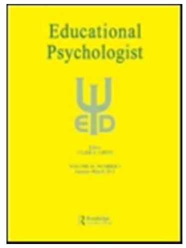

A Conceptual Framework for Disciplinary Literacy

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Disciplinary Literacies and Learning to Read for Understanding: A Conceptual Framework of Core Processes and Constructs

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Abstract

Abstract

This paper presents a framework and methodology for designing learning goals targeted at what students need to know and be able to do in order to attain high levels of literacy and achievement in three disciplinary areas –literature, science, and history. For each discipline, a team of researchers, teachers, and specialists in that discipline engaged in conceptual metanalysis of theory and research on the reading, reasoning, and inquiry practices exhibited by disciplinary experts as contrasted with novices. Each team identified discipline-specific clusters of types of knowledge. Across teams, the clusters for each discipline were grouped into five higher-order categories of *core constructs*: (1) epistemology; (2) inquiry practices/strategies of reasoning; (3) overarching concepts, themes, and frameworks; (4) forms of information representation/types of texts; and (5) discourse and language structures. The substance of the clusters gave rise to discipline-specific goals and tasks involved in reading across multiple texts as well as reading, reasoning, and argumentation practices tailored to discipline-specific criteria for evidence-based knowledge claims. The framework of constructs and processes provides a valuable tool for researchers and classroom teachers' (re)conceptualizations of literacy and argumentation learning goals in their specific disciplines.

It is now almost commonplace to cite the inadequate preparation of youth worldwide for the 21st century. In national and international assessments, the majority of students do not progress much beyond basic reading and math skills, resulting in inadequate complex comprehension and problem solving skills (National Assessment of Educational Progress (NAEP), 2009; National Center for Education Statistics, 2013; Organization for Economic and Cultural Development (OECD), 2013a). The available evidence suggests similar trends for the information literacy skills required to effectively use the internet, including systematic search and evaluation of search results using general and discipline specific criteria to determine trustworthiness, reliability, credibility, and validity of the information (e.g., Britt & Aglinskas, 2002; Bromme & Goldman, 2014; National Research Council, 2012; Rouet, 2006; OECD, 2013a).

Global recognition of these needs as well as changes in the literacy demands needed to be productive citizens have led to a number of initiatives designed to specify the skills students need opportunities to learn (e.g., Ananiadou & Claro, 2009; Griffin, McGaw, & Care, 2012; Voogt & Pareja Roblin, 2012). International efforts are increasingly placing attention on reading as a tool for problem solving and accomplishing specific tasks (OECD, 2013b). In the United States, the Common Core State Standards in English Language Arts, History/Social Studies, and Science and Technical subjects (CCSS) (CCSSO, 2010) are moving in similar directions to reflect literacy and knowledge generation demands of the 21st century. In addition to the traditional knowledge acquisition processes, the CCSS emphasize integrating and evaluating content in multiple media forms; analysis and critique (validity, reasoning) of arguments presented in text; and comparisons and contrasts across texts with respect to themes, arguments, and content. The CCSS standards also reflect contemporary research showing differences across disciplinary areas of study in the nature of the reading and reasoning processes involved. Similarly, the Next Generation Science Standards (NGSS) (Next Generation Science Standards Lead States, 2013) and the C3 Framework for College, Career and Civic Life (National Council for the Social Studies (NCSS, 2013) emphasize students learning to engage in authentic practices of knowledge generation in the disciplines and subdisciplines that comprise the sciences (NGSS) and the social studies.

However, standards specify targets, outcomes, or goals of instruction; they are not roadmaps for achieving them. Standards do not specify in sufficient detail what students would need to learn and know to achieve target performances that could provide evidence of having achieved the outcomes (CCSSO, 2010; Shephard, Hannaway, & Baker, 2009). Standards must be unpacked further in terms of what to teach, how to teach, what to expect from students, how those expectations progressively increase across years of schooling, and how to assess where students are relative to expectations. In addition, decisions about what to teach and how to teach it should address the challenges students are likely to encounter when approaching specific concepts, texts, and tasks. Thus, although standards can set worthwhile goals for educational systems, achieving them requires the design, implementation, and evaluation of instructional principles, strategies, materials, and assessments that are aligned with the standards. While this might seem obvious, it is a process rarely practiced. Rather, educational systems seem to rush to implementation with little understanding of what new standards imply for the work of teachers and students and the resources needed to support that work, including appropriate means of assessment and evaluation (e.g., Cohen & Hill, 2001). (See for elaboration of this argument Bryk, Gomez, LeMahieu, & Grunow, 2015.)

Six years ago we were faced with the need to unpack what adolescent students needed to learn if they were to take their places in 21st century society as literate generators as well as consumers of knowledge (Goldman & Scardamalia, 2013). A major outcome of the unpacking process was a framework for conceptualizing what one needed to know *about* the nature of knowledge, how it is generated (inquiry processes), and how it is communicated (literacy/argumentation processes) in specific disciplines. The framework did not attempt to encompass the *what* of a particular discipline, i.e., the existing knowledge base. Rather, the framework sought to reflect literacy, argumentation, and inquiry practices needed to engage in the knowledge discovery and generation processes that enhance, amplify, and re-direct the existing knowledge base. We thus distinguish between two dimensions of academic literacy: content and rhetorical processes (Geisler, 1994).

The need for the unpacking process arose in the context of a large, research and development project that we proposed in response to a request for proposals in 2009 by the USA's Institute for Education Sciences calling for research on *reading for understanding.* The project brought together models of complex, multiple text reading comprehension and problem solving tasks relevant to three high school content areas–literature, the sciences, and history. We formally defined reading for understanding as engaging evidence-based argumentation with multiple sources of information situated within the three distinct disciplines of literary reading, science, and history. Our phrase *multiple sources of information* reflects an expansive definition of text to include multiple media and forms of information representation (e.g., Kress & Van Leeuwen, 2001; New London Group, 1996; Unsworth, 2002). We adopted the acronym READI to emphasize the main foci of the project: Reading, Evidence and Argumentation in Disciplinary Instruction.

The READI definition of reading for understanding was initially proposed and developed independently and prior to the publication of the USA's Common Core Standards, the NGSS, and the C3. However, the definition dovetailed with important elements of each of these three standards documents, especially those elements critical for 21st century literacy and reasoning competencies in each discipline (Goldman, 2012, 2015; Greenleaf, et al., 2011; Lee & Sprately, 2010). As well, the funding for the work and the unpacking process occurred over the time frame in which these three sets of standards were emerging for comment and ultimately publication. Accordingly, we reviewed them in the context of READI work. Thus our unpacking process had direct implications and relevance to unpacking the standards put forth in the American context and we believe are applicable to designers in other nations who are working with their own national standards.

In this paper, we present the framework that grew out of the unpacking process. It specifies reading processes, and to some extent writing processes, along with the kinds of knowledge about the discipline that define and give purpose to reading, reasoning, and critical inquiry in a discipline. These disciplinary core knowledge constructs capture not only the conventions negotiated by the disciplinary discourse community for what constitutes legitimate knowledge claims and how they are made but the accepted means by which evidence is developed and related to knowledge claims (Gee, 1992; Lave & Wenger, 1991).

Developing the framework served as a critical first step in both designing research and instructional interventions to enhance reading to learn with understanding within the three specific disciplines of literary reading, science, and history. The framework of constructs and processes has also been a valuable tool for classroom teachers' (re)conceptualizations of literacy and argumentation instruction in their specific disciplines. It has helped them more clearly define and distinguish among instructional goals and targets encompassed by the CCSS, the NGSS, and the C3, particularly with the literacy and inquiry practices. These practices frequently remain tacit in their own minds and invisible in their interactions with students and those who are less expert in their fields of specialization. Making these processes more explicit is a first step in making them visible to students and thus objects of instruction. To concretize this point, consider the following incident that occurred during a professional development session in which teachers representing English Language Arts, Science, or Social Studies were reading and reflecting on their thinking about texts characteristic of each discipline. The literary text opened with one of the characters washing himself in a river (Wideman, 1998). Those steeped in literary analysis marked the scene as an unusual way to open a story and thought it might therefore have special meaning for interpreting the story. They also reported that it brought to mind themes such as baptism and renewal or innocence/loss of innocence and that the character's name (Orion) brought to mind Greek mythology. Science teachers also marked it as odd and wondered why the person was bathing outside. However, they did not see it as potentially having special importance for interpreting the work. Nor did they report associations to larger themes (cf. Grossman, Wineburg, &Woolworth, 2001). From a research perspective our claim is that the framework for conceptualizing sense making during reading as situated within a discipline suggests a variety of research questions that go beyond those typically asked about text comprehension (e.g., how well plot elements are remembered or symbols identified).

Thus a main purpose of this paper is to convey this framework of processes and constructs in hopes that other researchers and practitioners will find it useful in defining goals for instruction and research in these three disciplines and in similar unpacking efforts in other disciplines. We first elaborate on Project READI as the context for the development of the framework and discuss needed expansions of reading comprehension models that were developed as accounts of single text comprehension. These expansions to the single text model guided basic research studies and had implications for intervention design. We then discuss our design methodology for generating disciplinary constructs important to learning to read with understanding in each of three disciplines: literary reading, science, and history, including implications for learning goals in each. We conclude with a discussion of how the framework influenced teachers' and researchers' thinking about the design of instruction and critical research questions.

Context for Developing the Framework

In Project READI we committed to two interrelated strands of work: basic studies of models of reading from multiple sources and intervention design. The work focuses on adolescent students across the age span of 12 to 18 years, an age/grade span during which students are increasingly expected to use reading as a major vehicle for learning in multiple content areas (Alvermann & Moore, 1991; Lee & Spratley, 2010; Moje & O'Brien, 2001; Shanahan & Shanahan, 2008). However, the similarities and differences among disciplines with respect to how knowledge is constructed, represented and communicated and thus how it is "read" are typically not a focus of content area instruction. Thus, students are left to figure out on their own that the same "rules" do not apply across content areas. For example, what is important to include in a summary of a mystery story is not the same as a summary of a report of an unexpected scientific finding, nor can it be determined with the same knowledge and processes. Likewise, a first-person narrative may be a perfectly acceptable genre for an English class essay but not for reporting data one has collected for a science project. The same words (such as *symbols*) have different meanings in subjects such as literature versus chemistry. In

Project READI, we hoped to develop teaching and learning tools for promoting appropriate as compared to inappropriate transfer and generalization across content areas.

Expanding Reading Comprehension Models from Single to Multiple Sources

Extant research on multiple-text reading pointed to the need to expand single-text comprehension models in significant ways (e.g., Bråten, Britt, Strømsø, & Rouet, 2011; Britt & Rouet, 2012; Goldman, 2004; Goldman, Lawless, et al., 2012; Perfetti, Rouet, & Britt, 1999; Rouet, 2006). We expanded upon a class of single-text processing and reading comprehension models that originated in the work of Kintsch and colleagues (Kintsch, 1998; van Dijk & Kintsch, 1983) and that have been elaborated by a variety of discourse researchers (e.g., Goldman, 2004; Goldman, Varma, & Coté, 1996; Graesser & McNamara, 2010; van den Broek, Young, Tzeng, & Linderholm, 1999). Consistent with this class of models, we assumed that readers construct at least three types or layers of memory representations to capture different aspects of texts they read. The *surface level* is an unanalyzed verbatim representation of the text string (e.g., the words). It is created through decoding processes about which we have a relatively solid understanding, at least for early reading (up to grade 3) (Rayner, Foorman, Perfetti, Pesetsky & Seidenberg, 2002; RAND, 2002). The *textbase level,* or meaning level, is a representation of a set of propositions corresponding to the explicit content of the text. Words are converted into propositions based primarily on lexical knowledge, syntactic analysis, and information retrieved from memory through an automatic, passive activation process (Myers & O'Brien, 1998; Perfetti & Britt, 1995). The *situation model*, or interpreted level, is a coherent representation of the events described by the whole text, elaborated with relevant information from memory that is activated based on passive, "dumb" resonance mechanisms (Gerrig & McKoon, 1998; Myers & O'Brien, 1998) as well as through strategic, effortful inference mechanisms that help resolve coherence gaps (Coté & Goldman, 1999; Kintsch, 1998; Zwaan, Magliano, & Graesser, 1995).

Although this class of models has accounted well for single text comprehension, our definition went beyond existing models to highlight two foci of 21st century literacy skills: the demands of reading for understanding in authentic learning situations within a discipline and an orientation to disciplines as communities of practice (Lave & Wenger, 1991).

Reading for understanding in authentic learning situations. In authentic learning situations readers have specific inquiry tasks to accomplish and are often learning about complex situations and phenomena for which no single text provides a complete account. Competent readers must coordinate diverse–and sometimes contradictory–information and perspectives from multiple texts, accounting for authors' intent, evaluating evidence presented in the text, and judging the relevance and usefulness of each text for the task at hand. These additional dimensions of reading in authentic situations call for additional levels of representation beyond those constructed from single text reading. Three additional levels of representation have been proposed, two that represent the content (*integrated model* and *intertext model*) and one that controls the reading activity (*task model*). The integrated model level represents a reader's global understanding of the situation and phenomena described across texts, rather than from a single one. It comes about through creating inferences and interrelations across texts, and evaluating content (see for discussion Bråten, et al., 2011; Goldman, 2004; Rouet & Britt, 2011; Wiley & Voss, 1999). One challenge to synthesizing texts in these authentic learning situations is the presence of contradictory or incompatible information that commonly occurs when reading multiple sources that often reflect different perspectives.

The intertext model level is a representation of sourcing information, or information *about* its creation (e.g., who created the information, when, for what purpose, from what perspective) as well as connections between content and the sourcing information (e.g., which content came from which information source) and among information sources (e.g., information sources agree/disagree on what content points) (Perfetti, et al., 1999). Attention to the intertext model is especially important when reading within disciplines because developing one is a common expert practice; the intertext model is especially important in detecting, evaluating, and resolving apparent conflicts among information sources and expectations based on prior knowledge or accepted canon in the discipline. College undergraduates who spontaneously source develop higher quality integrated models as assessed by within and across text inferences and written essays (Bråten, Strømsø, & Britt, 2009; Goldman, Braasch, Wiley, Graesser, & Brodowinska, 2012; Strømsø, Bråten, & Britt, 2010; Wiley et al., 2009) and allow contradictory information to coexist in a global representation (Braasch, Rouet, Vibert, & Britt, 2012; Stadtler & Bromme 2014).

The task model level reflects the reader's understanding of the goals for reading and useful strategies or plans for achieving these goals (Rouet & Britt, 2011). It guides the creation of the integrated and intertext model levels when reading multiple sources.

Reading within disciplines can be viewed as a highly iterative set of processing steps: (1) creating a task model to represent the main goals, strategies, and criteria required to accomplish the reading task; (2) deciding whether information is needed from additional information sources; (3) evaluating the relevance of text segments and creating inferences within and across texts to create an integrated model guided by one's task model; (4) creating and updating one's task product such as an essay; and (5) evaluating whether the task product meets the goals or whether the goals or product need to be adjusted. Each of these steps implies decision-making criteria that reflect knowledge of the discipline beyond content knowledge. For example, creating a task model as well as evaluating whether the task product meets the goals both depend on having criteria for what constitutes an adequate product in that discipline.

Disciplines as communities of practice. The second focus our definition of reading for understanding highlights disciplines as communities of practice (Lave & Wenger, 1991), each of which has negotiated norms and conventions that shape knowledge claims and argumentation within each disciplinary community (See discussions in Applebee, Langer, Nystrand, & Gamoran, 2003; Bricker & Bell, 2008; Driver, Newton, & Osborne, 2000; Gee, 1992; Goldman & Bisanz, 2002; Lee & Spratley, 2010; Moje, 2008, 2015; Norris & Phillips, 2003; Osborne, 2002; Wineburg, 2001). However, the nature of the norms and practices differs across disciplinary communities as does the nature of the evidentiary process. In other words, what is taken as claims, evidence or principles, and the criteria for valid arguments or explanations differs from discipline to discipline (Moje, 2008). Furthermore, there are different purposes of argument (e.g., explanation, evaluating alternatives, proposing policies) that coincide with differences in the evidentiary process that is entailed (Braaten & Windschitl, 2011; Hillocks, 2011; Megill, 1989). These differences may explain research findings indicating that reading practices as well as the types of texts being read, differ from discipline to discipline (e.g., Langer, 2011; Lee & Spratley, 2010; Shanahan & Shanahan, 2008). Of course, there is also a great deal of variation within disciplines and sub-disciplines, and interdisciplinary work is more and more the norm. However, it is important from an instructional standpoint to make students aware of the appropriateness and indeed the need to vary reading practices depending on task and text (Goldman & Lee, 2014; Valencia, Wixson & Pearson, 2014). At the same time, evidence-based argumentation is a common and relevant structure that can be referred to across disciplines and across topics within disciplines. Thus, it has the potential to facilitate students' understanding of similarities as well as differences across different domains of study by examining constancies and variations.

Designing interventions: Instantiating expanded model of reading in discipline-based inquiry learning.

In the READI project, researchers collaborate with teachers to design interventions in each of the three content areas. In both literature and history, a focus on disciplinary texts is viewed as part and parcel of the discipline. Although text is often eschewed by science educators, text-based inquiry is authentic to the sciences. Scientists consult prior research to inform proposed research and interpret their findings. They also represent the data they gather in various visual representations, such as tables and graphs, and they create texts to communicate their own findings with other scientists (Goldman & Bisanz, 2002; Greenleaf, Brown, Goldman & Ko, 2013; Osborne, 2002; Pearson, Moje, & Greenleaf, 2010).

At the same time, we were well-aware that we were aiming for *classroom disciplinary communities* that were at developmentally appropriate levels. The interventions were anticipated to include inquiry tasks, sets of text materials that provided information that could address the inquiry tasks, and scaffolds that could help students develop the needed literacy and inquiry practices and skills. One of the posed but unanswered issues concerned the determination of developmentally appropriate levels of complexity and how that complexity ought to increase across a year and across multiple years of schooling.

A Methodology for the Design of Learning Goals for Instruction

As we thought about how to design learning environments across the three disciplines, we engaged in thought experiments about what a student would need to know to be able to demonstrate proficiency on particular standards such as those in the Common Core, the NGSS, the C3, or comparable standards in other nations (see OECE (2013b). In science, for example, Common Core Science Literacy Standard 9 for 11-12th grade states "*Synthesize information from a range of sources (for example, texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible"* (CCSS, 2010). Our thought experiment in this case suggested that, in addition to some fundamental content knowledge of the topic, they would need to know how to read and interpret data displays in multiple forms, as well as criteria for judging whether or not information conflicted including perhaps the concept of random error and replication, and an understanding of the tentative status of the knowledge base. These we defined as constituting literacy and inquiry practices of science as relevant in the age span with which we were concerned. Our conclusions from parallel thought experiments in the other disciplines were similar.

Across the three disciplines, we realized that we needed a way to think comprehensively about what students needed to know and thus where to focus instructional efforts. Consistent with the goal of providing a unifying framework however, we also strove for a level at which to represent the similarities across the disciplines. We refer to the effort we undertook as a conceptual metanalysis of extant theoretical and empirical work in each domain, drawing on expert-novice research as well as developmental and educational research in literary reading, history, and science. As such these metanalyses bear a family resemblance to what Mislevy, Steinberg, and Almond (2003) refer to as "domain analysis." We came to think of our process as a design methodology not for the creation of learning environments as in design-based research (e.g., Barab, 2006; Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003) but for the creation of the learning goals of instruction--i.e., the knowledge about the discipline and inquiry processes related to reading that we wanted students to master. We organized teams in each disciplinary area to conduct the conceptual metanalyses. These teams were interdisciplinary and professionally diverse, consisting of university-based researchers in the learning sciences, education, and psychology; curriculum and professional development designers and researchers; disciplinary experts; and collaborating classroom teachers. Each team reflected expertise in the disciplinary content area, the teaching of that discipline, and research on text-based learning in that discipline. For example, one member of the science team had previously worked as a research chemist at a Research I University before becoming a teacher and then moving into the roles of curriculum designer and staff developer. One of the members of the history team had earned a Masters in History and had been a history teacher and then department head for 25 years prior to joining the project. Teams consisted of 12 to 15 members, with between 3 to 5 members also participating in at least one other team. In addition, as our analyses proceeded and questions emerged, we consulted with various scientists, historians, and literary critics to help us think through specific conundrums.

Each team carried out a literature search and critical review of recent publications that discussed sociological and historical analyses of the three disciplines, work in the learning sciences, empirical studies of discipline-specific practices, meta-analyses and frameworks for discipline-specific instruction, and empirical studies of interventions aimed at improving discipline area instruction. Teams met three to four times per month over a period of 6 months, with cross-team meetings occurring once a month. Discussions occurred over almost every concept involved in the work, including evidence, claim, argument, reasoning, reading, text, and so on. Additional details of this work are provided below in discussing each discipline.

What emerged from the conceptual metanalyses of each of the READI disciplinary teams were discipline-specific clusters of types of knowledge critical to comprehending, constructing, and conveying evidence-based arguments from multiple sources of information. We organized the clusters for each discipline into five higher-order categories of what we called disciplinary *core constructs*: (1) epistemology; (2) inquiry practices/strategies of reasoning; (3) overarching concepts, themes, and frameworks; (4) forms of information representation/types of texts; and (5) discourse and language structures (see Table 1). Over the course of our work with these constructs, we came to see epistemology as central, providing purpose and motivation to the ways in which inquiry was conducted, the reasoning principles that were invoked, and the forms in which information was represented, expressed, examined, and critiqued, and negotiated in and through oral and written discourse and language structures. In subsequent sections of this paper, we elaborate the core constructs for each of the three disciplines, including reviews of the theoretical and empirical literature we examined as part of the metanalysis process.

The applicability of the five categories of constructs to each discipline allowed us to capture cross-discipline similarities whereas the instantiation within each discipline reflected differences in argument structure with implications for reading and reasoning processes and the task, intertext, and integrated model levels of representation. That is, across disciplines a general definition of argument includes use of information and rhetorical devices (e.g., facts, concepts, principles, symbols, metaphors) to make claims supported by evidence, where the warrant connecting the claim and evidence is a general rule or principle (Toulmin, 1958). At the same time the facts, concepts, principles, nature of the information, rhetorical devices, nature of the claims and relevant evidence reflect deep and important disciplinary differences in the core content areas for students in grades 6-12. The core constructs provided the basis for defining developmental targets for grade bands beginning with sixth grade and postulating the sequencing and progressive deepening of inquiry strategies and reasoning using overarching concepts and frameworks within a school year as well as over multiple years of instruction.

Connecting Core Constructs to Expanded Model of Reading: Learning goals for reading and reasoning

The conceptual metanalysis also surfaced reading and reasoning processes that are challenging for students but that are critical to developing the three additional levels of representation needed in multiple source reading situations, namely, the task, intertext, and integrated models as specified in the expanded model of reading described above. The core constructs helped us define the knowledge about the discipline and reading in the discipline that adolescent readers need to use to create each level of representation specified in the expanded model of reading, including content levels (surface, textbase, situation model, integrated model, and intertext model) and the task model level. For instance, to create a discipline appropriate task model, the reader has to have functional knowledge of what counts as knowledge (epistemology), strategies of reasoning, overarching frameworks, schema for and knowledge of relevant genre and language structures. This knowledge can then be used to create the goals, strategies, and criteria for success (i.e., task model) for the inquiry task.

We formulated a set of learning goals by connecting reading and reasoning processes with the disciplinary specifications of the core constructs. We provide general statements of these in Table 2 and discuss them in more detail within each disciplinary section. Each process goal references specifics of the discipline in which it is being enacted. Learning objectives 2-5 represent the set of reading and reasoning processes that a competent reader will use to create and carry out discipline appropriate text-based inquiry task models. Goals 1 and 6 will support the selection of strategies and criteria for accomplishing these goals. For example, close reading supports a variety of subgoals in the task model, including attending to verbatim representations (surface level), using prior knowledge to create inferences within (situation model) and across texts (integrated model), and comparing perspectives (intertext model). Discipline-appropriate epistemology influences both the interpretation of task instructions to form a task model and evaluations of whether the task-as-interpreted has been completed. For example, when the task involves using information from a text as evidence for a causal claim, readers need to invoke discipline-appropriate definitions and criteria for causal claims, evidence, and relevant information.

We now turn to reporting in more detail the nature of the conceptual metanalytic review we did in each of the three disciplines and the core constructs and learning goals that emerged from these reviews. In each discipline we interrogated theoretical and empirical literature on the nature of argumentation in each discipline and how experts and specialists engage in reading and reasoning in the context of authentic inquiry tasks in their disciplines. In addition, we drew on empirical reports of the ways in which adolescents and adults naïve to the discipline (novices) engage in text-based inquiry. Finally, we looked at the types of instructional intervention studies that have been conducted with adolescents for evidence regarding loci of challenge and instructional supports that appear to address these challenges as a means of gaining insight into the learning goals and core constructs. We conclude the paper with a discussion of how the learning goals and core constructs have influenced and been influenced by our instructional design, work with teachers, and research efforts.

Literary Argumentation and Inquiry Processes

The research base documenting what is entailed in comprehending and interpreting literature draws from several traditions: literary theory and criticism; psychological studies of narrative processing; and empirical studies of literature, in particular studies of the comprehension and interpretive processes employed by novice and expert readers of literature (Lee, Goldman, Levine, & Magliano, 2016). The core constructs articulated by the literature team have a scope and focus that have not been articulated in standards available to middle and high school teachers, including standards documents such as the College Readiness Standards (American College Testing, 2006) and the Common Core State Standards (CCSS0, 2010). One key difference is our focus on not only what students need to do (e.g., examine characters, interpret symbols, etc.), but equally on articulating important discipline-specific strategies for examining and evaluating literary texts. Furthermore, the Common Core State Standards indicate that *Standard 8: Delineate and evaluate the argument and specific claims in a text* is “not applicable to literature” (CCSSO, 2010), a claim that our analysis contradicts.

Project READI views argument structure in literature from two perspectives. The first has do with the competencies readers need to notice rhetorical and structural moves prototypically made by authors to convey meanings and make their argument, so to speak. Rabinowitz (1987) argues that literary authors assume that their readers share knowledge of these prototypical “rules of notice.” Depending on the critical tradition from which the reader works to make sense of the literary text, analyses of those rhetorical moves and structures can lead to very different interpretations about authorial intent (or may lead the reader to reject authorial intent altogether). The second perspective on argumentation has to do with what students who are learning to interpret literary texts need to know and be able to do to construct oral and written arguments regarding their interpretations. These two perspectives on argumentation were driven by the READI literature team's examination of the research in areas of rhetoric, literary theory and literary criticism, and the teaching and learning of literary interpretation (e.g., Appelman, 2000; Booth, 1974, 1983; Dixon & Bortolussi, 2009; Hillocks, 2011; Langer, 2011; Lee, 1995a, 2007; Lee & Spratley, 2010; Rabinowitz, 1987; Scholes, 1985; Smith, 1991; Smith & Hillocks, 1988). An extended, iterative process of proposing and revising the core constructs took place and resulted in the core constructs specifying strategies for literary inquiry.

Review of Empirical Findings

For the purposes of articulating the core constructs that would inform instruction for novices, it was particularly important to take into account what the extant literature suggests about differences in how experts and novices approach and engage in literary reasoning. Such studies typically involve the use of talk aloud protocols where participants are asked to read either a short story or poem and to talk out loud about (sometimes concurrently, sometimes retrospectively) what they are understanding and what they are doing to make sense of the text. In such studies, experts are generally professionals in the field (e.g., secondary English teachers, college literature professors, or advanced undergraduate or graduate students majoring in literary studies) (e.g., Graves & Frederiksen, 1996; Olson, Duffy, & Mack, 1984; Peskin, 1998, 2010). Novices are generally undergraduate college students not majoring in literary studies, high school students, or in some instances middle school students; novices can also be distinguished by degree of skill (Hynds, 1989; Janssen, Braaksma, & Rijlaarsdam, 2006; Strang

& Rogers, 1965). One issue that needs to be taken into account in any efforts to extrapolate across studies is the differences in the kinds of comprehension and interpretive problems posed by the texts. In Project READI we have tackled this problem of text complexity within the broader conception of the disciplinary comprehension problem space as entailing dynamic relations among characteristics of the reader, the text, the task, and the context (Goldman & Lee, 2014; Lee & Goldman, 2015; Valencia, et al., 2014).

Both novices and experts attend to issues of plot and character; even young children pay attention to what characters do and why, as well as to the "so what" or coda of narratives (Goldman, Reyes, & Varnhagen, 1984; Stein & Glenn, 1979; Trabasso & van Den Broek, 1985). The attention to the "so what" of stories suggests that both novice and expert readers seek to figure out what stories tell them about themselves as readers, about people, and about the world. This attention to the psychological states that stories or narratives can engender has also been documented in studies of the role of emotion in sense making and literary meaning making (Dijkstra, Zwaan, Graesser, & Magliano, 1995; Goetz et al., 1992; Levine & Horton, 2013; Zajonc & Marcus, 1984). This may include both the emotional stances readers bring to texts with regard to the kinds of characters they meet or the kinds of conundrums these characters encounter (Hynds, 1989), as well as the ways that language rich with emotional valence draws the reader's attention (Jakobson, 1987; Peer, Hakemulder, & Zyngier, 2007). Both novice and expert readers recruit emotions in acts of comprehension and interpretation.

Studies of adolescent readers have been useful because distinctions between competencies demonstrated by college students versus literary experts do not necessarily help us understand competencies and dispositions before students enter college. Studies of what adolescent readers do as they work to comprehend and interpret literary works show evidence that they–as one would expect–do attend to basic and literal features with regard to character and plot, examine motivations of characters, extrapolate thematic abstractions, and attempt to connect what they take from stories to life (Hynds, 1989; Janssen, et al., 2006; Squire, 1964; Strang & Rogers, 1965). However, these studies also introduce important variables that influence the frequency and depth with which adolescents engage in these meaning making processes. For example, Strang and Rogers (1965) compared high and low achieving 11th grade students and found that the high achieving readers understood implied meanings through symbolism and other uses of figuration, attributed significance to titles, and examined mood and point of view, whereas the low achieving readers did not. Together, these studies suggest a range of factors that differentiate the competencies in literary reasoning demonstrated by adolescents: differences in general reading ability and academic standing (Janssen, et al., 2006; Strang & Rogers, 1965), the complexity of readers' understanding of psychological constructs around reading the internal states of people (Hynds, 1989), attitudes toward reading in general and literature specifically (Squire, 1964), and broader dispositions with regard to motivation, identity, prior perceptions of issues related to themes and characters (Janssen, et al., 2006; Petrosky, 1976; Purves & Beach, 1972). The differential impact of these individual differences on the focus, scope and depth of processing of literary texts supports the broader proposition taken up by Project READI that understanding and influences on competencies in comprehension must take into account reader-text-task-context relationships, including how these relationships are influenced by the demands of comprehension and argumentation within disciplines. These studies of adolescent readers of literature also document the range of generic reading strategies adolescents employ and the functions such strategies play in comprehension.

However, expert readers draw in more elaborate ways on the language and structure of the text than novice readers, especially with regard to attention to features of language that may signal emotional valence (Gevinson, 1990; Peer, et al., 2007; Peskin, 1998). Levine (Levine & Horton, 2013) demonstrated how pedagogical strategies that focused attention on markers of emotional valence expanded the depth of interpretation that novice readers were able to generate. Hynds (1989) documented differences in how the complexities of adolescents' conceptions of the psychological complexity of their peers related to the depth of their interpretations of characters in literary works and their abilities to generalize from the story to the world outside the text.

Overall, there are several important distinctions that have been established in the literature about differences in the range of knowledge on which expert readers draw and the conception of the tasks of literary interpretation that distinguish novice and expert readers (Goetz et al., 1992; Graves & Frederiksen, 1996; Miall & Kuiken, 1994a, 1994b; Peer et al., 2007; Peskin, 1998; Zeitz, 1994). Expert readers are more likely to draw on inter-textual links to understand characters and theme. They are more likely to warrant their claims not only on evidence from the text but from literary constructs and theories. They are more likely to construct multiple interpretations of the text. They are more likely to attend to what Hillocks (Hillocks & Ludlow, 1984) calls structural generalizations--that is, attention to the choices authors make with regard to language, rhetorical moves and structure. They are more likely to examine the historical contexts of both the plot and the historical period in which the work was written.

Literary argumentation–like other formal models of argumentation–entails supporting claims with evidence, reasoning to support the evidence, warrants that provide credibility for the reasoning, and the response to actual and anticipated counter claims (Toulmin, 1958). What makes literary argumentation different however, is that the kinds of generative problems about which experts are more likely to raise claims are broad (e.g., claims about personal relevance; about structure, rhetoric, or theme; about connections to other texts and authors, or other texts by the same author; about connections to historical, political, social, or ideological positionings; about connections to literary or critical theory). Warrants and reasoning in literary argumentation can be grounded in personal beliefs and life experiences, in critical theory, in rhetorical theory, in philosophical tenets. Furthermore, the criteria for making judgments about such warranting are always open to contestation. Thus, the toolkit or meaning-making repertoires that middle and high school students need to develop in order to enter this problem-solving space require the skill sets and dispositions that are more reflective of what a range of expert readers bring to the enterprise. Without such a repertoire, novice readers, especially in middle and high school, are more likely to reject the value of complex literary texts out of hand, rather than being enticed by their complexity.

Thus, these expert-novice studies suggest that novice and expert readers share certain repertoires that clearly constitute basic meaning making processes entailed in comprehending and interpreting literature at the textbase and situation model levels of meaning. However, these studies also clearly document significant differences in the depth of knowledge expert versus novice readers bring as well as differences in conceptions of what literature invites readers to do (e.g., examine language, rhetoric and structure, connect to other texts and other authors, situate the problems the text poses with regard to literary theory and traditions of criticism, to warrant claims with theory). These differences have implications for the expanded model of reading that includes task, intertext, and integrated model levels discussed previously.

Instructional research demonstrates that the explicit teaching of literary heuristics can improve the literary analytic skill set of novices at these grade levels (Appleman, 2000; Lee, 1995a, 1995b; Peskin, 2010; Peskin, Allen, & Wells-Jopling, 2010; Smith, 1989, 1991). The READI core constructs and pedagogical design build on this extant body of work by expanding the range of competencies to be developed and generalizing a model of the demands of teaching particular comprehension strategies explicitly (Smagorinsky & Smith, 1992) along with epistemologies, patterns of discourse and rhetoric, and knowledge of genres (Lee, 2007).

We do not seek in this work to suggest that all students should become professional critics, but rather to suggest that the habit of reading literature as a life long disposition holds great potential for supporting people's development as humans (Holland, 1975; Mar, Peskin, & Fong, 2011). Furthermore, having a rich repertoire of knowledge, strategies and dispositions opens up more expansive opportunities for engaging with a wider array of literary texts within but also beyond school. The literary reading core constructs discussed in the next section are derived from our review of the nature of the discipline, the expert-novice research, and studies of adolescents' challenges in learning.

Literary Reading Core Constructs

Epistemology. Epistemological orientations to literary interpretation entail several dimensions (Lee, et al., 2016). One dimension privileges literature as a window into interrogating the human condition and the world in which we live, including the social, political economic, and cultural contexts of the human experience. Literature provides a terrain for interrogating the meanings of human experiences through archetypal themes and examinations of the psychological states of character types; and through the examination of worldviews that embody propositions about the ideal and the moral. A second dimension involves viewing literary texts as open to dialogue, privileging interrogating presumed authorial intent, valuing communities of readers who dialogue with one another within and across time. Third, a literary epistemological orientation values attention to both content and form as these work together to convey meaning. Much of literary criticism investigates how decisions by authors regarding structure and language use influence meaning.

Inquiry practices and strategies. Expert readers use a variety of strategies to construct arguments about the meanings of literary texts. This focus on strategies for constructing interpretations is typically not reflected in standards for literature (Grossman, 2001; Lee, 2011). Rabinowitz (1987) collapsed these strategies into 4 categories: (1) rules of notice where the reader draws upon knowledge of literary rhetorical traditions to notice signals in the text that are important (e.g., privileged positions like titles, repetitions, contrasts, etc.); (2) rules of signification–the knowledge on which the reader draws in order to impose significance or meaning to that which is noticed (e.g., who is speaking; does what is said represent the author's presumed point of view; assessing evidence on which we base moral and ethical judgments about characters such as names, physical appearance, actions that are morally linked, allusions to other texts, etc.); (3) rules of configuration–strategies readers use to make meaning as they are reading stretches of text and making hypotheses; and (4) rules of coherence–what readers do after reading the full text to confirm hypotheses and construct holistic interpretations. Rabinowitz (1987) argues that this family of "rules" constitutes the knowledge readers bring before they open a book and that authors assume readers will bring this knowledge.

Overarching concepts and frameworks. The focus of literary interpretation involves comprehending characters, their internal states and motivations; plot in terms of causal links among actions in the plot, setting, and what in the story grammar literature (Trabasso & van den

Broek 1985) is called the coda--the “so what,” or the theme. These targets of interpretation can be explicitly stated or may need to be inferred. Literary interpretation involves problems of point of view, including who is talking, whose point of view is being represented, is the narrator reliable (Booth, 1983); problems of figuration, including symbolism, irony, and satire (Booth, 1974; Ogborn & Buckroyd, 2001; Peskin, et al. 2010); and problems of structure at the macro level and micro level. Macro level problems of structure are typically thought of as genres, but in READI we included plot configurations (e.g., magical realism, the fable, mystery, etc.) and character types (e.g., the trickster, the tragic hero, the detective, etc.) (Smith & Hillocks, 1988; Smagorinsky & Gevinson, 1989). At the micro level, problems of structure include ways of creating suspense or oppositions,as well as problems of rhetoric such as language choice, repetitions, alliteration, oxymoron, etc.. (Fabb, 1997; Jakobson, 1987; Peer, 1991; Steen, 1999).

The overarching concepts and frameworks of literary reading capture knowledge on which readers draw as they construct interpretations of literary texts. This includes their belief systems with regard to what dimensions of a text or of the reader’s beliefs should take center stage in acts of interpretation. These belief systems include moral, philosophical, and religious content and archetypal themes. The historical contexts of settings and time period when the work was produced also assist in providing interpretive context and contribute to the intertext level. Also contributing to the intertext level are readers’ commitments to traditions of critical theory and theoretical orientations such as reader response, feminist, new criticism, black aesthetic or post structuralism. The integrated model level reflects the fact that intertextuality also provides an important framework for interpretation in terms of valuing relations among literary texts; among literary texts and texts of literary criticism; among literary texts and related historical, philosophical, sociological, etc. texts.

Types of Text Structures. There are also prototypical ways of structuring texts to represent literary information that invokes particular expectations about events and characters. These structures refer to types of plots and characters around which a narrative is structured. Sometimes the story is driven by the type of plot structure; other times it may be driven by the character type (Hillocks, 2016). Identifying a plot structure such as science fiction, fables, satires, myths, or magical realism allows readers to activate anticipations about what to expect in the narrative. For example, with magical realism, readers are likely to encounter ghosts or other fantasy, but these are likely to be symbolic and not intended to be read as one would in a ghost story. Likewise, recognition of excessive hubris in a character will lead the experienced reader to expect some tragic consequence, to anticipate the character potentially as a tragic hero.

Discourse and language structures. Discourse and ways of using language are particularly important to literary interpretation and argumentation. This refers to the rhetoric of literature: how an author's selection and sequence of action, dialogue and description create an imaginary world into which the reader is invited through the manipulation of language. In literary interpretation, relations among language, structure, and content are essential. The language of literature often includes imagery and other forms of figuration (e.g., metaphor, simile). It is important to note, however that some authors choose to use very stark and lean language, such as Hemingway. Figuration encompasses language uses to invite a figurative interpretation beyond the literal through, for example, symbolism, irony, or satire. Problems of point of view involve who is speaking (e.g., omniscient narrator, unreliable narrators, and multiple narrators) and their reliability, as well as the relation of narrator's point of view to the author (Booth, 1974). Finally, the focus on language and discourse structures includes attention to rhetorical patterns within and across the text. The significance of particular elements of the text is often only apparent as such patterns emerge. For example, typical rhetorical patterns include parallelism, contrast, repetition, understatement, exaggeration, allusion, and privileged placement. The reliability and significance of an interpretation based on particular types of evidence is strengthened when such patterns are discernible.

Learning goals. Hillocks and Ludlow (1984) developed and empirically validated a taxonomy of comprehension questions for fiction that range from the literal, to the inferential to the interpretive. The two most challenging tasks in the hierarchy are what Hillocks calls author generalizations and structural generalizations. They are interpretive tasks that require the reader to draw from across the range of knowledge we have identified in the literature core construct framework (e.g., epistemology, knowledge of text types, discourse and language, literary strategies, etc.). Author generalizations are generalizations the reader presumes the author makes about the world beyond the text, or what is typically referred to as theme. Structural generalizations focus on explaining how decisions made by the author with regard to organization, language, and rhetorical choices contribute the meanings the reader derives from the text. The literature goals for Project READI focus explicitly on supporting students in developing the knowledge and dispositions represented in the framework to be able to address author generalization and structural generalizations about individual texts, and as comparisons and contrasts across texts (see Table 3). These are areas that the literature reviewed previously indicates distinguish expert from novice literary readers and are challenging for adolescents to learn at least under conditions of traditional instruction (Sosa, Hall, Goldman, & Lee, 2016).

In literature team discussions, the characterization of the difficulty of literary texts emerged as a key issue (Goldman & Lee, 2014; Lee & Goldman, 2015). We came to recognize that quantitative measures for assessing complexity of texts, such as lexiles or coh-metrix dimensions such as coherence, narrativity, and syntax (Graesser, McNamara, Louwerse & Cai, 2004), seem less appropriate for capturing the challenges of literary texts than for capturing text complexity in other disciplines. We see this as related to the importance in literary interpretation of recognizing patterns in word, phrase, or image use that occur and re-occur over multiple segments of a text and that are not discernible from a focus simply on adjacent sentences or paragraphs. As well, conceptually complex ideas (e.g., valor, cowardice) may be conveyed in relatively simple words and sentence structures.

In summary, the instantiation of the six READI learning goals for literary reading reflect an explicit focus on *literary* argumentation. This focus helped differentiate the knowledge, skills, and practices READI wished to focus on from generic *persuasive essays*, a common way in which argumentation often finds its way into literature classrooms (Newell, personal communication, 2014). Furthermore, making explicit the reasoning that justified the use of specific segments of text as evidence for particular claims about themes, messages, or symbolic interpretations turned out to be a major source of difficulty for students. We found that it required repeated opportunities both oral and written for students to develop this aspect of argumentation (Sosa, et al., 2016), supported by starting with culturally familiar and relatively short literary pieces (Lee, 2007). Metacognitive conversations about how these processes occurred in these pieces was a key aspect of preparing students to use them with longer and less familiar literary works (Lee, 1995a, 2001).

Scientific Argumentation and Inquiry Processes

Science is fundamentally focused on explaining the natural and designed worlds (Rutherford & Ahlgren, 1990). Although there are many sub-disciplines within science and many different traditions of inquiry, science knowledge develops as scientists accrue evidence for and against potential explanations of science phenomena and communicate and justify their explanations in communities of similarly engaged scientists. These scientific argumentation processes encompass generating plausible claims, providing evidence for or against candidate claims, providing lines of reasoning, and convincing others through use of evidentiary support to account for phenomenon (Berland & Reiser, 2009; Ford & Wargo, 2012; Ryu & Sandoval, 2012). As scientists communicate the results of their experiments or observations in the form of models and/or explanations, they must argue for the viability of their understandings by demonstrating how well their explanatory models fit the data, by drawing on and connecting their results to the existing body of science principles, and by considering alternative explanations and showing why they are less accurate, powerful, useful, or parsimonious (Bricker & Bell, 2008). Explaining, justifying, evaluating, and challenging one another's ideas are thus central to scientific practice (Braaten & Windschitl, 2011; Chin & Osborne, 2012).

Scientists engaged in inquiry processes use multiple semiotic forms (e.g., graphs, data charts, exposition) to represent their ideas and build models and explanations of the phenomena they study (Cromley, Snyder-Hogan & Luciw-Dubas, 2010; Goldman & Bisanz, 2002). Valued epistemic tools for generating scientific knowledge include both primary data resulting from scientists' own investigations and data collection activities and secondary data derived from extant data and the work of other scientists, including texts such as graphs, data tables, and scientific models. Scientists understand that it is through this recursive practice of generating and revising models and explanations based on evidence and counter evidence that robust scientific knowledge accumulates. Thus, inherent in the epistemology of science is its tentativeness: extant theories, models, and explanations reflect the best accounts given the results of inquiries to date; but these are expected to change with new inquiries.

The Next Generation Science Standards (NGSS Lead States, 2013) are the latest reform effort in the USA to focus science education on deeper understanding of content as well as its application and to reflect the nature of science as it is practiced and experienced in the real world. The NGSS envisions a set of crosscutting concepts as well as practices of science and engineering to advance over the grade levels and topic areas in science and engineering education. The NGSS underscores argumentation as a central practice of science learning–an emphasis on articulating claims, entertaining alternative explanations, and providing evidentiary support. This requires shifting students from learning *about* science ideas to figuring out *how* and *why* phenomena occur, and finding the evidence that supports these claims. In this reform vision, as learners participate in scientific practices such as exploration, modeling, reasoning, reading what others have found, and writing what they themselves find, they gradually gain access to the language, norms, and habits of mind of the scientific community (Lave & Wenger, 1991; Latour & Woolgar, 1986). To do so, they require various kinds of sophisticated literacy skills, including the ability to make sense of scientific terminology; interpret arrays of data; comprehend scientific texts that convey information in "verbal" expositions as well as in graphs, tables, visual models, and diagrams; to use and interpret models and illustrations, and to read and write scientific explanations (Lemke, 1990; Osborne, 2002). The NGSS and the CCSS are thus aligned in calling for engaging students in authentic science practice, both in the context of first-hand investigations as well as in the context of working with and producing texts in science classrooms.

The READI science team used the abundant existing research and theory regarding the nature of science and scientific argumentation to inform the identification of core constructs in science. In this effort, we referenced the science education, science literacy, and science learning progressions literatures for guidance on various dimensions of the core constructs (e.g., epistemology, inquiry practices, discourse, and working with multiple representations) (e.g., Berland & McNeill, 2010; Cavagnetto, 2010; Corcoran, Mosher & Rogat, 2009; Goldman, Braasch, et al., 2012; Gotwals, Songer & Bullard, 2012; Lehrer, 2009; Radinsky, Alamar, & Olivia, 2010). We engaged in an extended iterative process of proposing and revising the functional definitions and illustrations of the core constructs for science, consulting literature on development of key science principles, rhetorical analyses of science texts (e.g., Kerlin, McDonald, & Kelly, 2010; Lemke, 1998; Waldrip, Prain, & Carolan, 2010; Yore, Bisanz & Hand, 2003), the role of diagrams, models, and simulations in science learning (e.g., Schwarz, Reiser, Acher, Kenyon & Fortus, 2012; Stieff, Hegarty & Deslongchamps, 2011), and research on the literacy practices of science (e.g., Cervetti & Barber, 2008; Cervetti, Barber, Dorph, Pearson, & Goldschmidt, 2012; Goldman & Bisanz, 2002; Norris & Phillips, 2003; Pearson, et al., 2010; Phillips & Norris, 2009; von Aufschnaiter, Erduran, Osborne & Simon, 2008; Yore, et al. 2003).

Because the project aimed to deepen students' reading for understanding, we focused on inquiry practices related to reading and interpreting scientific texts, including data representations, diagrams, dynamic visualizations, and models, rather than also attempting to include the design of experiments and training for measurement and data collecting and analysis, which have been the focus of many other science reform projects. In other words, the core constructs of interest in the context of the READI project are those important to what Magnusson and Palincsar (2001) called "second-hand inquiry." However, given that the inquiry practices of many scientists involve analyzing or re-analyzing extant data sets (e.g., climate scientists interpreting ice core samples or satellite data they have not personally collected), our focus on text-based investigations reflects the commonality of scientific inquiry and argumentation practices. Ultimately the varied practices associated with text-based and hands-on investigations will need to be integrated and coordinated in science classrooms, as that is the way they operate in authentic scientific inquiry. Work with teacher collaborators will be especially important to efforts to do this.

Review of Empirical Findings

Studies of science argumentation show that students as early as elementary grades can productively engage in making claims about scientific phenomena and finding evidence to support those claims (Chin & Osborne, 2012; Ryu & Sandoval, 2012; Sampson & Clark, 2008). This research also shows that younger students have more difficulty linking claims and evidence than do older students, and thus need more support to make explicit the grounds for their explanations and understandings (Berland & Reiser, 2009; Manz, 2012; McNeill & Krajcik, 2012; Windschitl, Thompson, Braaten, & Stroupe, 2012). A typical approach in science education reform projects focused on supporting students to develop explanatory models has been to provide students with frameworks for explanation, modeling, and argumentation, using datasets or hands on investigations as stimuli for modeling and explanation tasks (Krajcik, Reiser, Sutherland, & Fortus, 2011; Linn & Eylon, 2011; McNeill & Krajcik, 2012; Passmore & Svoboda, 2012). Often these tasks engage students in representing information in tables and graphs as well as in extracting and interpreting patterns from visuals, but there is little explicit instruction in learning how to read such representations.

Very little of the work on modeling and explanation has been carried out in the context of science reading despite evidence that engaging with science texts does enhance sense making and critical analysis of science information. For example, Ford (2012) reported that simulating interactions between science authors and reviewers for a scientific journal can support scientific sense-making discourse. Norris, Stelnicki, and de Vries (2012) have shown that using adapted primary literature resembling scientific writing increases the use of critical thinking skills with writing. However, argumentation studies have focused almost exclusively on hands-on investigations.

Studies of adolescents' science argumentation skills have focused both on how they argue with one another in the course of creating evidence-based claims from data and on the structure of their arguments. It is common to find that students are not explicit in their justification for their claims (Bell & Linn, 2000; Jiménez-Aleixandre, Bugallo, Rodríguez, & Duschl, 2000; Kelly, Druker, & Chen, 1998). When they do provide explicit justification, they often rely on multiple forms of evidence and (e.g., personal experience and beliefs, empirical evidence, naïve conceptions of science) only some of which meet criteria for sound scientific arguments (Duschl, 2008; Erduran, Simon & Osborne, 2004; Sandoval & Millwood, 2008). They also focus on arguing for their own position rather than considering the positions their opponents might hold and providing counterevidence to those opposing claims. Instructional efforts to improve argumentation have relied on a variety of scaffolds including visualizations (paper/pencil or computerized) for linking claims to evidence that supports them (Suthers, Weiner, Connelly, & Paolucci, 1995; Toth, Suthers, & Lesgold, 2002), and coaching that models argumentative discourse moves (e.g., countering, asking for reason) (Kuhn, Zillmer, Crowell & Zavala, 2013). These efforts produce some improvements in students' arguments but difficulties in differentiating claims from evidence persist (see Jiménez-Aleixandre, 2008 for a review of older studies).

Reading for understanding in science instantiates the general model of multiple source reading comprehension described earlier. Students need to build robust integrated models of science phenomena from evidence and ideas in source materials of a variety of types. However, observational studies in science classrooms confirm that, particularly at the secondary level, science is taught through lecture, demonstrations, or textbooks that are designed to "deliver content" to students rather than actively engaging students in the work of making sense of science phenomena (Alozie, Moje & Krajcik, 2010; Cervetti & Barber, 2008; Chiappetta & Fillman, 2007; Duschl, 2008; McNeill, 2009; Myers, 1992,1997; Weiss, Pasley, Smith, Banilower, & Heck, 2003). Thus, students are socialized to scanning science texts for information rather than to engaging intellectually with texts to construct deep understanding or to using texts as sources for inquiry (Berland & Hammer, 2012; Norris & Phillips, 2003). Such reading activity tends to produce transitory surface and textbase level representations of text rather than situation models for individual texts and integrated models of science phenomena (Coté, Goldman, & Saul, 1998). Engaging students in the inquiry practices of science, using science texts as resources for inquiry, will require fundamental shifts in science instruction (Greenleaf, et al., 2013; Greenleaf, et al., 2011; Pearson, et al., 2010). As noted above, the core constructs discussed below are derived from our review of the various relevant literatures, including studies of what students find challenging.

Science Core Constructs

Epistemology. Our characterization of the epistemology of science emphasized the tentative and iterative nature of efforts to explain phenomena that occur in the natural world (e.g., Bråten, et al., 2011; Chinn, Buckland, & Samarapungavan, 2011). Specifically, the epistemology core construct for science describes it as an attempt to build understandings of the natural as well as designed (engineered) worlds through constructed models and theories that are approximations that have limitations. These understandings are socially constructed, using peer critique and public dissemination, to create explanations that are based on sound empirical data and that are parsimonious and logically cohesive. However, scientific findings are subject to revision over time and successive empirical efforts that reflect changes in technology, theories and paradigms, and cultural norms.

Inquiry practices and strategies. Consistent with the epistemology, science inquiry practices build scientific knowledge by developing coherent, logical explanations, models or arguments from evidence (e.g., Chinn & Malhotra, 2002; Duschl & Osborne, 2002). In practice, development of explanations and models entails consideration of what are the bounds of the phenomena and what elements and interactions should be included in an explanation of model. Evidence is subject to evaluation through processes of internal and external corroboration or convergence. In practice development of science explanations and models includes evaluation of reliability of evidence and consideration of which evidence to use. It also entails consideration of multiple forms of representations and models, evaluating which forms may best support explication of novel phenomena. Thus, arguments advancing or challenging an explanation or model may address the reliability of the evidence, the scope of evidence, the scope of explanation, the form of representation or model, as well as how it accounted for the evidence.

Overarching concepts, themes, and frameworks. Evidence is warranted and connected to claims through principles emanating from frameworks, key concepts, and themes that reflect unifying or general concepts and themes in science, sometimes called enduring understandings (College Board Standards for College Success, 2009). More recently the Next Generation

Science Standards (NGSS Lead States, 2013) identified cross-cutting concepts as well as disciplinary core ideas in life sciences; physical sciences; earth and space sciences; and engineering, technology, and applications of science. For example, cross-cutting concepts are patterns; cause and effect; scale, proportion and quantity; systems and system models; energy and matter in systems; structure and function; stability and change of systems.

Representational forms. Science uses a variety of prototypical ways of structuring and presenting scientific information. Representational forms include tables, graphs, equations, diagrams, schematics (e.g., flowcharts), simulations, models, and exposition and narrative in oral and written text (e.g., Cromley, et al., 2010; Lemke, 1998; van den Broek, 2010). Furthermore, there can be a variety of explanatory purposes for the represented information. These include the expression of cause/effect, correlation, problem/solution, sequence, comparison, exemplification, descriptive classification, definition, and proposition/support of an information representation. Lemke (1998) pointed out that multiple representational forms are necessary to adequately capture the variety of relationships and interactions scientists seek to describe (e.g., continuous change, covariation, categorical differences and classification, co-distribution, topological aspects of the world). He characterized language as being particularly well-suited for "the formulation of difference and relationship, for the making of categorical distinctions" but "poorer (though hardly bankrupt)" for capturing a variety of other types of relationships, including for example, quantity, continuous change, varying proportionality, and complex topological relations" (Lemke, 1998, pg. 89).

Furthermore, different genres of science information are written for different audiences and purposes, and these have implications for their content and structure (Goldman & Bisanz 2002). Examples of different science genres that are typically meant for those within the science community include raw data, bench notes, journals, personal communications (e.g., interviews, emails, conversations), refereed journal articles, integrative pieces (e.g., handbook chapters, review articles). Genres used for communication with the general public include press releases, news briefs, online articles, and other popular press pieces. Tradebooks, websites, and blogs may be intended for both audiences. Typical genres used in science education include informational texts that give background about a topic, laboratory procedures, websites, science journals written for student, and simulations. Although textbooks are probably the first genre that comes to mind when thinking about science education, we see these as problematic in that while they can provide background information, they tend to do so in a manner that does not support an inquiry stance toward science. Thus we are not advocating them as a primary genre for use in text-based investigations, although they may be useful in the same way that encyclopedias are useful. However, the plentiful diagrams, data tables, and models in science textbooks can be useful when positioned as resources for inquiry into a phenomenon.

Discourse and Language Structures. Prototypical language structures in science can be contrasted with the language structures of narrative, a genre that adolescents are highly familiar with. Science text tends to contain a much higher use of nominalizations, passive voice, technical and specialized expressions due to the compression and density of ideas conveyed as well as the high value placed on objectivity (Fang & Schleppegrel, 2010; Lee & Spratley, 2010). Science discourse also indicates the degree of certainty, generalizability, and precision of statements through specific lexical forms and expressions. Particular text structures are associated with specific genres and the organization of information and categories of information found within a particular discourse will reflect this. One form of scientific discourse that is particularly relevant in the present context is the explanatory argument and the particular linguistic features of it, including claims, scientific principles, and descriptions of methods used to establish the reliability of the processes used to create the evidence (Bazerman, 1998; Berland & Reiser, 2009; Cavagnetto, 2010; Driver, et al., 2009; Passmore & Svoboda, 2012). Each of these has particular conventionalized linguistic expressions for their communication.

Learning Goals. The six READI science learning goals are provided in Table 4. They convey the reading and reasoning processes of text-based inquiry as appropriate to the science core construct knowledge, skills, and practices. That is, these processes constitute text-based inquiry that enables students to figure out how and why a phenomenon happens and the evidence that supports these claims. Note that in our work with text-based science investigations we have particularly emphasized comprehending and constructing explanatory models of phenomena (see Braaten & Windschitl, 2011; Pluta, Chinn, & Duncan, 2011). These explanatory arguments correspond to the integrated model level in the expanded model of reading but rely on textbase and situation models level representations of single texts. They reflect our foregoing synthesis of the literature on science argumentation and the challenges adolescents experience in doing science inquiry and comprehending the representational forms and discourse of science.

Because text-based investigation in science is largely unfamiliar to teachers and students, the learning goals and core constructs were particularly helpful in designing semester-long instructional sequences. Students first learn to close read science texts, including graphs and models as well as traditional print, with attention to linguistic and visual conventions that have particular conceptual, evidentiary, and explanatory importance for scientific thinking and reasoning. These experiences create a basis from which to engage students in using texts to construct explanatory models. To support this process, an important part of the design of the instructional sequences was sequencing texts to support building explanatory models. Synthesis, construction, and justification from a sequence of texts involves conscious attention to ways in which information in successive texts changes conceptions of the how and why of phenomena and/or poses new questions that need to be addressed and for which information resources need to be found. A second design decision stemming from a clear explication of the learning goals, core constructs, and starting points with text was to focus on texts and text sequences that were complementary to one another and from which students would be able to build an explanatory model. Thus, to date our work has not involved having students engage with texts for purposes of deciding between alternative explanatory accounts for a phenomenon, between positive versus negative evaluative judgments about some science-related phenomenon (e.g., cell phones are or are not hazardous to health) or about policies related to politically sensitive issues such as climate change. Evaluative and policy arguments can take students away from the fundamental science and into socioscientific argumentation, where economic, social, political, moral, and ethical concerns often weigh heavily (Sadler & Donnelly, 2006). Although socioscientific argumentation is an important type of argumentation critical for decision making and policy evaluation, and we made a conscious decision to focus on explanatory arguments for science phenomena. Thus, READI text-based investigations address the fundamental science that science teachers are accountable for teaching in middle and high school science classes, including the reformulation of standards in terms of cross-cutting concepts and disciplinary core ideas (NGSS Lead States, 2013).

History Argumentation and Inquiry Processes

Historians read traces of the past to make sense of the past, whether that past is yesterday or centuries ago (Bain, 2005; Carr, 1987; Collingwood, 1994; Munslow, 1997; NCSS, 2013). These traces constitute the historical record but need to be recognized as human constructions and as such are open to interrogation and inquiry through historical thinking and reasoning processes (Leinhardt & Ravi, 2012; Seixas, 2010; Lee, 2005; Mink, 1980; VanSledright, 2011; Wineburg, 1991b). There exist many schools of historical thought, different sub-disciplines within history, differing philosophies on the degree to which a historian can be objective, and varying interests and theoretical orientations that shape a historian's particular inquiries and methodologies. Despite this variation, virtually all historians agree that the purpose of their discipline is the generation of interpretations, not the cataloguing of names, dates, and other "facts" (Charap, 2015; Hexler, 1971; Leinhardt, Stainton, Virji & Odoroff, 1994; Megill, 1989).

Experienced readers of history understand that the historical record reflects competing narratives about the past, recognizing that there is no one history. The reading of history is always characterized by uncertainty, alternatives, different perspectives, conflicting motives, and missing and misrepresented voices. Accordingly, inquiry into the primary sources that constitute the historical record requires readers to place singular events and artifacts in a larger historical context, make comparisons to corroborate viewpoints and information among sources, hypothesize cause and effect relationships, investigate interactions among events and people, examine the impact of competing forces, and separate fact from fiction and opinion and perspective to evaluate the credibility and reliability of different primary sources (Leinhardt & Young, 1996; VanSledright, 2011; Wineburg, 1991a).

Historians work from deep knowledge of particular historical time periods and analysis of the inevitably incomplete historical record to set forth compelling, evidence-based interpretations of the past. They work to avoid misinterpretation of the historical record resulting from by projecting concepts or ideas from the present onto ages past (Hexler, 1971). Nevertheless, historical interpretations reflect the perspective of whoever created the account, based on the historical traces available as well as those selected by the historian as significant, inferences made to connect the pieces, and interpretive claims proffered about the past. It follows that knowledge in history is contested and contestable, as interpretations of the past vary. And because history tells a tale of power and interests that are often in conflict, the voices and perspectives present and absent in the historical record or taken up in historical interpretations matter a great deal. These inherent epistemological characteristics of history underlie all five of the core constructs as well as what changes and develops as individuals move from immature to expert historians.

To inform the identification of core constructs in history, the READI history design team consulted existing research and theory regarding expert historical argumentation in conjunction with work conducted on the beliefs, thinking, reasoning, and writing processes of students ranging in age from 8 years to late adolescence/young adulthood (Ashby, Lee & Shemilt, 2005; Greene, 1994; Leinhardt & Young, 1996; Leinhardt, 1997; Leinhardt, Stainton, & Virji, 1994; Seixas, 1994; VanSledright, 2002; Wineburg, 1991a; 1998; 2001). The team also reviewed reports on the kinds of instructional situations that are associated with improvements in their evidence-based thinking and writing (e.g., De La Paz, 2005; Greene, 1994; Hynd, Holschuh, & Hubbard, 2004; Levstik & Barton, 2005; Monte-Sano, 2008; Monte-Sano & De La Paz, 2012; Nokes, Dole, & Hacker, 2007; Wolfe & Goldman, 2005; Young & Leinhardt, 1998).

Review of Empirical Findings

Studies of the inquiry processes of historians suggest that they engage with historical artifacts, documents and accounts using processes that students do not typically use (e.g., Andrews & Burke, 2007; Wineburg, 1991a). They classify historical items for identification and interpretation (Leinhardt & Young, 1996). They source; that is, they think about who the authors were, their purpose in writing, venue of publication, and intended audience and consider the implications of these for interpretation. They contextualize, situating these historical remnants in their time period and thinking about what was taking place at the time that may have influenced their construction. And they corroborate, seeing if the information across documents agrees or conflicts, is additive or redundant (Wineburg, 1991a). These routines give historians a sense of each document's perspective and allow them to interpret the event about which they were reading in light of the time period, the different perspectives that were present at the time period, the characteristics of the writer, the venue for the writing, and the purpose for writing, and so on.

Historians also judge the historical significance of events and artifacts, organize ideas chronologically and in terms of periods of history, identify continuity and change, analyze cause and consequence, take historical perspectives to make historically valid interpretations, and consider the consequences of the past for the present (Charap, 2015; Schreiner, 2014; Seixas, 2010; Seixas, Gibson, & Ercikan, 2015). They read and reread documents to construct interpretations and they read intertextually (Leinhardt & Young, 1996). They pay attention to the language in primary source documents and the way documents are structured to provide further insight into an author's position (Schleppegrell, Achugar & Oteíza, 2004; Shanahan, Shanahan, & Misischia, 2011). They consider language in its political context, for example, understanding that a writer who refers to the Civil War, or the War Between the States, or the

War of Northern Aggression is laying bare his or her perspective. In this interpretive work, historians draw on core disciplinary knowledge about historical episodes, social structures, and patterns across events or structures that serve as interpretive themes in the field in order to construct valued explanations (Geisler, 1994). The way historians typically read history is sophisticated and complex, but the way students typically read history without instruction is not. Students have naïve disciplinary understandings (Lee, 2005) and do not naturally approach reading texts using historical inquiry practices (Wineburg, 1991a). Many studies show that students tend to think about history as a body of facts to be extracted from texts without questioning their authority (Paxton, 1999; Stahl, Hynd, Britton, McNish, & Bosquet, 1996). They often read documents to gather information, often either not noticing inconsistencies (Stahl et al, 1996) or ignoring contradictory facts (Wineburg, 1991a) in an attempt to build a mental picture of events (De La Paz, 2005; Rouet, Favart, Britt, & Perfetti, 1997).

In addition, middle and high school students read texts without looking for similarities or differences across sources, fail to take into account information about the author, the date, and the context of documents, and read historical accounts as if they are factual information that needs to be remembered for the purpose of test-taking (Stahl, et al, 1996; van Boxtel & van Drie, 2012; VanSledright, 2012; Wineburg, 1991a). Even when they know something about the historical content, they lack the disciplinary knowledge or habits of mind to create sophisticated interpretations of what they read (De la Paz, 2005; Wineburg, 1991a, 1991b; Young & Leinhardt, 1998). Regarding multiple document reading, students have been found to draw from only the first two documents they read in preparation to write an essay, stay close to the texts when writing a factual essay (account), but ignore text information when asked to form an opinion (Stahl, et al., 1996). In other words, they do not seem to have a sense of how to use evidence from the texts they read to back up their claims.

These findings should not be surprising given that most history classrooms do not teach students to engage in historical inquiry practices or foster students' understandings about history as a discipline (Neumann, 2010; Nokes, et al., 2007). Traditional instruction in history classrooms tends to rely on history textbooks as the principal medium for learning facts about the past, positioning textbooks as an authoritative source containing uncontestable information (Paxton, 1999) and history as a chronology of events. However, empirical investigations of instruction that introduces students to reading and writing like historians have shown that students begin to acquire the inquiry practices of historians, moving from knowledge telling to knowledge transformation as they integrated and interpreted evidence for arguments (Young & Leinhardt, 2008). When taught specific historical thinking skills, students picked up on perspective, bias, and sourcing (e.g., De La Paz, 2005; Herrenkohl & Cornelius, 2013; Reisman, 2012; VanSledright, 2002).

As well, instruction of this type may positively affect students' epistemic cognition about history. Hynd, et al. (2004) found that college students who were taught to use these processes changed their epistemological views of history. Where they previously described historians as recorders of events, they ended up thinking that historians had to decide among different perspectives and that they put their own perspectives into the accounts of events. They also reported increased engagement in history reading. Taken as a whole, what we know about teaching the reading and writing of history suggests that students can be taught to engage in similar processes as historians do.

In Project READI we were working primarily to advance students' reading and reasoning, so we focused on historical thinking based on making sense of primary sources. That is, we took up historical reading as reading with the understanding that the documents were human constructions whose "probity" (Wineburg, 1991a, 1991b) should be interrogated. Some secondary sources were also used; traditional textbooks were used as additional sources of information but were not the central reading materials. Our work centered on multiple source comprehension and argumentation. Thus, the following core constructs of knowledge were developed based on our examination of the existing research about the discipline in order to identify the types of knowledge students would need to orchestrate in order to construct historical arguments from reading multiple sources.

History Core Constructs

Epistemology. History as ongoing argumentation reflects an epistemological stance that what we "know" about the past is provisional and incomplete (Bain, 2005; Carr; 1987; Lee, 2005; VanSledright, 2002). This stance perpetuates the need for rigorous, methodological practices that yield "accurate, though tentative" interpretations of the past (Hexler, 1971; Neumann, 2010, p. 491) rooted in close scrutiny of multiple information sources, especially primary sources that originate from the time period in question (Anderson, Day, Michie, & Rollason, 2006; Wineburg, 2001; Voss & Wiley, 2006). As such, any remnant of the past conveys a particular point of view or perspective on the event in question.

The practice of history is a continuous process of dialogic interaction between the historian and sources of information about the past, which are viewed with skepticism. Historians both draw on and refute the work of other historians, whose writings are considered secondary sources, along with other interpretations of the past generated later than the time period under question. Thus, secondary sources serve as backdrops to their own interpretations as well as interpretive arguments with which they agree or disagree.

The incompleteness of the historical record, the inability to ascertain the degree of incompleteness, and the tendency for historians to engage in social and intellectual criticism result in any historical claim being an interpretation of the past that may be challenged on a number of bases, singly or in combination. Based upon newly uncovered evidence from the historical record, a different interpretation of evidence already uncovered, or a new question asked about that evidence, historians can add dimensions to, confirm, or revise (refute) a commonly held view of past events as reflected in secondary sources. For example, Columbus has been lauded, demonized, and accepted as emblematic of his time by various historians over the years. .

To summarize, historians take an epistemological stand about the past that is expressed in sets of claims that are constantly questioned, contested, and altered based on the way evidence for the historical record is interpreted. Interpretations of the past are the subject of never-ending conversation and argument due to the historical record being inherently incomplete and conflicting, and that each new "present" raises new questions about the past.

Inquiry practices and strategies. Strategies for doing historical inquiry reflect the epistemic character of history (Carr, 1987; Mink, 1980). Indeed, because understanding source perspective is critical to historical interpretations, a crucial aspect of "reading" artifacts of the past is identifying and understanding when, why, and who produced the document or physical artifact in the case of primary sources or the interpretive argument in the case of secondary sources described earlier. Historians also compare and contrast perspectives on events reflected in primary sources and interpretations of the historical record reflected in secondary sources (corroboration). These processes help historians understand perspective and evaluate the credibility of the source (Wineburg, 1991a).

We defined contextualization as the understanding of a particular historical document from the perspective of the time, place, and societal and physical conditions that existed at the time it was created (e.g., Bain, 2005; Lee, 2005). Contextualization goes hand in hand with sourcing because it enables an analysis and evaluation of documents and other artifacts from the perspective of the life and times of their creation. In addition, contextualization requires students to "collocate persons, places, and times" (Hexler, 1971) in periods of history or historical episodes, helping to construct a coherent narrative. Thus, contextualization is one aspect of the historical inquiry process where sheer knowledge of events from the past plays a critical role. This is one of the hallmark differences between experts and students of history, with experts possessing extensive background knowledge to bring to bear in interpreting particular documents. A challenge, then, is how to design historical inquiry that builds enough background knowledge for students to engage in significant contextualization during historical inquiry (van Boxtel & van Drie, 2012).

Sourcing and contextualization are particularly important for a third historical inquiry process–corroboration, the process of comparing documents to one another. Corroboration provides greater reliability (or stronger evidence) for the historical record, especially if the primary sources reflect *different* perspectives. When primary sources do not corroborate, understanding the perspective of the sources along with the purpose(s) for which the source was created provides the historian with a basis for evaluating discrepancies in the historical record.

Historians also consult other historians' interpretations and historical arguments. Evaluations of these arguments are based on choice of evidence presented, the reasoning linking the evidence to the claim, the analytical frameworks used by the historian and the historian's perspective as embedded in that historian's historical context. Whose voices or perspectives are prioritized? Whose are left out? How coherent and internally consistent is the historical narrative? Does it honor the complexity of human experience? All of these issues contribute to the weight given to the perspective and interpretation reflected in secondary sources. Students rarely have opportunities to read the historical narratives constructed by historians, yet they need to learn these critical analytic stances and inquiry skills if they are to learn to think, read, and write historically.

As reviewed above, historians exercise many inquiry practices to make sense of the historical record, including interpreting the past in the contexts of beliefs and values existing at the time, identifying patterns and themes within and across historical periods, evaluating certainty and coherence and claims about causation. The processes that historians use represent an *approach* to reading that questions the veracity of documents based upon their perspective (Wineburg, 1991a, 1991b). Thus, reading across multiple related documents and deep analytic reading of single critical documents is vital for students to experience (Leinhardt & Young, 1996). Similarly, Greenleaf and colleagues advocate a collaborative, metacognitive approach to engage students in close, engaged reading of sources for the purpose of developing inquiry dispositions and skills, to build students' document reading knowledge, and to support the exacting meaning making required in historical inquiry (Greenleaf & Valencia, in press; Schoenbach & Greenleaf, 2009). The C3 Framework for teaching in history and the social studies (NCSS, 2013) similarly foregrounds the important role of inquiry, writ large, as well as specific inquiry practices such as sourcing and interpreting documents, as central to reform that moves teaching and learning toward authentic disciplinary practice.

Overarching frameworks. Perspectives on the past and historical arguments also reflect *interpretive frameworks* that orient historians to pay particular attention to, and to prioritize, some evidence at the expense of other evidence and to create coherent accounts using particular organizational frameworks. For example, one historian might explain the American Civil War in terms of differences in the economies of the states that seceded as compared to those that remained in the Union. Another might argue that the Civil War was fought over the inhumanity of slavery, drawing on philosophical arguments and conflicts dating back to the nation's beginnings. Interpretive frameworks can reflect categorical forms of societal systems (e.g., politics, technology, geography), governmental systems (e.g., feudalism, monarchism, democracy, communism), relations among phenomena (e.g., chronology, cause-effect, continuity, change over time, contingency, chance (Andrews & Burke, 2007; Leinhardt & Young,1996; Seixas, 2010), themes (e.g., industrialization, patterns and processes of migration) (Leinhardt, 1993), and foci (e.g., the role of women, the arts, medicine).

Historians use frameworks to develop claims and organize evidence to support them as they develop an interpretation through multiple and cross-textual readings (Leinhardt & Young, 1996). These claims can be about cause and effect or other relations among events, characterizations or motivations of historical actors, the relative significance of certain events or actions over others, the interaction of societal systems, and so on. In addition, historians can read with particular lenses (neo-Marxist, social theorist, feminist, etc.), which influence their interpretations (Mink, 1980; Munslow, 1997). However, the evidentiary base--that is to say, the remnants of history in the form of documents and artifacts--must be accounted for in any historical argument (Carr, 1987; Munslow, 1997).

Representational forms. The types of texts and representations common to the study of history vary in terms of type of source, media, and structure. Primary sources that originate in the period of historical interest take varied forms and historians therefore must read and interpret disparate primary source documents (e.g., census data tables, diaries, letters, speeches, inventories and records of sale, advertisements, posters, and official government documents). *Primary sources* are often written documents, but include other media such as photographs, cartoons, maps, charts, art works, music, physical artifacts, and video and audio recordings, any of which may be available in digital form.

Secondary sources can also vary widely in their structure and form. Historians write biographies, construct maps and data tables to display their analyses, and compose monographs, journal articles, and editorials. In their notes, they assiduously document all sources referenced.

Tertiary sources are compendiums or summaries, such as textbooks, Wikipedia, and documentaries. They draw from both primary and secondary sources, and also proffer interpretations of the past. Tertiary sources, a mainstay of schools, are often written by historians or groups of historians but in providing only summaries of historical arguments, illuminate little, if any, of the evidence and reasoning that historians find critical to their interpretations (e.g., Loewen, 2013; Paxton, 1999). Thus, although historical claims and an author's perspective can be identified, the argument cannot be analyzed or evaluated against the historical record itself. Rather, history is portrayed as a set of undisputed facts.

Discourse and language structures. The fifth set of core constructs captures the ways in which language is used to express historical information and the forms of discourse that govern historical argumentation. These include conventionalized linguistic expressions and word choices for communicating authorial perspectives, positions, or frameworks; linguistic frames for organizing arguments; certainty of arguments and their elements, including refutations, multi-sided, or implicit arguments that might be embedded in narrative structures; genres such as debates, discussions or conversation; lexical expressions that mark chronology and the beginning and ending points of a historical story or argument; and linguistic signals of cause/effect, including particular forms of verbs and placement of information (Schleppegrell, et al., 2004).

Importantly for our work, historical arguments can be descriptive, answering the question, “What is the case?” as well as explanatory, answering the question, “Why was it the case?” (Megill, 1989). As discussed in our review of the empirical literature, multiple studies of students engaged in historical interpretation have indicated that students often need to come to understand what happened, or how life must have been, based on the historical record, before they can begin to engage in understanding why. In practice, narrative accounts interweave the two forms of argument (what and why?), and conventions govern the presentation of claims and evidence in oral and written forms. Specific forms of discourse and language conventions thus mark the ways historians communicate their arguments. We also note that arguments among historians are often aimed at determining whose is the most accurate interpretive argument of what was the case and why. They thus engage with one another in justificatory argument about historical interpretations.

Learning Goals. Based on the foregoing review, the core constructs recognize that the very nature of the historical record raises questions of interpretation and thereby motivates inquiry and argumentation, defining a general task model for history reading that is inherently intertextual. However, research suggests that adolescents experienced with traditional approaches to history instruction approach history as facts to be memorized and reiterated on demand. At the same time, instructional efforts demonstrate that adolescents begin to think like historians when they are introduced to reading and reasoning processes consistent with the epistemology of history as described. Consistent with these instructional efforts, the READI learning goals for history emphasize the reading and reasoning processes of history, integrated with the core constructs that are central to creating descriptive or explanatory historical accounts (see Table 5).

The READI work built on the approach taken by prior instructional interventions and developed topical inquiry packets of extensive text sets with integrated support for close disciplinary reading that teachers could choose to “drop” into their instruction. Our design team teacher collaborators contributed to designing two such packets. Each contained an inquiry question, primary source texts, including photographs, and instructional strategies for engaging students in reading and reasoning to address the inquiry question. However, the implementation of these in design team teachers’ classrooms revealed that we needed a different approach if teachers were going to be able to truly transform their history classrooms from fact-based to historical inquiry-based. Teachers found that trying to switch between 7-10 day inquiry-based packets and more traditional fact-based learning using their textbooks was insufficient for them to develop proficiency in supporting students in shifting to different orientations to history. As well, drop-in lessons conflicted with meeting their curricular requirements for topic coverage.

In response, the history design team modified its approach, instead mapping the learning goals and core constructs onto teachers’ existing courses. One advantage of this approach is that it allowed initial or entry levels of historical inquiry and instructional strategies that could deepen as they were revisited within a grade level over successive topics and historical periods and across grade levels. One of the biggest challenges in the design process was locating appropriate texts and analyzing them to anticipate and design instructional supports for the comprehension challenges they would pose for students. In Shanahan et al. (2016) we describe what this looked like for an 11th grade Advanced Placement American History class. For younger adolescents, the starting point was at a basic level of differentiating between observation and interpretation (What do you see when you look at this photograph? versus What do you think this photograph tells us about the period?). As the year progressed, these distinctions were mapped onto the language of claims, evidence, and the reasons the evidence supported the claim (Ko, et al., 2016). In addition, sources provided to students and the targeted inquiry strategies moved from simpler to more complex over the course of the year. With 10th grade students, we focused on the many supports necessary for students doing the intellectual work of close reading and building their knowledge of the historical context by reading multiple, unmodified, complex historical texts, as well as deepening their epistemic knowledge of history (Cribb, Maglio, Marple, Reade, & Greenleaf, 2015).

Summary: Core Processes, Constructs and Learning Goals

The learning goals provided in Tables 3, 4, and 5 reflect the use of similarly named core processes of reading and reasoning that are involved in building representations of integrated, intertext, and task models. The substance of each of these models derives from and reflects the epistemology of each discipline–the nature of knowledge claims, characteristics of appropriate or legitimate forms of evidence, and the principled reasoning that legitimates using particular evidence to support particular claims. As we argued based on the metanalytic reviews of each discipline, there are distinctive characteristics of the epistemology of each of the three disciplines discussed in this paper. We expect that applying a similar analytic process to other disciplines will yield distinctive characterizations as well. The distinctive epistemic characteristics circumscribe inquiry processes, reasoning principles and frameworks, and the operative representational forms, media, discourse and language structures of the domain. In other words, although we may use similar labels for processes, as reflected in the goal statements shown in Table 2 (e.g., close reading, synthesis, evaluation, pattern detection), the information on which these processes act is fundamentally different across the three disciplines examined here, and we dare say this would be so when examining other disciplines. Thus there are fundamental differences in what readers are close reading for, the language patterns that have interpretive value and significance and what they signify, decisions about relevance of information and how it does or does not fit in some evolving explanation. These differences reflect the epistemic nature of the discipline and define disciplinary literacy.

At the same time, the aptness of the five categories of core constructs (see Table 1) for characterizing important knowledge about disciplinary argumentation, inquiry, and literacy suggests that it may be useful as an analytic scheme for other disciplines. As an instructional tool it may have value in making explicit characteristics and properties of different disciplinary content areas and thereby sharpen the distinctions as well as similarities among them. By suggesting the types of knowledge learners need to know about a discipline it may provide valuable guidance for specifying trajectories and progressions in disciplinary literacy learning.

Framework of Core Processes and Constructs: Opportunities for Knowledge-Building for Teachers and Researchers

Developing and refining the framework of core processes and constructs in each discipline played key roles in addressing the need for teachers to unpack standards such as the

Common Core, the NGSS, and the C3 Framework in the design and implementation of instructional interventions that enable students to make progress toward achieving these standards. Likewise, the basic process research has been informed by the articulation of what students need to know about the nature of knowledge and how it is generated within each discipline through its implications for the reading and reasoning processes as they are enacted in each discipline. These learning goals are critical to readers constructing intertext and integrated models in pursuit of developmentally appropriate disciplinary tasks.

Intervention Design and Implementation

The articulation of the critical reading and reasoning processes specified in the learning goals and enacted for purposes of accomplishing authentic disciplinary inquiry tasks served as a conceptual tool for teachers (Grossman, Smagorinsky & Valencia, 1999) and, in fact, all members of the design teams, to build the kinds of pedagogical and theoretical understandings needed to design and implement change in instruction that supports disciplinary literacy and learning. As noted earlier, standards are neither instruction nor curricula (CCSSO, 2010). Attempting to turn the core constructs and learning objectives into enactable instructional interventions through iterative design based research deepened the unpacking process for all members of the design teams and fed back into both refinement of the core constructs and learning objectives, generation of modules that included tasks, sets of sequenced text materials, and formal and informal assessments intended to inform instruction (Evidence-Based Argument Instructional Modules). (See for discussion Ko, et al., 2016.)

Discussions and debates–often heated–among members of the design teams were frequent as the teams proceeded to instantiate relatively abstract concepts such as causality, argument, or symbolic meaning in instructionally actionable lessons and lesson sequences.

These interactions revealed the different perspectives on the discipline, literacy, and learning brought to the design table by the diversity of backgrounds and expertise among the members. It was through this *in situ* work that shared understandings emerged of "what students need to know and be able to do and how we would know if they do." Contrasting the instantiations at middle and high school grade bands contributed to what remain preliminary benchmarks for developmentally appropriate expectations, instruction, and outcomes. The entire process made more explicit and transparent to *all* members of the design teams sources of challenge, complexity, and leverage points in students' engaging in authentic and intellectually challenging disciplinary work. We contend that the core constructs and learning goals served to anchor this process in ways that led to productive engagement and instructional design rather than diffuse speculation.

Like members of the research team, the teachers who collaborated with us on design refined their understanding of reading in the three disciplines. Teachers' final reflections gathered at the last Project READI Teacher Network meeting (May, 2015) are illustrative of the kinds of shifts that occurred in teachers' planning, instruction and assessment practices.

> After contemplating and defining argument I began to reframe how I approached the task. I now look at the type of evidence the students use and have developed scaffolded lessons to help them extract the evidence. I now have the students consider why this all matters and how literature impacts their thinking, their view of the world, and their learning. This was not as big of a focus before I began this project and now it encompasses my assignments. NB (HS-Literature)

> My summative assessments have dramatically changed since working on the definition of argumentation. I used to have a final project or test that would "cover" the lessons taught. Now, I see a summative assessment could be the argument itself, provided that students root their claims with evidence and sound reasoning. This provides insight not only to the extent to which the students understands the science content, but whether or not they are practicing evaluation of evidence and considering properly controlled variables and other items that dictate sound scientific design. RL (MS-Science)

> Developing language around historical thinking has been an important area of growth for me. I have worked at developing consistent language that surrounds my approach to particular text to be explicit in my thinking about what it means to think historically. JH (HS-History)

The framework of core processes and constructs provided teachers a viable way not only to unpack standards (what students need to know and be able to do) but equally important to understand "the how" of designing and implementing instruction that enabled students to make progress toward achieving the standards.

Conclusions

The framework of core processes and constructs provides a way to systematically conceptualize the kinds of knowledge, skills, and practices that are required to meet the reading and reasoning expectations needed for success in 21st century society and captured in standards such as the Common Core for English language arts, History, and Science. There is still much to be explicated to move these into actual instructional designs, in part because there is very little research to indicate how various learning goals ought to be sequenced or how to conceptualize increases in complexity of the reading and reasoning processes, the texts, or the tasks that students are assigned and through which they will be expected to demonstrate mastery of particular standards. What these should look like at different grade bands is largely an unknown, as is what it will take to move students to these or similar standards by the time they graduate from high school. From our efforts to develop the framework presented in this paper and design and implement instructional programs based on it, it is clear that the knowledge, skills, practices and processes that are articulated in the core constructs and learning goals develop through an iterative process of introducing and then iteratively deepening them. These iterations need to occur over multiple years of instruction to effectively build robust competencies that can be flexibly adapted to new situations. Thus, schooling and student growth needs to be conceptualized from a longitudinal perspective rather than from a grade by grade perspective.

Our work on Project READI has been a part of a broad federal initiative to redefine reading comprehension for the 21st century, to identify malleable factors associated with high levels of reading comprehension, and to design and test interventions to address them. Moving toward the kinds of literacies envisioned in the CCSS, the NGSS, and the C3 and required in the 21st century will necessitate ways to help varied subject area teachers at the middle and high school levels see how reading and reasoning with texts can serve vital disciplinary learning goals. They will need to reconceive disciplinary learning as something other than, or at least in addition to, information (facts, dates, plot summaries). Our work is indicating that the core constructs and learning objectives presented here can serve as conceptual tools for teachers to support the enactment of new, and needed, instructional approaches. Our collaborations with teachers on instructional designs that build students' capabilities in each of these disciplines are providing valuable data that will help refine both the learning objectives and our understanding of how to progressively build these knowledge, skills and practices in developmentally appropriate ways.

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Table 1 Core Construct Categories and Definitions

Core Construct Category	General Definition
Epistemology	Beliefs about the nature of knowledge and the nature of knowing. What counts as knowledge? How do we know what we know?
Inquiry Practices, Reasoning Strategies	Ways in which claims and evidence are established, related, and validated
Overarching concepts, principles, themes, and frameworks	The core ideas and principles that serve as a basis for warranting or connecting claims and evidence
Forms of information representation/types of texts	Types of texts and media (e.g., traditional print, oral, video, digital) in which information is represented and expressed.
Discourse and language structures	The oral and written language forms that express information.

Table 2. Learning Goals for Reading and Reasoning from Multiple Sources

1. Engage in close reading of texts as appropriate to the disciplinary task and text.
2. Synthesize within and across aspects of texts important to the disciplinary tasks and texts.
3. Construct written arguments with claims, evidence and warrants, organized logically and expressed clearly and that reflect disciplinary norms for argument.
4. Establish criteria for judging interpretive claims and arguments that are appropriate to the discipline.
5. Construct arguments explaining the logic of how the claims are supported by evidence using appropriate disciplinary criteria for claims, evidence and logic.
6. Demonstrate understanding of the nature of knowledge and how that knowledge is constructed as appropriate to the discipline.

Table 3. Learning Goals for Literary Reading

1. Engage in close reading of texts and show evidence that the reader has employed literary strategies to notice salient details with regard to plot, characterization, and rhetorical as well as structural choices made by the author. 2. Synthesize within and across literary texts patterns and anomalies in order to construct generalizations about theme, characterization, and the functions of structural and language choices made by authors. 3. Construct written arguments with claims, evidence and warrants, organized logically and expressed clearly, using appropriate academic language. Arguments address author generalizations and/or structural generalizations (Hillocks & Ludlow, 1984) 4. Establish criteria for judging interpretive claims and arguments that address author generalizations, explaining how the text meets the criteria and justifies the claim (Hillocks, 1986, 1995). Justifications may be drawn from the text, from other texts, literary constructs or critical traditions or the reader's judgments from experience in the world. 5. Construct arguments addressing structural generalizations (Hillocks & Ludlow, 1984), explaining the logic of how the claims are supported by evidence in the author's choices about use of language (e.g., structure, word choices, rhetorical devices). 6. Demonstrate understanding that texts are open dialogues between readers and texts; literary works embody authors' interpretations of some

aspect of the human condition (which the reader may reject); authors make specific choices about language, structure and use of rhetorical devices upon which the reader may draw in constructing interpretations.

Table 4. Learning Goals for Text-based Science Inquiry

1. Engage in close reading of science information to construct domain knowledge, including multiple representations characteristic of the discipline and language learning strategies. Close reading encompasses metacomprehension and self-regulation of the process.
2. Synthesize science information from multiple text sources.
3. Construct explanations of science phenomena (explanatory models) using science principles, frameworks, enduring understandings, cross-cutting concepts, and scientific evidence.
4. Justify explanations using science principles, frameworks and enduring understandings, cross-cutting concepts, and scientific evidence. (Includes evaluating the quality of the evidence.)
5. Critique explanations using science principles, frameworks and enduring understandings, cross-cutting concepts, and scientific evidence.
6. Demonstrate understanding of epistemology of science through inquiry dispositions and conceptual change awareness/orientation (intentionally building and refining key concepts through multiple encounters with text); seeing science as a means to solve problems and address authentic questions about scientific problems, tolerating ambiguity and seeking “best understandings given the evidence”, considering significance, relevance, magnitude and feasibility of inquiry.

Table 5. Learning Goals for History Inquiry

1. Engage in close reading of historical resources to construct domain knowledge, including primary, secondary and tertiary sources. Close reading encompasses metacomprehension and self-regulation of the process.
2. Synthesize within and across historical resources using comparison, contrast, corroboration, contextualization, and sourcing processes.
3. Construct claim-evidence relations, using textual evidence and explaining the relationship among the pieces of evidence and between the evidence and claims.
4. Use interpretive frameworks developed by historians, such as societal structures, systems and patterns across time and place, to analyze historical evidence and argument, and to address historical questions.
5. Evaluate historical interpretations for coherence, completeness, the quality of evidence and reasoning, and the historian’s perspective.
6. Demonstrate understanding of epistemology of history as inquiry into the past, seeing history as competing interpretations that are contested, incomplete approximations of the past, open to new evidence and new interpretations.

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