Building Disciplinary Literacy through Popular Fiction

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Abstract

Science educators have noted the unique characteristics of science literacy in terms of text structure, vocabulary demands, and reliance on abstract concepts (Cervetti, Pearson, Bravo, & Barber, 2006; Fang & Schleppegrell, 2008; Pytash, 2013). Furthermore, other scholars have defined scientific thinking processes as inextricable from the reading and writing practices used to communicate them (Norris & Phillips, 2003). a collaboration between a literacy educator and a science educator provided the foundation to reimagine a content area reading course for middle and high school pre-service science teachers and incorporate a focus on the disciplinary literacy of science through popular fiction. Without positioning literacy as overly additive, pre-service teacher participant illustrated ways to logistically structure scientific inquiry to include and authentically underscore disciplinary literacy. Findings suggest specific practices for how teacher educators can best support the disciplinary literacy development of pre-service science teachers.

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Introduction

> *Only when we return to a more functional view of the role of language and literacy in supporting disciplinary learning [in science] can we achieve our goal of an informed citizenry who can use their literacy skills to think critically and flexibly across many domains of knowledge and inquiry* (Cervetti, Pearson, Bravo, & Barber, 2006, p. 3).

The dominance of literacy education has been critiqued as being a 'bully' rather than a 'buddy' (Pearson, 2010; Greenleaf et al., 2009) in supporting disciplinary content learning in science. In the quote above, researchers cal for literacy education that supports rather than excludes or undercuts learning in science. Given this focus for repositioning literacy education as an ally to science learning, many educators have investigated the ways in which disciplinary literacy can be used to emphasize and hone the unique literacy tools needed to participate in inquiry-based science. As defined by Shanahan and Shanahan (2008), *disciplinary literacy* is an emphasis on the knowledge and abilities possessed by those who create, communicate, and use knowledge within specific disciplines. They posit there are unique literacy skills necessary for

engaging in science that are different from engaging in other disciplines and these skills need to be explicitly taught to students as they learn and communicate about science.

Reform documents have recently called for literacy skills to be embedded in science teaching. The *Next Generation Science Standards* (2013) and the *Common Core State Standards* (2010) have both emphasized the importance of students comprehending and composing complex informational texts, integrating knowledge from multiple sources, and using evidence to develop arguments focused on disciplinary content. Similarly, the American Association for the Advancement of Science (AAAS) has detailed core competencies for the teaching of science that have included promoting the need for biology educators to guide students in "practicing the communication of science through a variety of formal and informal written, visual, and oral methods" (2011, p.15). Underscoring the need for disciplinary literacy in teacher preparation programs, the Carnegie Corporation for Advancing of Adolescent Literacy has been funding pre-service teacher (PST) education projects since 2003 to focus specifically on identifying effective practices for teaching adolescent literacy and develop course curricula that will help pre-service teachers integrate literacy instruction into their content domains.

Calls for improvement in intersections between ELA and science instruction have been coming from researchers who investigate ways to best support language development in English Language Learners. Lee, Quinn, & Valdés (2013) introduce the concept of 'language of the science classroom' to explicate the needs for disciplinary literacy in science to underscore the aims of the NGSS and CCSS. They propose teacher preparations programs need to respond by employing:

> (a) a shift away from both content-based language instruction and the sheltered model to a focus on language-in-use environments and (b) a shift away from "teaching" discrete language skills to a focus on supporting language development by providing appropriate contexts and experiences (Lee, Quinn, & Valdés, 2013, p. 228)

With regard to honing disciplinary literacy skills in science, researchers have begun looking at the unique skills necessary for science reading and writing (Shanahan & Shanahan, 2008). Exploring the link between literacy skills and scientific inquiry suggests that teachers need to incorporate disciplinary literacy (Cervetti et al., 2008) into the teaching of science. Moreover, researchers have shown the need for explicit literacy instruction in science (Pytash, 2013). For example, it is not adequate to simply assign science writing assignments, but rather science educators need to teach the skills necessary for scientific reading and writing. For this reason, it is paramount that teacher preparation programs support pre-service teachers with the knowledge and skills needed for such instruction.

While the standards documents emphasize the comprehension of complex informational texts, designing responding pedagogical approaches necessitates recognition of research on the types of texts important to learning science. Research has suggested fiction and nonfiction share a symbiotic relationship with one influencing the shape of the other (Coombs, 2013). It has also suggested students' out-of-school literacies embrace the complex relationship between these two forms as students draw heavily from popular culture texts during their learning of science (Moje, 2008). Thus, as educators try to develop a disciplinarily literate citizenry and attempt to underscore the aims of their discipline-specific curricular standards, they must pay close

attention to the intersection of fiction and non-fiction texts within their content area (Fang & Schleppegrell, 2008).

The overall goal for this study was to discern affordances of using one medium of text (i.e. popular fiction) to connect aims of science-specific content and process standards in the areas of reading, writing, speaking, listening, and critical thinking. We posit that incorporating popular fiction provides a convergence point for addressing multiple components of science disciplinary literacy and allows learners to explore the most meaningful and relevant connections of content to their lives through topics that require dialogue, discussion, and deliberation. Ultimately, we aimed to understand the ways in which teacher educators can utilize popular fiction to best support pre-service teachers in their development of disciplinary literacy. This exploration was guided by the following research questions: 1) How (the process) and in what ways (description of strategies) do pre-service teachers use popular fiction to draw connections among curricular standards?; 2) In what ways do pre-service teachers promote disciplinary literacy through instructional practices that incorporate popular fiction?

From Content Area Reading to Disciplinary Literacy

Supporting literacy development in all content areas necessitates an informed and differentiated understanding of what literacy strategies and skills are most meaningful in the various disciplines. Informed by the work of scholars who draw distinctions between content area reading and disciplinary literacy (Moje, 2004; Shanahan & Shanahan, 2008), we conceptualize disciplinary literacy as the specific practices of reading and writing within one's discipline. While the roots of disciplinary literacy stem from content area reading, disciplinary literacy practices draw attention to the differentiated literacy skills necessary for specific content areas. Content area reading tends to emphasize the teaching of a generalizable (across content areas) set of skills for use in various content-specific classes. Strategies like summarizing, questioning, monitoring meaning, etc. are general comprehension strategies that help students understand content presented in text. This approach assumes that accessing meaning in one text is equivalent to access meaning in a variety of texts. Disciplinary literacy, however, focuses on how disciplinary experts approach literacy tasks with an understanding of the unique demands, purposes, and uses of literacy (Shanahan & Shanahan, 2012). Teacher educator programs traditionally offer content area reading courses to equip pre-service teachers with universal strategies or tools to assist students with reading a variety of texts and writing within a variety of disciplines. Disciplinary literacy, however, focuses on the knowledge, abilities, and tools experts in a particular field use to create and communicate knowledge within their discipline and provides a foundation for the unique interpretive skills of reading and meaning making in specific disciplines, such as science.

Disciplinary Literacy Framework for Science

The empirical roots of disciplinary literacy stem from cognitive and linguistic research. Using expert read-alouds, research on disciplinary literacy in science has concluded that scientists read differently than those in other disciplines (Shanahan & Shanahan, 2008). Specifically, linguistic analysts have uncovered specific attributes in science text (such as the use of passive voice and abstraction of concepts) that are uniquely dominant in scientific written forms of communication. Fang & Schleppegrell (2008) posit that in science, vocabulary is used to make acts passive so as to attribute them to natural phenomena rather than to social actors—a

central premise of scientific objectivity and replicability. Moreover, science texts often use dense and specialized vocabularies (van den Broek, 2010). This high degree of lexical density and hierarchical terminology (Zwiers, 2008) calls for the use of Greek and Latin derivatives to help students understand the meaning and classification of the words. Furthermore, reading strategies in science include an emphasis on credibility of research designs, critical dissection of claims, determining ranges of doubt and certainty, and critiquing the sources of knowledge and their limitations.

Norris and Phillips (2003) argue that historic emphases on scientific literacy have been too narrowly focused on science as merely being knowledgeable about facts, concepts, and discrete bits of scientific information to the exclusion of the ability to effectively interpret and make meaning of scientific texts. This latter aspect of scientific literacy is characterized by an understanding of the very nature of science itself and cannot be divorced from the reading and writing of science:

> Reading and writing are inextricably linked to the very nature and fabric of science, and, by extension, to learning science. Take them away and there goes science and proper science learning also, just as surely as removing observation, measurement, and experiment would destroy science and proper science learning (Norris & Phillips, 2003, p.226)

The inclusion of science-specific literacy skills to undergird both content knowledge (big ideas, core concepts, nature of science) as well as scientific habits of mind (ability to read, write, and reason with science texts) is key to supporting students' development of scientific literacy. Pre-service teachers need opportunities to learn and practice these skills themselves and be able to guide their students in the elements that make effective readers and writers in science. Insights from disciplinary literacy thus help teachers understand the practices of their own discipline.

Synthesis of Relevant Literature

Research calling for embedding literacy practices in science instruction has: 1) provided a foundation for the complementary nature of both inquiry-based instruction and literacy skill development; 2) argued for the connecting to students' funds of knowledge through the use of popular media; and 3) emphasized the importance of pre-service teachers' explicitly learning how to embed literacy practices into their teaching of science. Below, is a brief synopsis of contemporary research in each of these areas, which played a central role in the design of this project.

Inquiry-based Science and Texts

A theoretical foundation for integration of inquiry-based science and literacy practices imply the same sets of cognitive and metacognitive skills: recognizing main ideas and concepts, analyzing critically, evaluating information, establishing relationships, formulating conclusions, and applying information to other situations. Research in this area has illuminated how process skills needed for literacy and inquiry are complementary, and the integration of literacy into the science curriculum yields increased learning in both reading and science as well as improved attitudes toward science (Pearson, 2010; Greenleaf et al., 2009).

Insights gleaned from Cervetti et al.'s (2006) work further elucidated the shared strategies of inquiry-based science and literacy. Both activate prior knowledge and aim to focus students on establishing goals, making predictions, drawing inferences or conclusions, making connections, and communicating information to the public. Research has found that inquiry-based science and text are mutually supportive and best approached in tandem (Cervetti et al., 2006). More specifically, text should be used at the beginning, throughout, and after first-hand inquiry-based science experiences. Text provides the context to wonder about science content, delivers some of the content connections (some of which is not observable in a classroom context), helps build student use of vocabulary, and can model inquiry practices and the nature of science—practices that are central to scientific literacy (Yager, 2004). Text can provide data on contemporary applications of science content through which the reader is challenged to draw conclusions and develop claims, while also helping to focus investigations and set objectives for learning science content.

Nevertheless, with emphasis on inquiry-based science being experiential in nature, text has largely been absent from inquiry-based science or at best taken a backseat to the hands-on nature of learning. Critiquing the use of texts in inquiry, Yager (2004) argues "First, science texts are more often "declarations of 'fact'" than real representations of the "heart and soul of the scientific enterprise" (p. 95). A related critique is that text can take precedence over scientific discovery—encouraging students to be but passive recipients of others' ideas and taking the place of observation, experimentation, and meaning-making (Peacock & Gates, 2000). In practice, teachers seem apprehensive about placing too much emphasis on text in the science classroom. Furthermore, secondary science teachers perceive teaching of literacy to be outside of their domain and feel unequipped to teach science-specific modes of literacy instruction (Pearson et al., 2010). Constraints such as adding reading and writing into an "already over packed curriculum, developing science teachers' knowledge of and commitment to reading, providing students easy access to quality science literature and motivating them to read it, and coordinating between science teachers and reading educators" (Fang et al., 2008, p. 2084) have been noted in research.

Scholars who have been focusing on the intersection of inquiry-based science and text point to the importance of developing students' academic language. Drawing from Gee's (2004) notion of the situated meaning students draw from inquiry-based experiences as they adopt new language to contextualize their experience, Weinburgh and Silva (2012; 2011) have developed an instructional strategy termed the '5R'—replace, reveal, repeat, reposition, and reload to guide teachers in privileging language development in science classrooms. The 5R model stems from their work with English language learners, but can be appropriately applied to science learners from all backgrounds in the sense that all students are expected to understand and use language consistent with the practices of the scientific community. As these researchers assert, inquiry-based learning that incorporates text creates a context or situation ripe for engaging students in deep thinking about academic language in science.

Use of Popular Fiction as a Context for Inquiry-based Science

The genre of text (i.e. informational text, trade books, video and online resources) teachers bring into the science classroom has also been a focal area of research in the bridging of literacy and science. Within these discussions, research informing this study has focused on

constructing what Moje et al. (2004) has referred to as 'third space' (whereby students connect their home lives with their lives in the formal classroom) in an effort to develop students' content area literacy through text that is maximally meaningful to students. Investigating the funds of knowledge students bring into the science classroom, Moje et al.'s (2004) longitudinal study of middle and high school students found students strongly reference popular culture (e.g., movies, novels, and television) when drawing personal connections to science content learned in the classroom. In their research, popular cultural funds were in fact the most predominant type of funds of knowledge; that is, students tended to draw on popular culture as much as, if not more than, they did their own experiences when discussing issues related to the science topics under study. As such, researchers suggest educators interested in constructing third space ought look to the area of popular culture as a means to engage students in science and literacy practices.

Few empirical studies have investigated linking popular culture funds to content area learning (Moje et al., 2004; Moje, 2008; Alvermann, 2011); however, several science educators have noted the importance of written genres that will engage and confer relevance to students. Keys (2000) argues that writing genres taught in school science should not only be reflective of scientists' writing, but should also assist students in unpacking scientific meaning contained in various forms of writing. Moreover, Hand and Prain (2002) argue that having students write in a diverse range of genres will support connections between classroom science and authentic science in the public sphere. Norris and Phillips (2003) support the notion that students be engaged in writing various forms within the science classroom and assert that popular media (newsprint, movies, fictional texts, and magazines) serve as good sources for such lifelong practices of science.

However, research in the area of embedding popular culture texts into curriculum suggests reluctance on the part of teachers to recognize the classroom as a legitimate place for popular culture (Marsh, 2005). For example, in a three-year longitudinal study of elementary pre-service teachers' perceptions about the use of popular culture in England's literacy curriculum, Marsh found that pre-service teachers did not make use of students' interests in popular culture despite having learned about and expressed approval for the use of popular culture in the literacy curriculum. Despite the potential for engagement, teachers tend to not use popular fiction in the science classroom for fear of misinformation (Marsh, Butler, & Umanath, 2012) and the perception that literature takes away from inquiry-based learning and teaching. Furthermore, popular fiction is often viewed as existing purely for enjoyment, not actual learning (Czerneda, 2006). This omission in the curriculum has potential consequences for students who so heavily draw from popular culture for their connections to science learning.

Pre-Service Teacher Preparation for Integrating Literacy and Science

There is a perception of barriers to teachers integrating inquiry-based science with texts (i.e. dominance of experiential learning at the exclusion of text-based learning, limited proficiency at the secondary level with literacy strategies, and perception that science teachers teach science only) (Alvermann, Phelps, & Gillis, 2010), and pre-service teachers' tend to de-privilege students' interests in popular culture in the classroom (Marsh, 2005). We also understand that secondary teachers have limited professional development regarding disciplinary literacy, and teacher preparation programs often approach disciplinary literacy through the teaching of generic reading strategies rather than utilizing a discipline-specific approach

(Shanahan & Shanahan, 2008). These findings beg exploration of the ways teacher preparation programs support the development of disciplinary literacy in pre-service science teachers.

Research has not yet thoroughly investigated the effectiveness of instruction on science-specific disciplinary literacy despite so many researchers calling for ways to help science educators better understand the literacy practices of their own discipline. In one of the Carnegie Corporation sponsored projects mentioned above, Shanahan and Shanahan (2008) worked with specialists in math, chemistry, and history to identify the content-specific reading skills that would better enable students to succeed in these subject areas. Their findings indicated that chemistry teachers resonated with text that entailed specific content through which students learn chemistry concepts, focused on how information learned in text could be transferred to problem-solve in other situations, and specified how vocabulary can have different meaning to the public than in the field of science. Implications from this study suggested the need for teacher education programs to explicitly support pre-service teachers' recognition of and ability to teach students about these discipline-specific literacy strategies.

With regard to the teachers' role in disciplinary literacy, research has called for explicit guidance from teachers to help their students conduct writing in science. Pytash (2013) found "the reading and deconstruction of texts is an active, meaning-making process to support the learning of writing and science concepts" (p.806). Writing cannot just be assigned in the science classroom, but must also be taught. Studies of adolescent students' science writing have found writing improvement when teachers show students how to write for different purposes (e.g., to describe, to persuade, and inform) and how to use different genres (e.g., research articles, lay explanations, patent applications, lab notes) for scientific writing (Hand & Prain, 2002). These studies challenge the perception of science-only instruction as well as traditional notions of what ought to be included in teacher preparation courses.

Research examining disciplinary literacy in science has called for the pairing of texts with inquiry-based learning (Cervetti et al., 2006), incorporating popular culture to create a third space (Moje et al., 2004), and the explicit teaching of unique science-based literacy practices (Shanahan & Shanahan, 2008). As such, we implemented an inquiry project in a content area reading course that aimed to account for these calls. The purpose of our inquiry project was to help pre-service teachers create learning experiences that leveraged popular texts and embedded disciplinary content with disciplinary literacy demands in science. Because literacy is understood as an inherently social practice involving the ways in which individuals utilize, interact with, make meaning from, and produce spoken and written language, the inquiry project required participants to approach literacy from an integrated perspective including reading, writing, speaking, and listening. Through this project, we hoped to understand: 1) How and in what ways do pre-service teachers use popular fiction to draw connections among science curricular standards?; 2) In what ways do pre-service teachers promote science disciplinary literacy through instructional practices that incorporate popular fiction?

Methodology

Building off the research advocating for the integration of text and inquiry-based learning experiences, this project began with two goals in mind: 1) help PSTs develop skills in using text

as part of inquiry-based learning; and 2) shift the use of text from passive consumption of facts to active engagement of questioning, interpreting, and synthesizing information gleaned from multiple texts. Thus, aiming to create a learning experience where text acted as a catalyst for inquiry, engaging students in an active thinking process of discovery, evaluation, and application.

To examine the ways in which PSTs understand how to foster disciplinary literacy and draw connections among curricular standards through the use of popular fiction, a case study design (Yin, 2014) paired with a teacher as researcher approach to data collection and analysis was used. The case consisted of science PSTs participating in a *Reading in the Content Areas* course taught by the second author. Previous iterations of the *Reading in the Content Areas* course utilized an additive approach to literacy instruction by focusing on transferrable reading and writing strategies teachers could incorporate into content instruction. The instructor sought to subvert this model by foregrounding disciplinary perspectives and helping PSTs cultivate science-specific approaches to literacy instruction while also gaining knowledge of reading and writing processes. This modified version of the course offered the opportunity to examine PSTs' understanding of and ability to develop lessons incorporating disciplinary literacy and provided a bounded system for the case: the semester-long duration of the course and participants' common disciplinary focus on science. As part of the course, participants created an inquiry project for use with high school students designed to support understanding of the unique literacy demands of science and the showcase the potential of popular texts to leverage content learning. This inquiry project acted as the key literacy event in that it provided us with observable activities, interactions, and artifacts to capture participants' thinking throughout their learning. The instructional context and role of the inquiry project are discussed in detail below.

Context & Participants

This study focuses on five science education students, three males and two females, pursuing secondary certification. All students were enrolled in a Reading in the Content Areas course as part of their program requirements, which met for five Saturdays for seven hours each session. All five PSTs had already spent extensive time in the field observing a range of science classrooms, and one student was currently teaching high school biology through an alternative certification program. Table 1 provides a description of these students.

Table 1. Background information on science PSTs

Participant	Science Disciplinary Focus	Undergraduate Degree	Teaching Experiences
Irene	High School Biology	BA in biology Minor in plant sciences	Two semesters away from student teaching; Working as an alternatively certified biology teacher at a high school serving a high percentage of low SES students and struggling readers; she was particularly interested in how to help struggling students access science texts.
Cassi	High School Biology	BS in biology with a minor in chemistry (also holds a MA in Communication)	Two semesters away from student teaching; Working as an administrative assistant in higher education;
Jerome	High School Biology	BS in biology with a minor in chemistry	Two semesters away from student teaching
Vincent	Middle School Science	BS in aviation and aerospace management	Two semesters away from student teaching
Anton	High School Chemistry	BS in chemistry with a minor in math	One semester away from student teaching

The course was taught by the second author, a literacy professor with expertise in adolescent literacy and experience working with secondary teachers to develop disciplinary literacy practices. This instructor sought to create a course that frontloaded the role of disciplinary thinking. The first author, a science methods professor, was interested how popular culture texts could be leveraged to stimulate inquiry-based practice. These two interests provided the foundation for informal collaborative discussions and iterative co-planning throughout the semester. The goal of the course was to develop PSTs' understanding of the overall relevance of literacy to student learning, emphasize the particular literacy practices of individual disciplines, and enable PSTs to create learning experiences that address these unique practices. Each class followed a similar framework that included reading discussions, introduction of core concepts, models of instructional strategies, and small group learning activities with the last one to two hours devoted to students developing their final inquiry projects. Further, students were required to bring their own digital device to class to live stream their thinking via online discussion and mediums such as TodaysMeet and Padlet. These digital discussions enabled a collaborative climate where students supported each other in their work and provided an additional medium for formative assessment.

Inquiry Project

The course provided participants with the opportunity to learn science-specific literacy strategies and develop materials for teaching students to read, write, and wield academic language like scientists. The course culminated in each student designing an inquiry project based on a popular text of their choosing that could be implemented in future classrooms. Each project design was required to: 1) identify and connect science content standards with a popular text; 2) incorporate strategies for teaching reading, writing, and academic language in tandem with content; 3) include three to five nonfiction texts; and 4) utilize literacy practices to assess students on their new understandings.

In guiding PSTs to develop their inquiry projects, each class followed a similar framework that included reading discussions, introduction of core concepts, models of instructional strategies (see Cook & Dinkins, in press for detailed instructional activities), and small group learning activities with the last half of class devoted to PSTs' development of their final inquiry projects. In order to transition from modeling the projects to guided practice and thus encouraging a gradual release of responsibility, PSTs debriefed their experiences by dissecting the instructor-led model and reflecting on their learning as students and future teachers. In the subsequent classes, the instructor shifted responsibility to PSTs by asking them to think through ideas for their inquiry project and begin designing it in chunks with peer and instructor support. PSTs were required to choose a fictional text that reflected elements of popular culture from which they could draw standards-based scientific concepts. They then researched the science behind their topic of interest in the popular culture text by reading both primary and secondary scientific literature (i.e. non-fiction) over the course of the week and began to develop possible inquiry questions and literacy learning goals for their projects. PSTs were free to include any instructional activity from course texts, class models and discussions, science methods courses, or field experiences.

During class two, three, and four, PSTs used online discussion forums to record their thinking, provide feedback to each other, and draft ideas for their project. PSTs were also

required to bring their own digital device to live stream their thinking during or after class via online discussion mediums such as TodaysMeet and Padlet to capture and share their thinking as they developed questions, concerns, and thoughts about the course activities. Instructional prompts for the online posts included explaining why the text was chosen, identifying core disciplinary concepts emerged from the novel, and discussing rationale and challenges for selecting nonfiction supplementary texts. This provided PSTs with multiple forums to communicate and/or collaborate with others during instruction and enabled us to explore their thinking as they developed their projects.

Data Collection & Analysis Techniques

To explore how PSTs used popular fiction to draw connections among curricular standards and the instructional practices they used to facilitate disciplinary literacy learning, we framed our data collection around two literacy events in the course: 1) the inquiry projects PSTs' designed for future classroom use and 2) the online posts made during their learning process. The inquiry projects provided credible data for understanding PSTs' thinking because the assignment required students to anchor instruction in both science and literacy standards; incorporate a popular text and a range of nonfiction texts; establish learning goals in reading, writing, and academic language; and plan instruction for helping students meet these goals. PSTs' in-process posts to various online media platforms used during class (Padlet, TodaysMeet, and Moodle) provided insight into the process of how they constructed their inquiry project at different points throughout the course.

A deductive and inductive approach to analysis and examined data across type and source was used. Deductively, given the focus on inquiry processes and standards alignment, data was coded for science content, science literacy strategies, and assessment practices. Throughout the process, data was co-coded, employing agreed upon deductive categories before shifting to an inductive process and comparing codes until consensus was reached. Collaborative coding enabled the authors to bring their content expertise to the analytic process. For initial reduction and organization, we grouped data by question, identified the science and literacy standards PSTs utilized, and examined the connections drawn among these standards and popular texts. As a second step to this process, instructional choices were coded for deductive categories that reflected how PSTs planned the central components of classroom instruction: literacy practices and assessment. Then these categories and corresponding evidence were inductively examined to understand how PSTs fostered disciplinary literacy through the use of popular texts.

Findings

Data indicated that PSTs chose similar instructional methods for embedding literacy practices into their science teaching. PSTs primarily approached the task of building inquiry units by leveraging popular fiction texts to engage students. However, their use of scaffolds to help build students' success varied considerably. Additionally, the ways in which PSTs chose to assess and logistically structure the integration of disciplinary literacy into their scientific inquiry also varied (see Table 2). Below, strengths and weaknesses in the PST's final projects are highlighted in an attempt to glean insights into how to better support science disciplinary literacy skill development.

Table 2. Inquiry projects developed by PSTs.

PST **pseudonyms used*	Central Question	Popular Culture Text	Disciplinary Content	Key Literacy Activities
Vincent	1) How do pathogens spread? 2) How does the spread of a pathogen in an ecosystem affect a population? 3) How do populations respond to selective pressures like pathogens?	*World War Z*	Viruses & Bacteria + act as a primer for a unit on natural selection	Answer central questions using evidence from texts for support *Project takes the form of an online quest via padlet
Jerome	1) How does group and individual behavior change during catastrophic events? 2) Do humans show "migration" patterns to that of other animals during such events? 3) What happens when groups begin to break down among themselves during these events? 4) Should humans be concerned with the group survival or the survival of themselves?	*World War Z*	Ecology and the study of populations & group mentality Nature vs. nurture	Construction of Venn diagram & Science journal writing addressing the following prompts: ✓ What advantages during times of stress and catastrophe do humans have versus other animals? ✓ What makes humans more likely to survive and or die?
Anton	1) What is the relationship between human behavior and the affects of a widespread epidemic have on the population? 2) Are there any specific examples that can be pulled from the text to show these relationships? 3) What affect (adverse or proactive) does it have on human activity and the environment?	*World War Z*	Ecosystems Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity	Students collaboratively select an environmental issue and utilize outside resources to research the topic and present it to the class in a formal proposal. Students will share (like a science fair) their proposals and possible solutions to their issue, as well as write a 1-2 paragraph summarizing their findings.
Irene	1) What is the role of government in regulating genetic engineering? 2) What is the role of companies and governments in safeguarding the public health? 3) What is the cost of genetic engineering? Environmental? Monetary? Human consumption?	*Hunger Games*	Genetics Ethics of genetic engineering	Vocabulary self-awareness chart Think-pair-share & GIST[1] statements Critical Response with 3-5 citations

[1] Generating Interactions between Schema and Text (Cunningham, 1982): a strategy to help students condense and summarize texts.

Ca[2]ssi	1) What is the role of government in regulating genetic engineering? 2) What's the role of companies and governments in safeguarding the public? 3) What's the cost of genetic engineering? Environment? Human Consumption?	*Hunger Games*	Genetics, genetic engineering, the ethics, benefits, and costs	KWLH chart 5 Ws & 1 H[2] GIST statements Admit/exit slips RAFT perspective writing Final goal: Informative science article

Use of Popular Fiction to Integrate Science and Literacy

All students recognized the potential of popular culture texts to engage students' out-of-school interests as part of classroom learning. As Jerome explained, popular culture texts "are usually books that are relevant to what students like and the books contain [scientific] messages that we as teachers can decipher and use in class. These books can provide a launching point for great lessons." Anton recognized that popular texts "easily relate to real world context students can further explore." Specifically, PSTs selected two popular culture texts that began as books and were later adapted into movies: *The Hunger Games* and *World War Z*, and emphasized the power of each text's cultural relevance. Vincent understood *World War Z* as indicative of "the popularity of the Zombie genre." Jerome echoed this idea explaining how, "Zombies have exploded in our culture over the past few years. From shows on television to books on survival, zombies are a sci-fi hit." Irene, the only participant actually teaching high school biology during this semester, offered a similar but expanded rationale for selecting *The Hunger Games*:

> I chose the book, *The Hunger Games,* because it is a popular work of fiction that is made even more popular with students in the high school age range by the movies that are being released. The second movie in the series is being released in the next week, actually, so it is current and relevant to popular culture. Also, this text is written for a young adult audience, so I know that there will not be any issue with inappropriate content for my students' age group. Finally, I chose this text because it is written where students at a lower reading level can access the content as well as those at grade level.

Irene's position as a working classroom teacher enabled her to recognize the accessibility of the text as well as its cultural relevance. These findings indicated PSTs' recognition of the importance of building third space by intentionally bridging student interests with science concepts explored in the classroom.

In addition to engaging students through the popularity of *The Hunger Games* and zombie culture, PSTs unearthed scientific concepts from these texts to create a platform for their inquiry units. PSTs working with *World War Z* all leveraged the zombie phenomenon to explore different aspects of viral outbreaks, pathogens, and natural selection. Vincent described how "zombie outbreaks are typically explained as viral or bacterial infections" providing an "exciting petri dish for students in which their imagination and content assimilation can grow naturally." Jerome explained how *World War Z* "connects the societies love for zombies and actual

[2] Who, what, when, where, why, and how: a strategy to help students recall key ideas reported in a text.

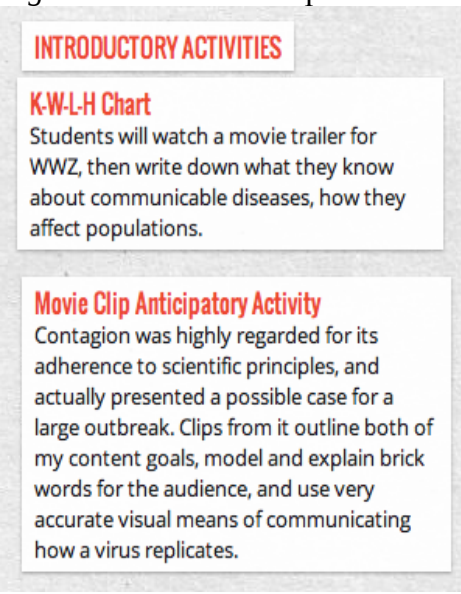
science." Two students working with *The Hunger Games* planned to leverage, as Irene explained, "the animals described as muttagens" to introduce students to genetics, genetic engineering, and the current debate about genetically modified organisms. Cassi used explicit examples to draw connections between the text and today's world:

> …it is a hot topic in regards to ethics in the field of science and medicine today. Genetic engineering is taking place all around us from the crops we eat (e.g. corn) to the ethics and politics of cloning, stem cell research, and reproductive genetics (e.g. from making the perfect fish to making the perfect baby). Genetic engineering provides a depth and breadth of research for students to dive into. As well, it is a subject that is both interesting and relevant to their lives.

Thus, PSTs used popular texts to not only make science content relevant to students' lives, but also uncovered and aligned the science concepts they found important in the popular texts to the science concepts they would be expected to teach in their future classrooms.

Drawing from scientific concepts from *The Hunger Games* (i.e. implications of genetic engineering) and *World War Z* (i.e. pathogens, viral outbreaks, natural selection), PSTs then thoughtfully integrated literacy standards to support students' science explorations. One student, Vincent, very intentionally supported students' reading, writing, thinking throughout the inquiry process. In doing so, Vincent integrated the science performance expectation that students develop arguments from evidence regarding differential survival and reproduction with the literacy standard of drawing evidence from literary or informational texts to support analysis, reflection, and research (NGSS, 2013). As such, he created a Padlet (see Figure 1) to guide students in gathering evidence from multiple texts before, during, and after instruction in order to help them write a final persuasive argument to the World Health Organization (WHO).

Figure 1. PST's padlet creation to guide students through inquiry project.



Vincent's use of the *World War Z* text set the context for exploration (as seen in his introductory activities), but also provided excerpts for the students to dissect during the project as they read non-fiction resources to elucidate and extend the content. Vincent also leveraged the literary nature of the text (i.e. its "narrative structure" or structural framework that underlies the order and manner in which a narrative is presented) to motivate students and structure their inquiry experience. Using the text's plot and structure, he challenged students to become "infected" with academic language, explaining that students must love "gnawledge" like zombies love brains. By asking students to create a plea for help to the WHO, he placed students in the position of characters and rewarded their success by unlocking the next steps in the assignment. While building academic vocabulary and ultimately writing a persuasive plea to the WHO, the project

culminated by addressing the disciplinary core idea of a populations' response to selection pressures.

Some PSTs, however, attempted to incorporate too many performance expectations in their inquiry units, which were not always aligned well with their essential question. For example, Irene's driving question for her inquiry project using *The Hunger Games* was for students to determine the role of government in regulating genetic engineering and safeguarding public health—a question directly related to the tension in the text regarding government control. The performance expectations she wished to address, however, were those of the specifics of the structure and function of DNA, gene expression, and recombinant DNA. Thus, the inquiry question did not align with the intended focus on specific disciplinary core ideas. This was problematic in that Irene's choice of supporting non-fiction texts included information on genetic modification (i.e. cases of Bt-Corn and genetically engineered fish), but did not provide the policy documents or guidelines for policy analysis that would equip students to be able to address the driving question of the unit. While Irene's inquiry unit could have inspired position taking based on learning about authentic cases of genetically modified organisms, neither the resources she provided nor the learning targets outlined would have adequately addressed her essential question.

An additional finding regarding the ways in which popular fiction enabled PSTs to integrate science and literacy was related to the logistics of how they organized and utilized resources to support their units. Specifically, PSTs showcased numerous ways to incorporate disciplinary literacy practices into their scientific inquiry with regard to frequency of instruction and use of resources. The majority of PSTs utilized a project-based learning approach by having students conduct independent research to address a driving or essential question and develop a final culminating project. As described above, Vincent incorporated a Padlet technology that connected to *World War Z* at various points throughout the unit to guide students through their inquiry project. Two other students (Cassi and Irene) established a "Literacy Friday" during which they would revisit the popular culture text and continue with the unit over the course of the semester. Irene also employed the use of a literacy specialist to co-teach aspects of the text with her students. Her inclination to integrate subject areas was evident in her online posts in discussions about developing her inquiry project. Irene wrote, "I think this is something that could be taught across disciplines between English and content teachers so the kids get more exposure and practice." Thus, the level of scaffolds to assist students in staying focused throughout the long units varied with regard to the types of supports (i.e. use of technology; embedding designated literacy time; use of partnering teachers).

PSTs' Instructional Choices

In drawing connections among science and literacy standards, PSTs made selections about which literacy practices and assessment opportunities to employ in their inquiry unit. Below, we describe both the common patterns and unique approaches PSTs employed to utilize popular fiction as a springboard to connect disciplinary literacy and scientific inquiry.

Science Literacy Practices

From among a wealth of strategies modeled for them during the semester, PSTs chose to utilize similar instructional strategies (jigsaws[3], KWL charts, think-pair-shares, read alouds, and vocabulary building strategies) in designing their inquiry units. While their choices of instructional methods often overlapped, the ways in which PSTs used the strategies differed with respect to their instructional goals and the scaffolds they provided for students. For example, as part of their course assignment, PSTs were required to choose nonfiction sources to explore the science in their novels. In doing so, all of them elected to pair these sources with a jigsaw strategy designed to promote exploration of the multiple dimensions of the science underscored in their popular fiction text. For example, using *World War Z* as his chosen novel, Jerome used the jigsaw as a starting point to hook students' interest in the topic. His supporting articles highlighted how humans as a whole respond to catastrophic situations—serving as a springboard for discussion and providing a rationale for his inquiry unit, which focused on group survival strategies across the animal kingdom. All other PSTs, however, used the jigsaw to provide background and multiple perspectives of the topic. For example, Vincent (also using *World War Z* as his popular fiction text) included a jigsaw of three supporting articles describing recent viral outbreaks and human responses to help students develop petitions to the WHO for funding to fight the spread of a specific pathogen. In contrast to Jerome, Vincent's jigsaw provided students an opportunity to build their understanding of potential solutions to viral outbreaks by exploring case studies of strategies used in the cholera outbreak in Haiti and the smallbox outbreak among Native Americans.

In terms of differential scaffolds provided for students, several PSTs used read alouds of the nonfiction texts to help students learn what information scientists discern as important when they read (i.e. determining credibility, plausibility of results, developing vocabulary). Two of the PSTs explicitly scaffolded the reading process of students, though again did so in different ways. For example, before jigsawing articles with students, Cassi embedded explicit instruction on how to do a read aloud—mimicking the kinds of questions scientists ask themselves as they read. In her inquiry unit, she states, "I model for them [the students] how to break apart an article/reading for the essential information (an example of an 'I do, we do, you do')…they may be in a place to move right into the first article as part of a jigsaw reading." In this way, Cassi provided explicit instruction on the elements in the articles students ought to be privileging as they read scientific text—a skill important for the students to develop before writing their own scientific article for their culminating project. Irene, however, chose nonfiction texts that represented multiple perspectives on genetic engineering and showcased different reading levels (based on, as she stated, "the students' tested reading levels—this way it is challenging reading while not being unobtainable"). She asked the students to identify brick and mortar words[4] in their texts and to participate in a think-pair-share to discuss the meaning of the text—ultimately creating a GIST statement about how the group summarizes and interprets the text. Although not explicitly teaching students how scientists read, Irene utilized literacy strategies to scaffold students' meaning making of the texts and attended to differences in reading ability levels.

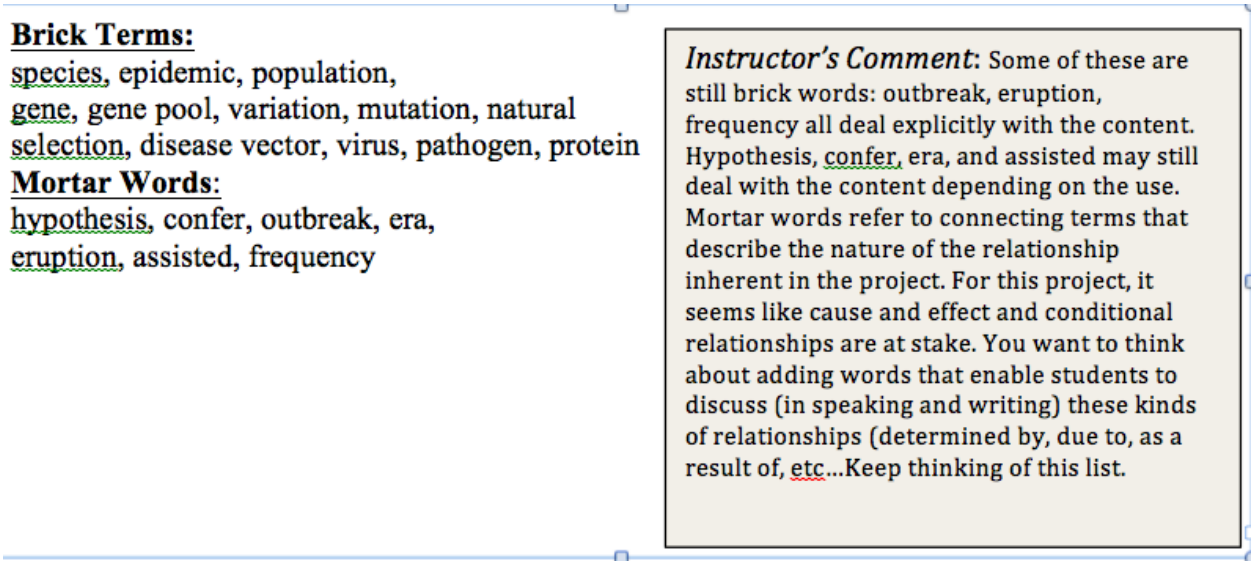
[3] A two-level grouping structure in which students are first grouped to read and comprehend a common text and then regrouped as "experts" to discuss multiple texts addressing a common theme (Fisher & Frey, 2012).

[4] Brick words refers to discipline-specific terms like *mitosis* and *chromosome* while mortar words refers to more general words and phrases used to connect ideas and facilitate academic discussion like *however*, *in conclusion*, and *evaluate* (Zwiers, 2008).

Aside from Irene, none of the PSTs addressed text complexity or difficulty to ensure all students would have reading material appropriate to their reading ability. Irene was the only PST who held a teaching position during the course of the semester (she taught high school biology in the local school district), and it may be that her privileging of differentiated reading material was a result of her experience in the classroom working with students of varying reading abilities. As such, the other PSTs relied on the assumption that students would have equal access to the nonfiction text and therefore did not address issues of complexity in the reading.

PSTs did place heavy importance on vocabulary or what they termed in a group online post: "the prevalence of brick words[4]," as indicated by their use of vocabulary developing strategies such as awareness charts, brick and mortar word identification, and word walls. In an online post, Vincent recognized "the main literacy challenge is going to be brick words - technical vocabulary" and opted to teach words explicitly, while Jerome approached the same challenge via whole class discussion of words based on context with the goal of helping students "be more critical readers and hopefully be able to re-read texts to find the meaning of words." Despite this, we noted some PSTs themselves had difficult identifying brick and mortar words. Figure 2 showcases Vincent's struggle to identify the brick and mortar words in his texts.

Figure 2. PSTs' identification of brick and mortar words and corresponding instructor comments.



In employing strategies to expose and reinforce vocabulary, PSTs more frequently asked students to anticipate and identify important brick words by creating word walls students could develop and reference across the unit. Words walls and vocabulary awareness charts were selected strategies to support students in identifying brick words on which they needed to focus. The PSTs tended to focus more on the brick words, rather than the mortar words—so that in effect, they focused students' attention on the vocabulary rather than the relationships among concepts.

Assessment

PSTs approached the assessment component of their inquiry project by incorporating one or more of the literacy goals of reading, writing, or communicating. In their culminating activities, PSTs asked students to develop argumentation either by presenting their positioning on topics they independently researched, writing a scientific position piece, or identifying the central tenets from multiple texts to develop a critical response. For example, in Irene's assessment, she asked students to develop a critical response to their readings by identifying vocabulary (i.e. dissecting brick and mortar words in the texts) and by incorporating multiple citations to connect their critical responses to the data they have gathered in their jigsawed readings. In doing so, Irene had students develop GIST statements as they read multiple texts to answer the central question of the governments' role in genetic engineering. As an additional formative support during the unit, students participated in think-pair-shares of their understanding of text and complete vocabulary self-awareness charts to determine their level of understanding of key terms. Irene's final assessment, then, incorporated both communication and reading aspects of literacy.

The PSTs' inquiry designs for assessment varied with regard to ways in which explicit literacy instruction helped support students' success. In their online discussions during class, PSTs asserted writing is important to science meaning making. For example, Anton wrote, "Our group agreed that a student could write well in one subject but struggle in another because writing in different content areas is very different." Despite this sentiment, however, he did not actively scaffold opportunities for his students to practice scientific writing. In his culminating activity, Anton provided a rubric for students' research presentations on widespread epidemics' effects on human behavior. In the rubric, other than 'writing mechanics' (i.e. grammatical correctness and organization), no other focus on literacy was included. Consequently, no clear focus on what constitutes scientific writing (i.e. determining credibility or identifying/critiquing claims and evidence) was present in the unit.

In contrast, Cassi supported students' writing throughout the inquiry unit by providing many opportunities for students to both practice writing and critique scientific writing. In her inquiry project plans, she wrote:

> I plan to include informal writing projects…during the teaching of content and following all their readings to increase their learning [of scientific literacy skills] before they embark on writing their article [i.e. culminating project]...it will help scaffold their reading and writing for the project.

Cassi's use of literacy strategies served as an important scaffold to student writing, which she believed teachers "don't emphasize enough" in science classrooms. In her online posts during the development of her inquiry project, she wrote, "There are many literacy strategies that can serve as formative/summative assessments." Cassi's intentional focus on developing students' literacy skills and providing multiple opportunities for pre-writing should help to ensure the students' can successfully write their scientific article. The PSTs who, like Cassi, provided a clear set of scaffolds to guide their students toward a successful culminating project employed literacy strategies prior to, during, and at the end of the multifaceted inquiry project.

Discussion Related to the Teaching & Learning of Science

In considering the first research question about the ways in which pre-service teachers used popular fiction to draw connections among curricular standards, note the potential for text to be leveraged throughout the inquiry process. Consistent with Moje (2004; 2008) and others' (Alvermann, 2011; Norris & Phillips, 2003) call for popular culture text to bridge the third space between home and school, PSTs readily chose texts in which teens would have strong interest. The choice PSTs made to focus on texts associated with film genre (both *The Hunger Games* and *World War Z* were developed into blockbuster movies) increased accessibility to the popular culture third space. Cultural referents such as zombies and 'muttagens' served as entry points to evoke student engagement into the science inquiry. Consistent with Yager's (2004) idea about text providing the context to wonder about science, PSTs approached the task of building their inquiries using the popular culture text to support engagement and build off of students' interests. PSTs employed popular fiction as a hook by drawing relevance to students' lives and setting the parameters for the inquiry unit (i.e. content to be studied, external resources, guiding/essential question, and culminating project). This instructional decision reflected the ways in which text could act as a starting point for the inquiry process whereby students actively and critically evaluate and develop questions about scientific concepts.

In some instances, PSTs went beyond using the popular culture text as merely an engagement tool and did what Cervetti et al. (2006) describe as tandem use of text and inquiry processes. For example, Vincent's use of the narrative structure of the text itself enabled him to scaffold and assess students' experiences throughout the inquiry process. Similarly, Cassi and Irene use their text to structure an extended exploration of broader socio-scientific issues during their Literacy Friday platform in which they revisited the popular text throughout the semester to enrich student learning. In these instances, PSTs showcased how textual resources can be used before, during, and after inquiry experiences to not only engage students but also provide an anchor for instruction and reflection throughout extended units.

In terms of literacy instructional practices, PSTs tended to adopt strategies that had been discussed or modeled by the instructor. All PSTs relied on the jigsaw structure and central questions to provoke a critical argument, both of which were modeled for them. The jigsaw structure facilitated the use of multiple texts while the central question set a purpose for negotiating a more nuanced understanding of content. Shanahan (2013) asserts that the use of multiple texts promotes critical thinking and enables students to mimic the reading behaviors of disciplinary experts. These choices indicate that PSTs valued literacy as an authentic process of collaborative meaning-making (Barton, Hamilton, & Ivanovic, 2005) and understood how to push students to read, think, listen, and speak critically about science concepts across a range of texts.

In this investigation of the ways in which pre-service teachers foster disciplinary literacy through instructional practices that incorporate popular fiction, several opportunities for teacher preparation programs to better support PSTs in honing literacy skills important in science teaching were noted. First, while PSTs succeeded in selecting engaging and relevant popular fiction texts, they needed more instruction in how to select nonfiction texts that provide adequate scaffolds. Some participants incorporated too many performance expectations that were not always well-aligned with the essential question. In these instances, driving question prompts

jumped from micro-processes to government control and ethics. It is problematic to propel students into higher-level synthesis and evaluation of complex topics such without the proper scaffolds (Cook, Buck, & Park Rogers, 2012). The selection of nonfiction sources needed further development with PSTs, and they need opportunities to hone the ability to choose texts that best underscore educational aims in the inquiry as well as those that incorporate a range of perspectives. Specifically, scaffolds can include selection of supporting materials and opportunities to explore multiple data based viewpoints to encourage discussion and debate. As indicated above, some PSTs scaffolded their inquiry units well by explicitly referencing the popular fiction throughout the unit so that students were exploring the nonfiction sources in the context of the essential question. Using a narrative structure, Vincent used the popular fiction as a 'touchstone text[5]' to ensure students did not lose the connection to the driving question when exploring nonfiction texts.

How PSTs selected and taught vocabulary reveals a second implication for teacher educators. Science texts have a high level of "lexical density" (Shanahan & Shanahan, 2008, p. 53), and PSTs recognized this characteristic as inherent to science literacy. Academic language includes both brick and mortar words (Zwiers, 2008). Brick words enable students to name key concepts, while mortar words enable students to connect ideas and develop academic discussions. Mortar words are essential to students' expressive vocabulary as they put the brick words into communicative action. Here, PSTs gravitated to brick words (i.e. pathogen, biosphere, mutation) by identifying a significant number of terms to teach as part of their inquiry projects. Although PSTs planned to teach these words through explicit instruction, they neglected to consider how multiple interactions with words supports student learning. Weinburgh and Silva's (2010; Silva, Weinburgh, Smith, Malloy, & Marshall, 2012) 5R model, provides an instructional framework that uses inquiry to teach academic language and offers students rich interactions with new terminology. Because this model prioritizes the role of science experiences, student learning is anchored in authentic and repeated interactions with scientific terminology. Additionally, the fifth R, *reload*, enables students to leverage their inquiry experience to make deeper meaning of each new word (Silva, Weinburgh, & Smith, 2013). This 'reloading' prioritizes student understanding and communicating with academic language in science.

PSTs also struggled to identify useful mortar terms when selecting key vocabulary for their inquiry projects. The potential effect of this imbalance is an over-emphasis on receptive comprehension without fostering students' ability to communicate about and with the same key ideas. This tendency indicates that PSTs need support in identifying appropriate mortar vocabulary for scientific texts and strategies for how to teach these terms. Concept mapping with a specific emphasis on labeling relationships is important in science vocabulary development. As noted in literature on mapping, the existence of the important links on a concept map indicates whether the student knows that there are relationships among those concepts (Yin, Vanides, Ruiz-Primo, Ayala, & Shavelson, 2005). Some other strategies might include: teacher educators modeling text-dissection with an explicit emphasis on the use of mortar words, examining key sentences then substituting different prepositions or connecting terms to clarify their function,

[5] Texts used as models of structure, language, and writing craft (Wood Ray, 1999).

and/or focusing PSTs' thinking about mortar terms by asking them to seek out the mortar terms prior to identifying any brick terms.

Finally, PSTs' approaches to writing in science also lacked strategic instruction. All PSTs valued writing and found it essential to teaching science; they incorporated writing goals as part of their inquiry project and their online discussions acknowledged that science writing posed unique challenges for students. This understanding, however, did not translate into effective instructional practices for teaching writing. Cassi included scaffolding to support the production of a final writing product while all other PSTs assigned writing without preparing students to succeed in this task. This finding echoes extant research indicating that PSTs need explicit instruction on writing in science through different genres (Pytash, 2013; Hand & Prain, 2002). Science writing encompasses explanatory, descriptive, and argumentative purposes in a variety of forms (i.e. lab reports, research articles, lay explanations); thus, PSTs need experience analyzing and modeling these forms and purposes. Some strategies might include: teacher-educators modeling use of concept maps as prewriting tools and practicing the use of mortar terms in writing, the use of sensory details to create objective descriptions, teaching students how to compose cause and effect sequences, and supporting students' development of scientific arguments through use of scaffold such as the claims, evidence, reasoning framework (proposed by Zembal-Saul, McNeill, & Hershberger, 2013).

Overall, PSTs incorporated a range of literacy practices that attempted to address the demands of reading, writing, and communicating in science. PSTs paired popular fiction and nonfiction texts to facilitate collaborative practices focused on comprehending and interpreting science concepts through reading and discussion. PSTs were less successful in utilizing practices to foster written expression of key ideas. Science concepts identified through the popular fiction texts offered potentially rich writing opportunities, but PSTs were unsure of how to scaffold and explicitly teach scientific writing. In our future research, we will follow students into the field (i.e. classroom setting) to investigate the implementation of their developed curricula and provide opportunities for practice and refinement of their skills.

Without positioning literacy as a bully in the science curriculum or overly additive to the science curriculum, PSTs illustrated there are numerous ways to logistically structure scientific inquiry to include and authentically underscore science disciplinary literacy. By employing the use of technology, partnering teachers, and designated 'Literacy Fridays,' PSTs showcased their ability to find space to connect literacy and scientific inquiry—an indication there are many creative ways to privilege both in the science classroom (Cervetti et al., 2006). Thus, asking PSTs to develop inquiries around popular fiction text not only supported their building of disciplinary literacy, but also legitimized the place for popular culture text in the formal classroom. As noted in previous research (Marsh, 2005), PSTs tend to hesitate bringing popular fiction into the formal classroom for fear it will be perceived as too divergent from the official curriculum. In this content area reading course, however, popular fiction text took a central role in the development of scientific inquiries that aimed to integrate science and literacy content and practices. In doing so, literacy practices became a buddy, rather than a bully to support deeper engagement with the texts and connections to science content.

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