floor over here?’”
In both of these examples, contradictions arise in the planning phase of her instructional activity. These were not observed classroom problems, but internal struggles over the most effective means to achieving her set objectives. During her planning, the tension over choosing mediational tools that are authentic and those that will create less conflict at the expense of disciplinary process learning is both cognitive and linguistic in nature.

Unable to replicate the kind of authentic disciplinary activity she experienced in her own forensic training—observing forensic scientists testifying in court and reviewing real (confidential) forensic reports—Ms. Hawthorne used her disciplinary knowledge to focus on other forensic practices tied to the legal process which could be replicated with limited resources:

“I try to do some sort of activity with them in the crime scene unit . . .but a crime scene investigator is there to document the scene and to collect evidence. They are not actually interviewing any witnesses. . . They’re just there to document the scene and to collect evidence, so those are the two things I have to teach them. . . then I try to give them different scenario-based type questions in there”

Testifying in court is not a practice she could practically replicate in her classroom, so she chose objectives related to the legal process based on the tools available to her. An example was how she referenced a real-world example of a court case derailed by mistakes made in the forensic evidence collection process:

“The legal unit, I always look at the issues with evidence in the OJ Simpson trial because both police and scientists and there are so many mistakes that were made during that trial that actually forced people to look at the practices of how they were doing them and
made them rewrite those practices to make sure that nothing else like that ever happened again.”

Here, her negotiation was both sociocultural and linguistic, as she changed both the objectives and mediational tools of her activity system to alleviate tensions between the disciplinary processes that she values and the mediational tools at her disposal.

Regarding the authenticity of her crime scene activities, those tensions over choosing mediational tools that were authentic and those that would create less conflict at the expense of disciplinary process learning—Ms. Hawthorne chose to divide the disciplinary processes for crime scene investigation into smaller tasks. Rather than creating full-scale crime scenes for students to investigate, she designed scenarios in which students were responsible for documenting and analyzing only one type of evidence at a time. Moreover, she carefully prepared these lab activities to minimize confusion and contamination of evidence as well as maximize class time:

“I will have the students walk and make the drops, but more as a demonstration so they can visually see what’s happening with that, but there’s just so much work involved with the number. . . that is just so time consuming when at the end I really just want them to compare the size of the drops, the distances, so. . .I premade the activity, had my honor students help take all of those measurements, so now instead of taking two class periods and just that one lab and trying to get students to walk the right speed and know what they’re looking at, now we can just do like a quick half a class period, draw it, talk about it, ‘awesome, you got the concept. Let’s move on’. . . If I pre-cut the bigger sheets of paper for them, the activity goes a lot smoother.”
Here, again, Ms. Hawthorne modified both her objectives and the mediational tools of her activity system to negotiate challenges stemming from a conflict between her disciplinary and pedagogical values and her available resources.

Lastly, Ms. Hawthorne negotiated challenges to authentic DL instruction by infusing disciplinary tools into the activity system that supplement traditional pedagogical tools. An example of such negotiation was evidenced by one of Ms. Hawthorne’s assessments on fingerprinting:

“On a quiz that I gave them earlier in the unit, they didn’t need a magnifying glass because I physically made the picture of the fingerprints bigger. On the test, I gave them the magnifying glass because I left the pictures of fingerprints more realistic sized. . . I’m going to provide them the tool so that they have it because in the real world, it would be available to them.”

In this last example, Ms. Hawthorne acknowledges that she could and has in the past used less authentic methods of asking students to apply disciplinary knowledge. However, even with limited resources, she still found a way to turn a traditional multiple-choice assessment into a task that required the application of disciplinary process knowledge by the students using authentic disciplinary tools. These negotiations of the conflicts between her instructional tools and her own disciplinary values constitute linguistic and sociocultural solutions informed by her knowledge of context, pedagogical and disciplinary knowledge.

**Summary**

Because Ms. Hawthorne was not a biology teacher like the other participants, she did not experience the same external pressures on her activity system. Ms. Hawthorne was able to design
her own curriculum, choose her own methods and assessments, and establish her own pacing
guide without any departmental expectations or measures of accountability; yet, she still
encountered some of the same challenges as the other two participants. Overall, her lessons
usually went smoothly, and students regularly interacted with authentic disciplinary tools. Most
notably, her lessons always framed content by its practical application and real-world relevance.
In this way, she was able to design instruction that was hands-on and engaging for students and
fully utilize her disciplinary knowledge and experience. However, while her complete freedom
afforded opportunities to implement interesting and authentic disciplinary activities based on her
own professional disciplinary experience, teaching such a broad subject as forensics without a
shared curriculum or common assessment to outline the most important information led to her
feeling like she was constantly behind, not covering enough material, or failing to target the most
appropriate content for her students. In other words, Ms. Hawthorne was oppressed by
autonomy.
Chapter 7: The Secondary Science Instructional Gauntlet

In comparing these three cases, there were notable similarities and differences among contexts, instructional challenges, and approaches to negotiating contradictions. Because two of the observed units were on the same topic (genetics), and the third was on a similar topic (fingerprinting, DNA, and blood spatter), clear connections could be drawn between the themes produced by analysis of their instructional activity systems. Findings reflect an instructional gauntlet of challenges that persisted for each of these teachers from the moment they began planning the observed curricular unit.

Contextual Typification

In all three cases, the subject of the activity had similar professional and educational backgrounds. They all had bachelor’s degrees in biology and experience working in a sub-discipline of biology before becoming teachers; however, only Dr. Elm and Ms. Hawthorne had professional experience directly related to the topic of the observed units. In addition, they all expressed the desire to design authentic disciplinary activity that was relevant to students’ personal lives and interests. In practice, Ms. Alder more frequently foregrounded student relevance and interest over authenticity. Ms. Hawthorne and Dr. Elm made more concerted efforts to utilize discipline-specific tools in favor of more authentic activity; however, Ms. Hawthorne’s view of authenticity differed from that of the other two participants. In addition to discipline specific differences, Ms. Hawthorne discussed publishing research, professionalism, and accountability as authentic scientific values—values neither of the other two participants mentioned as important to them.
Ms. Alder and Dr. Elm shared the same objects of activity prescribed by the biology department. They came primarily from the same EOC and state biology standards. Whereas, Ms. Hawthorne had complete freedom over her own curriculum. Similarly, the mediational tools used in Ms. Alder’s and Dr. Elm’s class were also mostly prescribed by the department and mostly reflected a cognitive orientation toward DL instruction. Without common planning, Ms. Hawthorne chose to use similar mediational tools (guided notes, PowerPoints, etc.) in her instructional activity, but more frequently infused the system with supplementary disciplinary materials (magnifying glasses, fingerprinting kits, protractors, etc.).

Finally, all three teachers experienced varied degrees of success in producing desirable outcomes from their instructional activity. Each teacher asserted at different points during the observed units that students were struggling with specific objectives according to formative data. At the same time, all three teachers reported that students performed to expectations by the time summative assessments were administered.

**Common Challenges and Contradictions**

There was only one single theme shared by all three cases; however, there were three additional themes regarding challenges to participants’ instructional activity that were shared by two participants each.

**Expectations.** Challenges that stemmed from curricular and department expectations were identified in all three teacher cases. For Ms. Alder and Dr. Elm, these expectations limited their ability to design authentic disciplinary activities using authentic disciplinary tools and contradicted their disciplinary values. Most notably, the expectation that teachers adhere to strict pacing guides while using common assessments and teaching materials made it difficult for them
to differentiate their instruction. Moreover, they did not always agree with the target objectives prescribed to them through the curriculum.

Ms. Hawthorne, on the other hand, experienced the opposite challenge stemming from the same source—that is, she had no expectations at all, which required her to design an entire curriculum on her own without any guidance or support. Not only did this result in extra work for her, but she feared her students may have missed out on relevant content that she was less equipped to or chose not to teach.

**Time.** Both Dr. Elm and Ms. Hawthorne shared challenges related to time. In both cases, unusual circumstances caused them to lose entire class periods of instruction. For Dr. Elm, this loss of instructional time compounded an existing challenge stemming from the formidable breadth of the curriculum. Already having a tight schedule turned small delays like tornado drills into a major obstacle.

Whereas, Ms. Hawthorne did not have such an expansive list of objectives. Moreover, she was not held to the same standards of accountability as Dr. Elm. However, the amount of instructional time that she lost was so much more significant that making it up would have been impossible. In addition, with such a temporal gap in learning for her students, she would likely have to had restarted the unit from the beginning, costing even more instructional time.

**Assessment.** Finally, assessment proved to be a persistent challenge for both Ms. Alder and Dr. Elm. As teachers of biology, they were both held accountable to the biology EOC. For this reason, EOC content was privileged by their department and student learning objectives were prescribed to teachers. For both Ms. Alder and Dr. Elm, these assessment driven objectives did not lend themselves to the type of DL instruction they hoped to enact in their classrooms.
The biology EOC did not measure the kinds of practices and processes they valued as disciplinary experts. In addition, like other department norms and expectations, the standardization of instructional tools based on EOC content made it difficult for them to differentiate their instruction in response to individual student needs.

**Training and Experience.** Lastly, Dr. Elm and Ms. Hawthorne both experienced challenges to classroom management and/or differentiating instruction that they attributed to a lack of pedagogical training and experience. Each cited a gap in their coursework and professional development where common pedagogical practices would have been taught. As a consequence, they were both left to figure out solutions to this problem without adequate support or guidance, and they consistently had to negotiate new solutions while planning and enacting their DL instructional activities.

**Common Negotiations and Solutions**

Although similar challenges were identified among the three participants in this study, none of their negotiations of those challenges were identical. In most cases, their approaches involved modifications to the same components of their respective activity systems; however, the modifications themselves were unique to each teacher. The following sections highlight commonalities regarding modified components of instructional activity in response to instructional challenges as well as those specific details that make each negotiation contextually unique.

**Expectations.** Ms. Alder and Dr. Elm had different approaches to negotiating challenges that stemmed from department expectations. They both chose to integrate their own instructional tools with those prescribed by the department as part of their negotiations. Ms. Alder created her
own pre-assessments where the district-mandated version was insufficient. Dr. Elm brought in technical equipment used in professional labs to demonstrate processes that were not a part of the common curriculum. However, Ms. Alder could not bring herself to violate department norms around grading, so she was unable to negotiate a solution to her challenge of providing enrichment to her more advanced students.

Ms. Hawthorne was forced to rely on her own disciplinary expertise to negotiate the challenge of having no standards or curricular expectations. In addition to drawing on her own experience working in forensic laboratories, she leveraged current events and extra-departmental resources to help her determine appropriate learning objectives and mediational tools for her students’ learning. Although, she admitted that she continually reevaluates and modifies her self-made curriculum each year in order to improve the outcomes of her instructional activity.

**Time.** Dr. Elm and Ms. Hawthorne both lost instructional time that proved to be an obstacle to their DL instructional activity; however, their approaches to solving this problem were nearly opposite. Where Ms. Hawthorne sacrificed specific objectives and activities in order to maintain a curricular pace, Dr. Elm focused on modifying his classroom norms to allow more in-class time for one-on-one instruction. In his case, he allowed more advanced students to catch up on their own when they would normally be ahead and focused on supporting struggling students to keep them from falling behind. However, Dr. Elm would have been violating department norms had he used the same approach as Ms. Hawthorne, which would have resulted in yet another tension in his instructional activity. Moreover, he admitted that his negotiation did not lead to a permanent solution, and that further negotiations may have to be made in the future.
Assessment. Ms. Alder and Dr. Elm were the only teachers bound by standardized assessment. For both of these teachers, the immense amount of content material and the short amount of time in which they had to teach said material caused tensions in their instructional activity. Moreover, the target concepts and practices measured by their biology EOC were often misaligned with the valued learning outcomes shared by these two teachers. Both wanted to engage students in authentic disciplinary processes using authentic disciplinary tools for authentic disciplinary purposes. However, The EOC content reflects subject-specific facts and information to be remembered and regurgitated by students. Without an assessment to measure students’ DL proficiency, teaching for DL instead of teaching for the EOC would have been in violation of department norms and standard expectations.

Training and Experience. Finally, Dr. Elm and Ms. Hawthorne negotiated challenges stemming from a lack of pedagogical training and experience (subject) through intuitive pedagogical choices. Dr. Elm modified the degree of student monitoring (decreased) as well as the layout of his classroom and the expressed roles for teacher and students in different parts of the classroom. These were all modifications to the mediational means of his instructional activity. Ms. Hawthorne provided more explicit instructions (mediational means) to her students as a modification and increased monitoring of her students. In both cases, teachers had little to draw on but their knowledge of students, personal experience, and intuition to inform potential solutions to this tension in their instructional activity systems.

Teachers’ knowledge. Emergent patterns among the knowledge bases participant teachers utilized in their negotiations of instructional challenges revealed a preference for sociocultural and linguistic approaches to negotiating DL instruction. In nearly every example,
the nature of the contradiction was also the nature of the solution—that is, where contradictions in their activity system arose that stemmed from the object of the activity (sociocultural), negotiations involved some changes to the object of the activity (sociocultural). Likewise, contradictions stemming from the mediational tools (linguistic) in the activity were negotiated by substituting or modifying the mediational means of instruction (linguistic), and so forth.

Ms. Alder was the only teacher to experience challenges that were cognitive in nature during this study. Specifically, her challenges surrounding students’ vocabulary acquisition and assessment skills. Although Ms. Alder said in our first interview that she did not expect nor see any value in forcing students to use key vocabulary in their speech and writing, she responded to challenges related to vocabulary acquisition among her students by modifying the linguistic component of her instructional activity, increasing her focus on students’ repeated exposure to content information, using and expecting students to use more subject-specific language in their speech and writing, and increasing the amount of practice articulating disciplinary concepts. In other words, she compromised her personal values to preserve the prescribed objects of her activity by using methods she herself might not have advocated.

Of the sixteen total challenges identified in this study, each teacher felt that one of their own challenges went unresolved, at least for the observed unit. Ms. Alder never made any attempts at negotiating enrichment into her instructional activity system. Dr. Elm was not confident that his linguistic negotiation of modifying the classroom and clarifying student and teacher roles based on classroom location combined with increased one-on-one instruction had been enough to compensate for instructional time lost to tornado drills and flood warnings.
Lastly, Ms. Hawthorne still felt underequipped and unsure what support would be available to her in the future or from where it would come.

Ten of the identified challenges were linguistic in nature—that is, stemming from the mediational tools used to facilitate instruction. In those examples, teachers cited methods, strategies, and materials as the source of conflict in their activity systems. Seven of the challenges were sociocultural in nature, stemming from either the students whose learning was the object of activity or from the objectives themselves. In most cases, objectives either did not align with the teacher’s values or were inappropriate for students. Finally, there were no challenges or solutions that were critical in nature that could be observed or were discussed by participants. At no point during our interviews or classroom instruction did any of the participants explicitly cite engaging students in reflection on activity system outcomes in relation to other similar activity systems and contexts as a learning objective, desired outcome, source of conflict, or potential solution. Overall, those critical perspectives on disciplinary literacy instruction were completely absent from these three teachers’ situated instructional systems.

**DLPCK in Action.** Finally, regarding the knowledge bases used to inform teachers’ negotiations of instructional challenges caused by conflicts among the discrete components of their classroom activity systems, emergent patterns revealed all linguistic and sociocultural challenges were negotiated through approaches that involved modifications to the mediational means or objectives of instructional activity. The knowledge bases that informed these negotiations always included, at minimum, knowledge of students and/or knowledge of context. There were only five examples from this study in which negotiations required teachers to draw on their specialized disciplinary knowledge. In these situations, such as designing a full-scale
curriculum (Ms. Hawthorne) or creating a lab demonstration that is not already a part of your curriculum (Dr. Elm), the unique knowledge and experience these teachers brought into their instruction activity systems may have been the only thing that made those negotiations possible. However, overall, the most utilized knowledge bases across all negotiations were pedagogical knowledge and subject-specific content knowledge. Teachers utilized those knowledge bases in nearly every negotiation observed in this study.

**Summary of Findings**

According to GOAT theory (Fisher, 2019), key instructional practices for disciplinary literacy instruction that attends to all four theoretical orientations toward DL instruction would include activating schema and modeling disciplinary thinking (cognitive), purposefully selecting and deconstructing mediating tools (linguistic), designing authentic scientific tasks where students’ and disciplinary experts’ motives/purposes align (sociocultural), and engaging students in reflection on activity system outcomes in relation to other similar activity systems and contexts (critical).

Each teachers’ lack of attention to the critical component of their instructional activity spoke to the localized cultural context in which they were situated. Student awareness of their position in the hierarchy of a discipline, awareness of their power within that system, metacognitive awareness of the disciplinary boundaries they cross and the literate practices that do and do not transfer from one disciplinary context to another, and self-empowerment were not explicit goals of the EOC, the Park Forest biology department, or state standards. Moreover, there was no method for assessing student improvement in these areas that was required or provided to participants. If students’ critical learning is not assessed, and teachers are not
required or explicitly supported in critical instruction, the absence of such instruction will likely continue, and to the detriment of students disciplinary literacy development.

In addition, embedding a linguistic component (mediational tools), cognitive component (subject), critical component (outcomes), and sociocultural component (object) within a sociocultural framework complicated analysis. For example, in Ms. Alder’s classroom, background knowledge activation was a built-in component of her activity system (a sociocultural practice). It was a matter of routine for both her and her students, as each lesson began with a question prompt designed to stimulate students’ schema. The idea that activating schema can help students learn new information better stems from sociocultural theories such as González, Moll, & Amanti’s (2006) funds of knowledge. However, the prompt itself constituted the linguistic component of her activity system (mediational means).

Her choice of tools, however, did not reflect those used by disciplinary experts. Moreover, she did not attend to deconstructing those tools with students to help them better understand the historically cumulated activity from which those tools derive their functions. Her objects of activity also skirted disciplinary norms in favor of content-area and local community of practice norms, as she often chose not to assign tasks and purposes that would include attention to use of disciplinary tools and processes because the EOC did not assess those skills.

Dr. Elm did not activate background knowledge with his students as broadly as Ms. Alder. He waited until students were working independently or in groups. Then, based on student questions and challenges, he utilized students’ individual schema to draw connections with target content objectives. Dr. Elm went through great lengths to introduce his students to disciplinary tools. In some cases, they were not permitted to actually manipulate certain tools because they
were dangerous or expensive, but they were exposed to specialized technical equipment that disciplinary experts use in the field. Finally, Dr. Elm mostly kept his instructional objectives in alignment with curricular and department standards. However, he also broadened the scope of his objectives to include disciplinary process knowledge where it was absent from the standard curriculum.

Finally, Ms. Hawthorne rarely utilized strategies to activate students’ background knowledge. In fact, the few times I observed her attempting to leverage this pedagogical tool, her focus was more on establishing relevance than building upon existing knowledge. However, she regularly incorporated disciplinary tools and tried to recreate disciplinary environments in which to situate her teaching activity. Even with limited resources, she managed to extend the authenticity of her disciplinary instruction to include disciplinary process application as a means of assessment. Lastly, Ms. Hawthorne, who had no other source on which to draw for guidance in designing her self-made curriculum, leveraged her disciplinary knowledge and experience to select authentic scientific tasks where students’ and disciplinary experts’ motives/purposes were in alignment. Students often did what forensic scientists do.

**Implications**

This investigation into the DL instruction of career-changing, non-traditional secondary science teachers, the challenges in their instructional practices, and how they negotiate those challenges sought to obtain “as much information about the problem as possible with the intent of analyzing, interpreting, or theorizing about the phenomenon” (Merriam, 1998, p. 38). Investigating the situated practices Ms. Alder, Dr. Elm, and Ms. Hawthorne used to negotiate tensions in their DL teaching sheds light on how DL theory can and cannot be translated into
practice. By illustrating the multiple domains of knowledge that secondary science teachers must command in order to teach for DL, content area educators, literacy specialists, and administrators can think more purposefully about what DL instruction could and should look like in their schools. This study provides examples, such as Dr. Elm’s live DNA extraction demonstration, Ms. Hawthorne’s lab-based fingerprinting exam, and Ms. Elm’s use of discipline-specific vocabulary in her classroom speech, that can inform such thinking. By highlighting how each teacher negotiated DL instruction for adolescents, administrators, teachers, and literacy specialists can use the results of this study to inform their evaluation of local school reform efforts by drawing attention to the instructional challenges that impact disciplinary learning outcomes, the impact standards and assessments have on teachers’ instructional choices, and some ways instruction can be adapted to accommodate these ongoing attempts to improve literacy instruction in secondary science.

In addition, this study contributes local understandings about the complexities of DL instruction to a wider body of knowledge about secondary DL—that the challenges teachers face are numerous and diverse. Moreover, that these challenges change with the context of activity. This study details more than just those challenges teachers faced in their attempts to enact DL instruction, but also the sources of conflict from which those challenges stem. By applying GOAT theory as an analytical framework for deconstructing disciplinary instructional activity, this study demonstrated that Fisher’s (2019) framework can be an effective tool for identifying the sources of systematic breakdowns in teachers’ instructional practices. In particular, it provided a starting point for analyzing such a complex task as teaching. It provided concrete references for discussion with my participants about their instructional choices, allowing us to
backtrack from undesired outcomes through the entire system to identify where contradictions may have occurred and how they might have contributed to the undesired outcomes. Moreover, the constant remapping of each teachers instructional activity system helped in identifying which aspects of their instructional activity had become “typified”—that is, the GOAT framework helped keep my observations of a complex activity with numerous influencing variables focused and consistent so that I could paint an accurate picture of their typical instructional practice.

However, during the course of this study, it became apparent that the first generation activity theory framework is a limited one. For example, many challenges faced by the participating teachers in this study stemmed from contradictions between their own goals and the rules and expectations by which they were bound. In these examples, I classified those variables as part of the “object” of the activity system. Strictly speaking, the object of the activity system is the purpose driving the subjects participation in an activity. The object of their teaching activity was always for the purpose of student learning; however, compliance regarding what students were meant to learn, how, when, and with what tools was also a collective goal of the department to which two of the participants belonged. Moreover, each teacher’s instruction simultaneously constituted both an individual and collective action. Using the first generation activity theory model for this study forced individual and collective objects to share one place in a four-piece framework. Consequently, there may have been contradictions among variables within the object of activity that were not identified. This limitation suggests that a later, more comprehensive version of the activity theory model would have been more helpful as an analytic lens. Engeström’s (1987) second generation activity theory (see Figure 2), for example, includes rules, community, and division of labor as additional components to the triangular framework.
Where participants in this study experienced contradictions that stemmed from collective rather than individual objects, such as types of assessments, grading norms, and pacing guides, a second generation framework would have distinguished those variables and helped inform more nuanced understandings of emergent challenges. Lastly, in the hands of practitioners, it could help to more directly inform potential negotiations of instructional challenges by more specifically locating the source of contradiction in their teaching activities.

Figure 2: Second Generation Activity Theory (Engeström, 1987, p. 78)

Although my interpretive lens and methodological approach did not seek to generalize findings across all science classrooms in any secondary school, I have constructed reasonable and trustworthy assertions within these local contexts in hopes of transforming the reader’s own understanding of DL and how he or she might use that understanding to inform their own negotiation of tensions related to disciplinary knowledge, pedagogy, student needs, and curricular standards within their own complex teaching contexts. The detailed descriptions of the teachers and their context can help readers determine how closely their contexts reflect those of the teachers in this study. Moreover, readers who find that they also experience the specific
challenges faced by teacher participants can use the negotiations identified in this study to inform their own solutions. At the very least, findings that suggested instructional challenges stemming from specific elements of the teachers’ activity systems were successfully negotiated by modifying those elements. That negotiations informed by a sociocultural orientation toward DL tended to successfully solve challenges stemming from the sociocultural component of their activity system—the object—and that this pattern held with little variation across all four elements of the activity system and the theoretical orientations they represent, provides valuable insight regarding the different ways DL theory can be applied to practice.

The results of this study also have implications for university and teacher certification programs as well as science teacher professional development. For each teacher, pedagogical knowledge was a constant contributor to the design, enactment, and modification of their instructional activity systems. In some cases, it was the source of conflict. The findings from this study suggest that alternative teacher certification programs—especially PACE—need to include more pedagogical training. In particular, teachers in this study found that they were ill prepared for classroom management and differentiated instruction. As two of the teachers were quite experienced (seven and twelve years), this implication extends beyond initial training and certification to include teacher professional development—especially in school districts like Glenwood where there is a high percentage of alternatively certified teachers. Professional development designers should also consider that at least two negotiations identified in this study were made possible because of the teachers’ specialized disciplinary knowledge and experience. As Ms. Hawthorne shared, there are few opportunities for professional development that
attended to the teaching of disciplinary process knowledge. Most options were domain-based or limited to core content areas.

Finally, the overwhelming impact external expectations and standardization had on two of the participants has implications for administrators and policy makers. First, increased standardization made differentiation very difficult for two of the three teachers. Moreover, the disciplinary and pedagogical values of individual teachers are diverse, so increased standardization also increases opportunities for conflict between teachers’ valued objectives and curricular objectives, which happened often in this study. In addition, administrators and policy makers should consider standardized assessments that actually align with educational reform efforts. As evidenced by Ms. Alder’s instructional activity, there is little incentive for implementing DL instruction with students who will not ultimately be tested on DL practices and processes.

If DL is to remain a viable theoretical approach to improving the scientific literacy of secondary students, public education must make some accommodations. First, we must better equip our traditional teachers with disciplinary process knowledge, and we must equip our non-traditional teachers with better pedagogical training. Second, administrators and curriculum designers need to make sure that high-stakes assessments like End of Course Exams align with literacy-based reform efforts. Third, in-service teachers need access to professional development related to pedagogy and disciplinary expertise. In addition, teachers need support systems to help them navigate instructional challenges and develop typified solutions to those problems. Finally, teachers need access to the mediational resources and tools necessary to design instructional activity authentic to real-world disciplinary practices and processes. With 12.3% of public school
science teachers moving schools or leaving teaching altogether annually (Ingersoll & May, 2012), and with a lack of adequate support cited as a significant predictor of science teacher attrition (Ingersoll & May, 2012), it is imperative to respond to the expressed needs of secondary science teachers like those who participated in this study.

**Limitations**

At the start of this study, the teachers agreed to participate for up to nine weeks of classroom instruction. However, in April 2020 (approximately five weeks into the study), global spread of the novel COVID-19 coronavirus caused the participating school district and my own university to indefinitely cease all in-person data collection. Although I had already collected a wealth of data, I ultimately lost the opportunity to discuss student performance on summative assessments for the observed units. This suspension of research activity also eliminated any possibility of using a focus group interview to support my cross-case analysis. Most significantly, the participating school district did not reopen schools until the following semester, and they imposed virtual instruction requirements on teachers, forcing many of them to completely redesign their long range, unit, and individual lesson plans for each class. Consequently, my participants have not responded to any of my contacts after the initial closure of schools and suspension of research, not even to member check the results of the study.

Though I relied heavily on the participants actual words to paint a picture of their instructional context, the challenges they faced, and how those challenges were negotiated, the validity of this study would have been strengthened by their verification of its accuracy. Moreover, despite a rich supply of data, four more weeks of observation (including at least one additional unit of instruction), four more interviews, a focus group interview, and additional
artifacts all collectively could have strengthened the validity and bolstered the final arguments of this study. However, state and local restrictions in response to a global pandemic prohibited me from researching any further, forcing me to limit my analysis to and draw conclusions from the first five weeks of instruction. Though this was a deviation from the original proposal, I am confident that enough data was collected to provide a thorough, detailed, and accurate analytical representation of these three teachers’ perspectives on the challenges of teaching disciplinary literacy in secondary science.

**Future Research**

Although the purpose of this study was to explore the challenges former scientific experts, who have changed careers to secondary science education, face and how they leverage their real-world disciplinary experience and knowledge to support the DL of students, this study also sheds light on directions for future research. First, more research needs to be conducted using GOAT theory as an analytical framework for understanding DL instructional activity. Such research could build on the methods of this study and expand the GOAT framework to include components from second and third generation Activity Theory (Engeström, 2012). Such investigations could also contribute new practical strategies and approaches to negotiating DL instruction. In addition, further research into the role disciplinary process knowledge plays in designing and negotiating DL instruction is also needed. Determining the knowledgebases teachers use to inform their instruction can support the design of professional development that develops those knowledgebases. Finally, continued short-term and longitudinal research on the challenges secondary science teachers face and how they negotiate solutions to those challenges could further inform policy, science teaching practices, assessment, and teacher preparation and
professional development. If these lines of inquiry are not pursued, and public education fails to accommodate educators who try to respond to literacy-based reform efforts in the wake of persistent challenges, teachers will continue to struggle, attrition will continue to rise, and DL will become another pedagogical relic among countless other abandoned educational movements, and we will be no closer to producing a scientifically literate citizenry than we ever were.
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Appendices
### Observation Protocol: Data Collection Template

<table>
<thead>
<tr>
<th>Cognitive (Subject)</th>
<th>Linguistic (Mediational Tools)</th>
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<tbody>
<tr>
<td>Instruction that addresses the cognitive processes habitually employed by disciplinary experts</td>
<td>Instruction that addresses the language habits of disciplinary experts</td>
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<table>
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<tr>
<th>Sociocultural (Object)</th>
<th>Critical (Outcomes)</th>
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<tbody>
<tr>
<td>Instruction that addresses the practices in which disciplinary experts engage</td>
<td>Instruction that involves critique or production of disciplinary knowledge and analysis of the relationship between disciplinary knowledge/practices and privilege/power</td>
</tr>
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Appendix B

Interview Protocol: (Audio Recorded in an office after class)

Question Types (Patton, 2002):

A. Experience & Behavior Questions: observable actions (what someone does)
B. Opinion & Values Questions: goals, intentions, desires, & expectations (“head stuff”)
C. Feeling Questions: about emotions, not opinions
D. Knowledge Questions: facts and information (what someone knows)
E. Sensory Questions: what do you … (smell, taste, hear, see, feel)?
F. Background/Demographic Questions: Age, Education, Occupation, etc.

Interview Questions:

1. What was the most difficult thing you taught in class today? D
2. What made that concept easier or more difficult for you to teach? B
3. What were you thinking when you first introduced the concept? B
4. How do you feel about your students’ understanding after the lesson? C
5. Which questions and comments from your students during the activity will inform future lessons? B
6. How did their participation make you feel about your own instruction? C
7. What made you decide to ask the questions/design the tasks you did? A
8. What similarities do you see between expert practices and your lesson? B

9. How did you expect students to respond to your lesson? B

10. What expectations do you think they had of you? B