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RESEARCH REPORT

Cognitively Based Assessment of Research and Inquiry Skills: Defining a Key Practice in the English Language Arts

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Current educational standards call for students to engage in the skills of research and inquiry, with a focus on gathering evidence from multiple information sources, evaluating the credibility of those sources, and writing an integrated synthesis that cites evidence from those sources. Opportunities to build strong research skills are critical, yet empirical research demonstrates that students from Grades K–16 struggle with inquiry tasks, particularly in online environments. There is a need to create models that will support teachers in developing students' research skills and can be used to develop reliable and valid assessments of such skills while aligning with standards. Under the *CBAL*™ research initiative, we have developed a model of conducting research and inquiry as a key literacy practice in the English language arts (ELA). In this paper, we draw on literature from the cognitive and learning sciences—including work in discourse processing, science education, educational technology, and information literacy—to provide the theoretical background for this key practice. We identify a set of activities and skills that are critical for participating in research; each skill is accompanied by a set of provisional learning progressions, which outlines tentative predictions about the qualitative changes in a skill that develop over time with appropriate instruction. These learning progressions and their relation to the key practice can be leveraged in the design of cognitively based assessments of research and inquiry that are sensitive to students' developmental level. We conclude, with an example design for such an assessment to illustrate how key practices and learning progressions can be integrated to support measurement of research and inquiry skills.

Keywords English language arts; learning from text; reading and writing; multiple-source comprehension; assessment

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The Common Core State Standards for English Language Arts and Literacy (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010) calls for students to engage in the skills of research and inquiry, with a focus on gathering evidence from multiple information sources, evaluating the credibility of those sources, and writing an integrated synthesis that appropriately cites evidence from those sources. In order to achieve the vision of college readiness outlined by the standards, students need opportunities to build strong research skills, yet reviews of empirical studies have demonstrated that students both in college and grades K–12 experience difficulty with conducting research, particularly in online environments (Kuiper, Volman, & Terwel, 2005; Walraven, Brand-Gruwel, & Boshuizen, 2008). Efforts to support improvements in the teaching and learning of research skills in K–12 settings are therefore critical for helping students achieve true readiness to participate in college and careers where technologically supported knowledge work is increasingly the norm (Levy & Murnane, 2004). Further, developing students' proficiency with research skills is also likely to benefit their decision-making and problem-solving skills in everyday personal information-seeking and social contexts (Brand-Gruwel & Stadtler, 2011; Kovach & Rosenstiel, 2010), underscoring the importance of such 21st century research skills (Partnership for 21st Century Skills, 2009) for success in work and life.

Thus, the challenges for K–12 instruction and assessment are to create models that will support English language arts (ELA) teachers in developing their students' research skills (that is, their ability to select, evaluate, and build knowledge from multiple sources in response to an inquiry question or problem) and to develop assessments of such skills that provide evidence of students' proficiency. Given the centrality of research skills for college readiness, it is important to develop assessments of those skills that effectively measure students' proficiency while aligning with standards. The development of cognitively based assessments of reading and writing literacy under the *CBAL*™ research initiative at Educational Testing Service (ETS; Bennett, 2010; Bennett & Gitomer, 2009; Deane, 2011; Sabatini, O'Reilly, & Deane, 2013) represents an important contribution to such efforts.

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In this paper, we apply the framework of key practices outlined by Deane et al. (2015) to develop a model of proficiency with activities required to conduct research and inquiry in the context of ELA instruction. According to Deane et al. (2015), the key practice, conducting research and inquiry, involves "mastery of skills and strategies needed to participate in a research community, including the abilities to gather, evaluate, and synthesize information from multiple sources, to conduct inquiry and experimentation, and to present information one has learned from sources in appropriate forms and formats" (p. 12). Here, consistent with principles of CBAL (Bennett, 2010; Bennett & Gitomer, 2009), we draw on literature from the cognitive and learning sciences — including work in discourse processing, science education, educational technology, and information literacy fields — to provide the theoretical background for this key practice. We present a detailed analysis of the theoretical and empirical work that informed this model, including identification of skills that are critical for participating in research as a literacy practice. These key skills are accompanied by a set of hypothesized learning progressions — specifying the qualitative changes in a skill that develop over time with appropriate instruction — that outline tentative predictions about the development of research skills. While these learning progressions represent our best current understanding of the development of research skills from isolated activities to integrated, expert-like performances, it is important to note that they are still provisional and subject to revision based on additional empirical evidence and theorization. Finally, we describe ongoing efforts to validate this theoretical model and to use it to support assessment design.

Conducting Research and Inquiry: Framework for a Key Practice

As described in detail by Deane et al. (2015), the definition of a key practice in terms of an *activity system* (cf. Brown, Collins, & Duguid, 1989; Engestrom, Miettinen, & Punamaki, 1999; Vygotsky, 1978) — coordinated sets of goal-driven behaviors within a structure of social norms and expectations for participation — provides a schematic representation of the activities that define successful performance within the constraints of that key practice. This schema should be specified at a level such that it generalizes across a variety of specific practices and identifies the cognitive foundations as well as the enduring understandings and strategies that characterize expert performance of the practice (Zane 2009a, 2009b). In the context of activity theory (Jonassen & Rohrer-Murphy, 1999), one must consider the subject (who is performing the activity), the object (the ultimate goal or product one aims to achieve), tools (anything the subject uses to achieve the goal), and activities (goal-directed actions or sequences of actions that are deployed in an effort to achieve the object) as elements that define an activity system. Applying this theoretical framework to an analysis of the research domain, we can derive a descriptive model of research and inquiry as a situated practice.

The practice of conducting research and inquiry — and specifically, participating in a research community to which one makes active contributions — requires interactions among multiple people who are engaged in the process of conducting investigations and represent the subjects of this activity system. The subjects for this activity system would certainly include professional research scientists working in academic or applied settings, but they could also include many others engaged in research activities, such as employees, data analysts, undergraduates, and importantly for the current work, K – 12 students in ELA classrooms or in disciplinary classrooms where literate research activities are part of the curriculum, as in science or social studies domains. The object of research and inquiry is to build a synthetic, deep understanding of a topic or phenomenon by reading and integrating information from multiple, reliable sources of evidence and to communicate that understanding to others in a coherent way, typically in the form of an explanation or argument, to enter one's claims into an emerging knowledge base and thereby submit them to the scrutiny of one's peers and other scholars in the field. Defining the object of conducting research in this way highlights the importance of conceptualizing research as a social practice, involving interactions and exchange among multiple parties — including those with perspectives that differ considerably from one's own — as a fundamental element of the research enterprise. The tools of research and inquiry are varied, depending considerably on the nature of one's research questions and the methodological approaches one uses to find evidence bearing on those questions; these tools could include systematic observation, controlled experimentation, or close reading, analysis, and critical evaluation of multiple text or multimedia sources obtained via Internet searches. Here, and throughout this paper, we use the term *sources* to refer to any number of different types of texts, documents, or other materials in which information can be transmitted; this includes but is not limited to books, textbooks, newspaper articles, journal articles, websites, personal blogs, letters, online discussion forums, political cartoons, text messages, tweets, datasets, simulation results, infographics, YouTube videos, or conversations (face-to-face or virtual) with experts or interested parties. Importantly, one's choice of methodological approach and information-gathering strategies (including

the types of sources one seeks out) must be appropriate given the questions one wishes to answer or the phenomena one wishes to explain, so that one's claims and conclusions will be considered valid by other members of the research community. That is, the choice of tools is constrained by both task goals and disciplinary standards that specify the criteria for evaluating the validity of knowledge claims (for example, in scientific fields, application of the scientific method and use of appropriate controls to rule out confounds, as well as adherence to norms and expectations of the research report genre; Goldman & Bisanz, 2002). In this way, research and inquiry has important connections to notions of disciplinary literacy, which emphasize the unique sets of tools and knowledge that experts bring to bear when creating, communicating, and using disciplinary knowledge (T. Shanahan & Shanahan, 2008, 2012). Finally, various activities (such as information gathering, analysis and synthesis, and communication of results) serve to coordinate the subjects, objects, and tools in the service of accomplishing various goals and subgoals that must be satisfied to achieve successful performance. Although some activities remain constant across disciplines (i.e., general reading and comprehension strategies), others are specific to the discipline (i.e., data collection).

When viewed as a literacy practice in ELA, research and inquiry is fundamentally a process of reading, writing, and thinking with multiple documents (cf. Perfetti, Rouet, & Britt, 1999; Rouet, Britt, Mason, & Perfetti, 1996). The specific tools and activities may vary as a function of specific disciplinary constraints. Extant work on disciplinary literacy that seeks to characterize the differences in reading and writing activities among the disciplines, in order to develop ways to teach and assess literacy activities within those domains (T. Shanahan & Shanahan, 2012), can inform an understanding of the literate activities that are required for conducting research in different disciplinary contexts. For example, Latour and Woolgar (1986) characterized the practice of scientific research as one of involving translation (i.e., reading and integrating) and inscription (i.e., writing and communicating) of a multitude of documents (including data and interpretations of data) with particular attention to detailing one's procedures, explaining phenomena, and persuading colleagues that one's findings are credible by engaging in evidence-based argumentation.

Consider, in particular, how attention to the author of a text varies in importance across disciplines. Research on historical inquiry reveals that historians must model the author of a text and use this understanding to interpret text information (Wineburg, 1991, 1998), whereas scientists may use author information as a heuristic indicating the relevance of the topic or the quality of the work, using this information to evaluate whether or not a scientific text is worth reading (C. Shanahan, Shanahan, & Misichia, 2011). Analyses of think-aloud protocols during disciplinary reading indicate that scientists and mathematicians find consideration of the author "a distraction" that does not assist them in interpreting or comprehending text contents (C. Shanahan et al., 2011); however, in history, consideration of the author of a text is central to the work of the discipline. Importantly, disciplinary literacy extends beyond reading to learn specific content and involves learning about the various practices used by professionals in the context of their work (Goldman, 2012; C. D. Lee & Spratley, 2010). Whether in scientific, historical, or literary disciplinary contexts, effectively pursuing answers to an inquiry question through research requires the successful deployment of a variety of skills, including critical evaluation, analysis, and synthesis of information or evidence (in textual, numerical, visual, or graphical modes) drawn from a variety of sources presenting a range of views, evidence, and conclusions about the issue under discussion (Bazerman, 1985; Goldman et al., 2010; Wineburg, 1991). Some scholars have framed these various academic practices as reasoning from multiple sources (Perfetti et al., 1999; Rouet et al., 1996).

When research and inquiry skills are conceptualized in this way, it follows that these skills include reading activities required for successful comprehension and learning from single texts, including activating prior topic knowledge, identifying main ideas, generating inferences, and building a mental or situation model of the text, which can be extended or applied to answer questions or solve problems (Kintsch, 1998; Kintsch & van Dijk, 1978). These skills, in addition to related skills such as summary writing, outlining, and communicating with others about informational texts, are represented in the CBAL ELA framework under building and sharing knowledge, which describes the key practice of comprehending, building, and sharing the knowledge one has learned from informational texts. Because this key practice is described in detail elsewhere (see O'Reilly, Deane, & Sabatini, 2015), these activities are not dealt with in detail here except to emphasize that the model-building skills of building and sharing knowledge are considered prerequisite skills that support students' performance of the key practice, conducting research and inquiry, which is considered an applied literacy skill in the CBAL key practices framework (Deane et al., 2015).

Our definition of the key practice of conducting research and inquiry involves mastery of the knowledge, skills, and strategies needed to participate in a research community, including the abilities to gather, evaluate, and synthesize

information from multiple sources, to plan and conduct inquiry and experimentation to answer driving questions or solve problems, and to present information one has learned in appropriate forms and formats, adapting information as needed given the knowledge, interest, and perspectives of one's intended audience. In contrast to building and sharing knowledge, another prerequisite key practice that emphasizes building a coherent mental model of text content (Deane et al., 2015), research and inquiry, involves as a primary emphasis the evaluation and deep synthesis of multiple sources. While the key practice building and sharing knowledge sometimes involves learning from multiple texts, its focus is on comprehension and understanding, rather than the critical analysis and synthesis of multiple documents that is a central focus of inquiry in ELA. Engaging in research is therefore primarily a process of building knowledge from multiple authoritative sources where credible resources are used to extend and advance one's thinking in a process of continual improvement of ideas (cf. Scardamalia & Bereiter, 2006).

The degree to which an individual will be successful in conducting research is a function of knowledge, skills, the nature of the required tasks, and available resources, as well as *performance moderators* (O'Reilly & Sabatini, 2013) such as prior topic knowledge, metacognitive and self-regulation skills, and epistemic beliefs about the nature of knowledge and knowing, which have been empirically demonstrated to influence inquiry practices (Barzilai & Zohar, 2012). The processes of evaluation, integration, and communication depend heavily on the researcher's content knowledge as well as knowledge of specific disciplinary standards and procedures for producing new knowledge (Goldman & Scardamalia, 2013).

Development of proficiency with inquiry practices may require attention to supporting learners in building their metacognitive skills and strategies and, in addition, explicit modeling of the various literacy and inquiry activities that disciplinary experts perform in the service of their professional research practices (cf. Chinn & Malhotra, 2002). This conclusion aligns with perspectives on situated cognition, which suggest that learning occurs through interacting with others in a social context resembling the real-life conditions in which the learned skills will be applied (Brown et al., 1989). This theory also suggests that expertise develops through continued participation in communities of practice (Lave & Wenger, 1991), wherein novices interact with and learn from experts in the context of their authentic activities (Rogoff, 1990). Consistent with these perspectives, the current key practice is specified at a general level, such that the same model can be used to characterize learners' inquiry skills across multiple levels of proficiency from preliminary (novice) to advanced (expert) performance.

Conducting Research and Inquiry Activity Diagram

Figure 1 presents a schematic representation of the conducting research and inquiry key practice, as defined above. This overview, or *activity diagram*, identifies the major subgoals and associated activities involved in the key practice of conducting research and inquiry from multiple evidentiary sources. The activity diagram corresponds to the critical knowledge, skills, and activities identified from a review of the cognitive and learning sciences literature and is also informed by previous analyses of reading and writing literacy practices conducted under the CBAL initiative (Deane, 2011; Deane, Fowles, Baldwin, & Persky, 2011; Deane, Sabatini, & O'Reilly, 2013; Deane et al., 2008; O'Reilly & Sheehan, 2009). This diagram illustrates the key activities that literate people might perform if their purpose is to conduct research and inquiry from multiple sources of evidence, in order to advance their understanding of a topic, event, or phenomenon and to apply that understanding to answer questions, solve problems, or communicate with others.

Our analysis suggests that the behaviors that characterize expert participation in research and inquiry can be categorized under three major phases of activity. Each phase addresses different sets of goals, which require a variety of reading, writing, and critical thinking skills to be deployed; these skills are represented in Figure 1 by the questions corresponding to each phase. We describe each phase below and then present a detailed literature review discussing the key aspects of each phase in turn. The following activities are involved in this key practice:

1. *Inquiry and information gathering*. This class of activities corresponds to strategies for planning, monitoring, and executing information-gathering or data collection strategies. It includes strategies for assessing information needs, formulating and revising research questions, and generating plans for obtaining reliable evidence that both bears on those questions and fills gaps in one's understanding of the topic. Performance on these kinds of activities is perhaps most likely to be associated with constructs like information literacy, information and communication technology literacy, and scientific thinking skills.

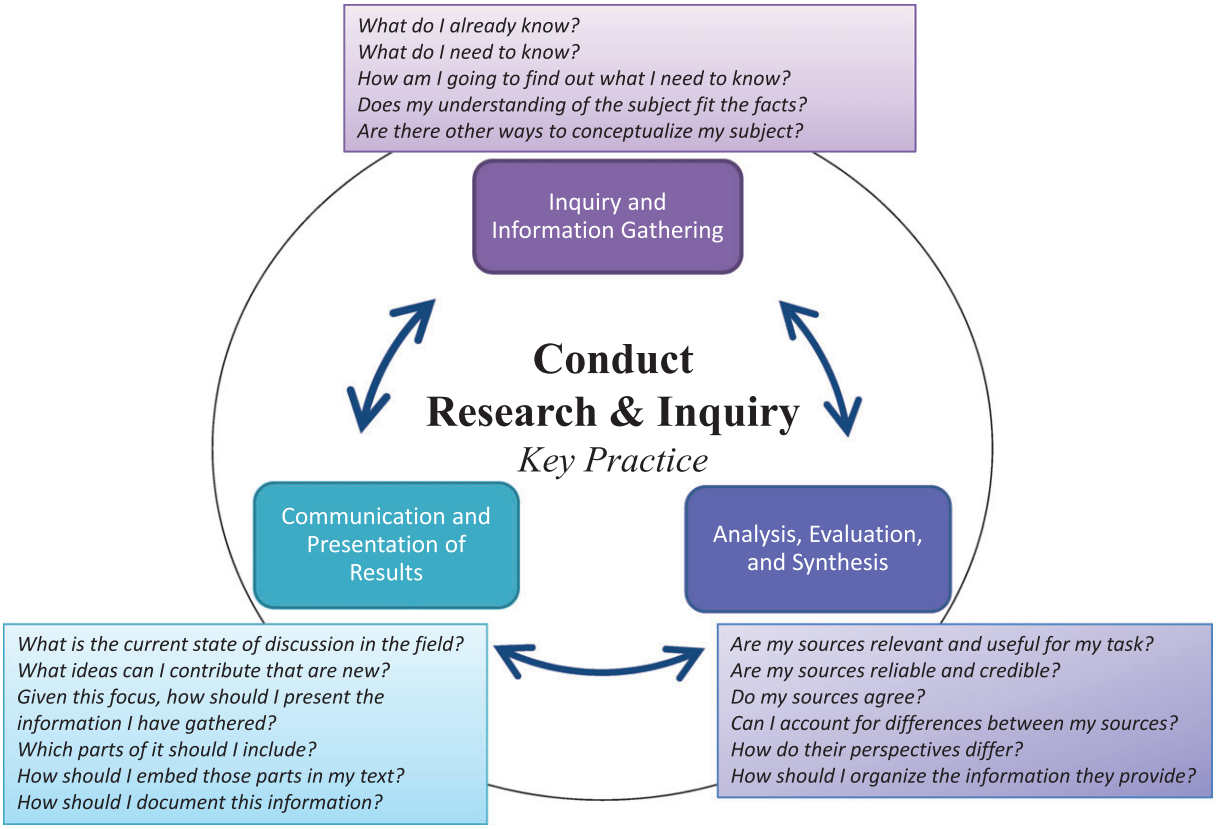

Figure 1 Framework for the key practice conducting research and inquiry.

2. *Analysis, evaluation, and synthesis*. This class of activities corresponds to strategies for comprehending, evaluating, and consolidating information drawn from multiple information resources. The skills required for successful multiple-document comprehension (e.g., Goldman et al., 2011) are best represented in this set of activities, including skills required to comparatively evaluate sources that represent different perspectives or are presented in different formats and to build a coherent understanding of a topic or event from multiple, possibly conflicting sources. Performance on these activities is likely to depend on the goals of the task, as well as an individual's topic knowledge, understanding of the task, and epistemic beliefs.
3. *Communication and presentation of results*. This class of activities comprises the writing skills needed to organize and present information drawn from multiple sources, particularly informational texts that describe the results of research studies or reviews of research results, and then to present this information to an audience while avoiding plagiarism. Communicating and presenting the results of one's inquiries also requires, at the highest levels, consideration of disciplinary expectations regarding how one should represent, communicate, and evaluate evidence obtained from various sources, including norms for engaging in argumentation.

In Figure 1, each of these three activity types includes a set of questions designed to illustrate the kinds of goals or subgoals that individuals might try to achieve in the service of those activities.

We have represented these activities in a circle with an implied clockwise flow from inquiry and information gathering, to analysis and synthesis, and finally to communicating and presenting results. However, it is important to note that these activities may occur in various sequences and configurations, as is consistent with the nonlinear and iterative approaches that characterize experts' inquiry practices (Rouet & Britt, 2011). Although generating guiding questions is an important early step in the inquiry process, we do not mean to suggest that all inquiries begin with the explicit formulation of a question; for example, one might read a text that contradicts or challenges one's prior understanding, or one might encounter conflicting information within or between sources, thereby generating a need to resolve the apparent conflict by gathering additional information or data. Individuals might also vary in their engagement in some activities, depending

in part on their understanding of what is required to complete the task. A two-step clockwise sequence from inquiry and information gathering to communicating and presenting results might represent a simplistic, uncritical approach to conducting inquiries in which an individual queries a search engine, quickly scans the first available result, and submits a pasted excerpt from the text as one's response, which is characteristic of young students who view research as a process of looking up answers (e.g., Bilal, 2001). In contrast, proficient research and inquiry will include multiple cycles of scanning, reading, evaluating, and synthesizing across information sources and repeated cycles of writing, revising, and editing to avoid plagiarism or strengthen one's arguments. In sum, this diagram represents the major activities and activity sequences that commonly occur in the practice of conducting research and inquiry, but it does not define a strictly ordered process model.

In the following literature review, we discuss each activity in Figure 1 in terms of its supporting set of skills, considering what is known about how these skills develop and, in particular, how students' performance of these activities differs from the performance of experts. This analysis is intended to motivate the conceptual framework and learning progressions that are presented in the final section of this paper. The framework provides a model of how research and inquiry skills may develop qualitatively through instruction and experience. To the extent possible, we have attempted to identify critical qualitative shifts in inquiry skills as well as specific strategies or techniques that may support students in achieving more sophisticated levels of performance. The progressions are intended to be used to support assessment design; one of our ongoing projects is to develop a series of assessment tasks that are intended to measure different levels of targeted research and inquiry skills.

Literature Review

Here, we review a number of topics that are central to understanding students' efforts to conduct research and inquiry. The subsections are organized with respect to the major activities in each phase of the practice (see Figure 1). First, we review literature relevant to the first phase, inquiry and information gathering, including discussion of skills related to scientific and information-literate inquiry, with a focus on research conducted in online contexts. Next, we discuss prior work that informs the phase of analysis, evaluation, and synthesis, including work on comprehension and learning from multiple documents. In the third phase, communicating and presenting results, we draw on research from cognitive science and linguistics to develop a model of writing and citing information from sources. Finally, we review related research on the metacognitive and self-regulation skills that are essential to conducting inquiry and recruited across all phases of the key practice. Taken together, these lines of research form the evidentiary bases for the conceptual framework presented in the final section of this report.

Inquiry and Information Gathering

The first phase, inquiry and information gathering, involves skills related to scientific inquiry, such as question generation, data collection, interpretation, and hypothesis testing, as well as the skills required to locate relevant information from existing data sources, such as content available from the Web. Here, we describe literature that informed our conceptualization of the skills within this phase of the key practice.

Inquiry as a Key Practice in Education

The importance of inquiry in education has been evident since John Dewey articulated a belief that learning is "primarily an activity which arises from the personal experience of grappling with a problem" (Soltis, 2002, p. 579). Dewey envisioned learners coming into the classroom, posing questions deeply rooted in their everyday experiences, and engaging in inquiry and debate as they tested their hypotheses about the world. This vision of science as a way of knowing and learning about everyday phenomena is underscored by the National Research Council (NRC; 1996), the American Association for the Advancement of Science (1993), and more recently, the Next Generation Science Standards (Next Generation Science Standards Lead States, 2013), which specify the knowledge, skills, and abilities that constitute proficiency in science. The NRC *Framework for K–12 Science Education* (NRC, 2012) specifies a set of eight science and engineering practices that are considered essential for students to learn: asking questions and defining problems; developing and using models; planning and carrying out investigations; analyzing and interpreting data; using mathematics and computational thinking;

constructing explanations and designing solutions; engaging in argument from evidence; and obtaining, evaluating, and communicating information. The components of the inquiry process are explicitly treated as practices in order to underscore that "engaging in scientific investigation requires not only skill but also knowledge that is specific to each practice" (NRC, 2012, p. 30). These inquiry practices occur not in isolation but in sequential and intersecting ways. Notably, students are expected to engage in these inquiry processes at all grade levels but in successively more sophisticated ways as their knowledge and skills develop.

Inquiry as a practice is also embodied in the National Council for the Social Studies (NCSS) *College, Career, and Civic Life Framework for Social Studies State Standards* (NCSS, 2013), which emphasized the development of deep knowledge of social studies topics through posing and answering compelling, deep questions about topics in history, geography, civics, and economics. The C3 Framework organizes the structure of each of these disciplines in terms of an inquiry arc, which includes four dimensions: developing questions and planning inquiries, applying disciplinary concepts and tools, evaluating sources and using evidence, and communicating conclusions and taking informed action. The view of social science as inquiry put forward by these standards is consistent with the emphasis on inquiry in both science and ELA standards. While in this section we primarily focus on research from scientific and online inquiry contexts, a great deal of research on multiple document integration and synthesis (as reviewed in the next major section of this paper) has been conducted in the context of history learning (e.g., Britt & Aglinskas, 2002; Wiley & Voss, 1999; Wolfe & Goldman, 2005).

Fundamentally, inquiry tasks require individuals to coordinate their previous ideas with new evidence gathered about a topic or phenomenon (Kuhn, 1989). This coordination process includes at least four components specified by Kuhn and Dean (2008): (a) intent, identifying the driving questions that will guide one's inquiry, and knowing how to productively constrain those questions to test a hypothesis—for example, by examining the effect of only one variable at a time; (b) analysis, the processes of designing a method for investigating one's intended question and interpreting the data resulting from an investigation; (c) inference, the process of drawing conclusions, or synthesizing information from multiple sources (e.g., coordinating theory and evidence); and (d) argument, the process of making and defending a claim to an audience, such that one's claims enter the scientific discourse. Here, we focus primarily on skills related to the intent component, including formulating questions, gathering data (i.e., locating relevant information sources), and generating and testing hypotheses.

Authentic Inquiry Versus Inquiry-Based Learning

Research in science education has considered authentic inquiry—as performed by professional scientists and researchers—as distinct from inquiry learning, consisting of classroom-based or researcher-developed tasks that engage learners in some facet(s) of the inquiry process (Chinn & Malhotra, 2002). Authentic scientific inquiry requires experts to engage in the cognitive processes of generating research questions, designing studies or plans for data collection, making observations, explaining and critiquing results, developing theories, comparing and coordinating results from multiple studies, and studying research reports produced by other scientists with different perspectives (Chinn & Malhotra, 2002). These steps are consistent with but not identical to instructional models of inquiry learning, such as the inquiry cycle of White and Frederiksen (1998), a model that includes processes of questioning, predicting, experimenting, modeling, and applying information. For example, project-based science incorporates inquiry into classroom activities (Krajcik et al., 1998). Such projects include a driving question, which anchors learning of meaningful scientific content in the context of a real-world problem; investigation and artifact-creation activities that give students opportunities to learn concepts, apply information, and represent what they have learned in different forms and formats; collaboration among students, teachers, and community members; and the use of technological tools to support one's inquiries. Experiments demonstrate that students better understand course concepts introduced through problem-based learning as compared to lecture methods, with these benefits appearing to be driven by a focus on deep engagement with a problem, rather than the social or collaborative elements (Pease & Kuhn, 2011).

Common to both authentic inquiry and inquiry learning in science are the processes of orientation to the research topic, hypothesis generation, experimentation, reaching conclusions, evaluation of acquired knowledge, planning and monitoring inquiry activities, and monitoring whether one has accumulated sufficient knowledge to address the research questions or hypotheses (de Jong, 2006). These steps are undertaken both by expert researchers and by novices who are still developing their inquiry skills, but students often have difficulty with some aspects of the practice. In general, accounts of young students' attempts at scientific inquiry reveal that they have difficulty drawing meaningful conclusions from data collected,

carrying out procedures in a systematic and logical way, and designing investigations that represent meaningful tests of specific hypotheses (Krajcik et al., 1998). College students also experience difficulties with hypothesis-testing procedures, such as confusion between descriptive and causal (relational) questions, trouble distinguishing between hypotheses and predicted patterns of results that follow from those hypotheses, and difficulty drawing scientific conclusions from observational data (Lawson et al., 2000). Thus, difficulties with hypothesis-testing procedures that students experience in middle school (when many students begin their experiences with conducting scientific inquiries involving designing and conducting investigations) are likely to persist through adulthood without appropriate instructional intervention.

Similarities Between Scientific and Information-Literate Inquiry

The view of scientific inquiry as a process is consistent with K–12 ELA perspectives, which argue that teaching research and inquiry, particularly in online contexts, should highlight inquiry processes (Guinee, 2004). Notably, Julien and Barker (2009) identified several similarities between scientific inquiry and information-literate information seeking, conducting online inquiry from multiple sources with a particular focus on obtaining reliable sources (also known as information problem solving [IPS]; Brand-Gruwel, Wopereis, & Vermetten, 2005). Both information problem solving and scientific inquiry involve the following:

- *Working to achieve a goal*. Information-seeking tasks have a goal of locating reliable information in order to satisfy an information need or answer a question, whereas scientific inquiry tasks have a goal of developing evidence-based explanations for natural phenomena. In both cases, the goal can be viewed as answering a driving question that guides one's information or data-gathering strategies.
- *Activating prior knowledge*. This category includes organizing information that is known and information that one needs to find out—an important process for both task types.
- *Planning for gathering information or data collection.* Information-seeking tasks require students to plan a search strategy for locating relevant documents, including identifying search keywords, appropriate alternatives to those keywords (i.e., synonyms or combinations of terms), and possible sources of credible information on the topic. In scientific inquiry, students generate hypotheses, which guide the design of one's observations or data-collection strategies.
- *Executing strategies to gather information or collect data*. When solving information problems, students need to carry out their planned search strategies and iteratively revise those strategies as needed depending on the quality of results obtained, whereas in scientific inquiry, one conducts experiments or makes observations in order to obtain evidence that either supports or refutes a specified hypothesis.
- *Evaluating information*. In information-seeking tasks, students evaluate information resources with respect to common criteria, such as relevance to one's goals and the reliability and credibility of sources. In scientific inquiry, such evaluation tends to be conducted in the service of constructing an argument, paying attention to relationships between claims and evidence, and how evidence either supports or refutes one's tentative claims about the world.
- *Communicating and presenting results*. Both types of activities require students to represent their new knowledge in some way and to share the results of their research with others.

Indeed, some science education researchers consider the above information-seeking activities to constitute a subset of or complement to the practice of scientific inquiry (e.g., Windschitl, 2008), a view supported by the NRC's (2012) *Framework for K-12 Science Education*, in which obtaining, evaluating, and communicating information is included as one of the practices involved in science inquiry. In addition, these steps are largely consistent with the inquiry arc described in the *C3 Framework for Social Studies* education (NCSS, 2013). In line with Julien and Barker's (2009) analysis, we consider the processes of locating information sources and developing and testing hypotheses to be complementary activities, which students might engage in differentially depending on the specific goals, requirements, or context of a particular investigation. Importantly, inquiry tasks on scientific topics might require students to engage in both direct experimentation or observation and the extraction of relevant evidence from text or multimedia materials, whereas inquiry in a historical context might be more reliant on the use of extant documentary evidence, requiring students' textual analysis and argumentation skills (cf. Perfetti et al., 1999; Rouet et al., 1996; Wiley & Voss, 1999). Argumentation is particularly important in the practice of research and inquiry across disciplines: scientific argumentation is a social, collaborative process that is critical in science inquiry (Duschl & Osborne, 2002; Latour & Woolgar, 1986) as well as history (Wiley & Voss, 1999).

Students' argumentation skills might be appropriately implicated in both scientific and historical inquiry tasks, given that one must defend one's claims or conclusions using evidentiary support in both disciplines, though the specific disciplinary standards for evaluating or incorporating evidence into one's writing might vary (Britt & Rouet, 2012; Goldman et al., 2011; T. Shanahan & Shanahan, 2008). It is worth noting that one might not represent the results of all inquiries in the form of an argument, but perhaps as a summary, an explanation of an event or phenomenon, a narrative account, or some other product, such as an informational website. It is also clear that developing a driving question, planning and carrying out an investigation, drawing conclusions, and using evidence to support one's conclusions are common features across scientific and historical inquiry tasks in addition to general IPS tasks. In the next section, we discuss features of IPS tasks that are specific to conducting research in online contexts.

Inquiry and Information Gathering in Online Contexts

In addition to the skills associated with scientific and information-literate inquiry described previously, it has been suggested that several unique processes may be specifically recruited when engaging with Internet resources. For example, some have argued that the digital information age requires the development of new literacies (Leu, Kinzer, Coiro, Castek, & Henry, 2013; New London Group, 1996) for locating and successfully building meaning from the relatively small subset of reliable information sources scattered among the multitude of input available via the Web. These digital literacy skills include effectively using search engines and digital databases to locate sources, critically evaluating information as a function of its content as well as its source; dealing with multimedia resources—texts of various genres and purposes, video, audio, photos, animations, and advertisements; constructing a deep, coherent understanding of those resources; and interacting with and synthesizing those resources in order to transform them into one's own creations and productions, which can be communicated and shared with others via traditional and emerging methods and technologies (Coiro & Dobler, 2007; Coiro & Kennedy, 2011; Gilster, 1997; Goldman et al., 2010; Lawless et al., 2012; Leu et al., 2013). In particular, these perspectives assert that the nature of what it means to be literate in the 21st century necessarily includes these additional skills (Lankshear & Knobel, 2006; Leu et al., 2013), given the ubiquity of using online resources from a diverse range of sources to answer questions and solve problems in our everyday lives (Kovach & Rosenstiel, 2010; Metzger, Flanagin, & Zwarun, 2003). As literate practices change in response to technological and societal developments, definitions of the literacy construct must also evolve to reflect the nature of those practices as they unfold in the everyday experiences of literate individuals (Coiro, 2003; Lankshear & Knobel, 2006; Leu et al., 2013), consistent with situated cognition perspectives (e.g., Brown et al., 1989; Lave, 1988). This evolution includes attention to contemporary genres, contexts, and purposes for reading and writing, which, by virtue of its current ubiquity, includes the Internet.

Students' Difficulties With Conducting Online Inquiry

Students often lack experience with many of the subtasks involved in using online resources to conduct inquiry research projects (Eagleton & Guinee, 2002). Students enter the classroom with little previous experience with the following tasks: choosing an appropriate topic, audience, and purpose for the assignment; accessing relevant background knowledge; envisioning or planning for the final product of one's inquiry; specifying research questions; recognizing useful information; gathering and synthesizing information; assembling information into a written product and revising that product; and presenting information to an audience. Using the Web for research tasks poses particular challenges for developing students (Bilal, 2000, 2001, 2002; Braasch et al., 2009; Henry, 2006; Hirsh, 1999; Hoffman, Wu, Krajcik, & Soloway, 2003; Kafai & Bates, 1997; Kuiper, Volman, & Terwel, 2005, 2009; Large & Beheshti, 2000; Lorenzen, 2001; Rouet, 2006; Rouet & Coutelet, 2008; Schacter, Chung, & Dorr, 1998; Wallace, Kupperman, Krajcik, & Soloway, 2000). Therefore, students' proficiency with online inquiry skills varies widely (Kiili, Laurinen, & Marttunen, 2008). Students' difficulties with conducting online inquiry may be due to a lack of familiarity with or strategic knowledge about particular steps in the inquiry process (Guinee, 2004), as well as developmental constraints on their reading skills (Lorch, Lorch, Gretter, & Horn, 1987; Rouet & Eme, 2002).

Kuiper et al. (2005) presented a review of literature from information literacy and education perspectives examining Web search and information-processing behavior of upper elementary and middle school children. Based on their summary of 24 empirical studies, the authors characterize students' interactions as demonstrating the following characteristics:

- A preference for using a browsing strategy (defined as "skimming over information and selecting choices"; Borgman, 1995, p. 666) rather than using directed keyword searching strategies
- Difficulty in formulating appropriate search keywords to locate information effectively
- A limited tendency to explore a variety of sources and frequent reliance on familiar or well-known websites
- Little patience for reading through long lists of search results, and disengagement or boredom when encountering large amounts of text
- Difficulty with reading and comprehending extended texts, due to complexities in text structure and lack of clear formatting (e.g., headings and advance organizers)
- A focus on collecting and accumulating factual knowledge about a topic rather than thinking about how the information could be applied to the task
- A tendency to search for a single correct answer (Bilal, 2001); for example, Wallace et al. (2000) found that sixth grade students tended to view an online science inquiry task as one of finding the right answer or finding an ideal website rather than one of using evidence gathered from multiple resources to construct an answer to an inquiry question
- A tendency to revise one's research question when literal answers are not readily obtained, rather than revising one's search strategy to obtain more relevant or useful results
- Little attention to reading, processing, and analyzing the information found
- Difficulty in evaluating the relevance of Web information for one's purposes (Bilal 2000, 2001; Hirsh, 1999; Large & Beheshti, 2000); in particular, Kafai and Bates (1997) concluded that as children develop from first through sixth grade, they are better able to explain why a website is useful or not, while younger children can only indicate whether or not a website is useful
- Difficulty in attending to and evaluating the reliability of Web information, with little attention to authority, expertise, credibility, and trustworthiness (Hirsh, 1999, Wallace et al., 2000)

Given these difficulties, Kuiper et al. (2005) concluded that educators can support elementary and middle school students in conducting online research in the following ways: help students to develop critical thinking skills, including how to assess the relevance and reliability of online information given a particular assignment or research question; help students acquire searching skills; provide reading strategy instruction specific to reading extended and discontinuous text on the Web; engage students in critical thinking about the visual/multimedia nature of Web texts and their consequences for understanding and communicating; engage students in conducting inquiry-based assignments that require searching for information online; and take into account the student and task characteristics that influence students' choice of information search and other online inquiry strategies.

The Centrality of Reading Skills for Online Inquiry

The vast amount of information available and the absence of an obvious linear structure on the Web pose particular challenges for poor readers (Coiro, 2003) who not only lack patience for wading through lengthy online texts, but also may lack the decoding, vocabulary, or comprehension skills necessary to effectively navigate, process, and evaluate information from online sources, where it is especially important to question the accuracy of the content and the motives of the author (Coiro & Dobler, 2007). Conducting inquiry from online sources, according to Kuiper et al. (2005), is "a question of reading critically—reading and simultaneously evaluating the relevance and reliability of what you are reading" (p. 305).

The importance of selecting appropriate information resources, and being able to read and evaluate those resources as a function of their source characteristics, was further emphasized by Goldman et al. (2011), who presented a model of multiple-source comprehension developed for the purposes of building assessments of deep comprehension of texts. This model was designed to capture the important elements of the domain of multiple-source comprehension specific to the context of historical and scientific inquiry tasks. Derived using an evidence-centered design approach (Mislevy, Almond, & Lukas, 2003; Pellegrino, Chudowsky, & Glaser, 2001), the model specifies the knowledge and skills that students should be able to demonstrate as evidence that they are proficient with some aspect of inquiry from multiple sources (i.e., interpreting the inquiry task, searching for and gathering resources, attending to and evaluating documents' source information, interpreting and synthesizing information from sources, and applying information extracted from sources to achieve one's task). The authors emphasized sourcing, searching for, and selecting resources and interpreting and

synthesizing resources as activities in the model that are more distinctly characteristic of multiple-text versus single-text reading situations (Goldman et al., 2011). We return to this model in the section on analyzing, evaluating, and synthesizing multiple sources. Next, we focus on a critical aspect of source selection—namely, the ability to identify information relevant to a topic.

Students' Reliance on Cues to Information Relevance

To successfully select information resources that will be useful for a particular task requires inquirers to attend to and integrate multiple cues to textual relevance (Rouet, 2006). However, as noted by Kuiper et al. (2005), young children's conception of relevance is limited, which might lead to difficulty in subsequent inquiry activities. Consistent with analyses of adults' relevance judgments (Xu & Chen, 2006), Hirsh (1999) observed that fifth-grade students were most reliant on the criteria of topicality and personal interest when searching for information in a constrained research task, with a shift toward reliance on novelty of information as work on the project progressed and students focused on finding information that filled gaps in their expanding knowledge of the topic (cf. Kuhlthau, 1997). However, these students mostly relied on the titles or summaries of documents (i.e., abstracts in bibliographic records or summaries from a list of search engine results) when making judgments of topicality, and they had difficulty detecting relevance when titles were nonliteral or did not explicitly refer to the research topic (see also Kafai & Bates, 1997). Some students overlooked resources that did not directly match their research topics, leading Hirsh to characterize them as "concrete thinkers [who] have trouble with anything that is not an exact fit with their understanding of the question" (p. 1279).

Cues to the relevance of information include both surface cues and deep semantic cues, which in the context of a search engine results page, could involve bolded search keywords or use of phrases associated with—but not explicitly matching—words used to describe the topic (Rouet, Ros, Goumi, Macedo-Rouet, & Dinet, 2011). In a set of experiments, Rouet et al. (2011) showed that fifth-, seventh-, and some ninth-grade students are sensitive to surface features of search results, being more likely to select website titles that emphasized matching keyword terms but that were irrelevant to the topic upon deeper semantic inspection. In contrast, 12th-grade students were able to overlook misleading surface features and to select websites purely on the basis of their semantic relevance (i.e., their "aboutness"; Xu & Chen, 2006, p. 962). Prereading to build knowledge of the topic prior to selecting resources reduced fifth and seventh graders' reliance on surface cues, but only for good readers who were able to successfully comprehend the prereading text and apply what they had learned from that text to constrain their search. Specifically, good readers who engaged in this prereading task were less likely to select semantically irrelevant websites with cued surface features (capitalized search keywords in the title), and both fifth and seventh graders were able to profit from this intervention. Poor readers will likely require alternative supports to develop their skill in selecting sources on the basis of topical relevance, as prereading scaffolds are insufficient for helping these students make appropriate choices among alternative information resources.

Development of Strategies for Locating Relevant Information

Students can effectively employ strategies for locating relevant information, though their preferred strategy seems to follow a developmental trajectory from random browsing and linear reading to top-down, goal-driven use of text organizers, headings, and other elements of document formatting (Rouet, 2006). When locating information in texts, third graders primarily use a linear reading or browsing strategy; fifth graders prefer use of tables of contents, document headings, and topic sentences; and seventh graders tend to use the index to look up the topic of interest (Rouet & Coutelet, 2008). Thus, a progression from more linear reading strategies to more top-down, relevance-driven location strategies is apparent as students develop metatextual knowledge about how structural features such as headings, tables of contents, and indices function in texts (Rouet & Eme, 2002). However, although students can rely on these organizers and headings when locating information within books, it is more difficult to apply these strategies to reading Internet texts due to differences in the types and consistency of headings and organizational cues across different websites (Large & Beheshti, 2000). Even with the development of metatextual knowledge relevant to hypertext environments, limited topic knowledge, including knowledge of topically related vocabulary, constrains the ability to identify information as relevant at a deeper semantic level (Rouet et al., 2011) if it does not match the topic-related terms the student has in mind. Unfortunately, opaque titles are common on the Web, making it easier for children to be misled or to mistakenly classify information as irrelevant (Kafai & Bates, 1997).

Difficulty locating relevant information can lead students to feel frustrated with the research process (Large & Beheshti, 2000), particularly when students have something specific in mind but are having difficulty locating that information. Instruction in specific search strategies, such as how to combine multiple terms to limit search results or how to use quotation marks to locate verbatim phrases, might be helpful in reducing such frustration (cf. Kuiper et al., 2005). Specifying appropriate search keywords is critical for locating relevant and reliable information, but selection of keywords is constrained by an earlier step in the inquiry process—specifying research questions to be investigated. Literature related to students' skill in generating research questions is addressed in the next section.

Asking Driving Research Questions

Developing driving questions represents a critical first step in science inquiry, and the types of questions that students ask can be used as evidence of students' thinking (Yarden, Brill, & Falk, 2001). Questions such as *What do you think about this? What would you like to know?* and *How will you find out?* are considered to serve as an initial foundation for engaging students in an inquiry (Kuhn & Dean, 2008). However, the questions that students propose to investigate must be framed appropriately to support the task of research. Specifically, engaging students in inquiry requires first ensuring that students understand inquiry as a process of "seeking information that will bear on a question whose answer they do not already know" (Kuhn & Dean, 2005, p. 867). Otherwise, such activities might be misinterpreted as attempting to collect evidence to reinforce one's existing knowledge or to simply look up answers to straightforward, factual questions (Kuhn & Dean, 2005, 2008). While obtaining answers to simple factual questions may be an important component of building knowledge about a topic, such questions may not require multiple sources to obtain a reliable answer and are therefore not rich enough to support a sustained inquiry. Therefore, students must understand the need to formulate a question as well as how to develop effective questions that are appropriate for research. This may include both descriptive questions, which can be explored by making systematic observations and comparisons without directly manipulating variables, and relational questions, which examine associations between variables or phenomena and employ experimental designs to compare and contrast multiple levels of those variables to evaluate the nature of those relationships (Krajcik et al., 1998). Further, when students conduct online inquiry with a clear driving question in mind, their searching and reading is more meaningful (Burbules & Callister, 2000), as these processes are enacted from the perspective of locating answers to specific questions or solutions to certain problems.

Challenges in Generating and Evaluating Research Questions

Evidence suggests that middle school students have difficulty formulating appropriate questions and judging the appropriateness of others' questions (Hoffman et al., 2003). Specifically, Krajcik et al. (1998) observed that seventh graders have difficulty assessing the scientific value of questions due to a lack of background knowledge, relying instead on personal experience, preferences, or uniqueness (i.e., distinctiveness of a question from the ones being investigated by other student groups) as criteria for choosing a question to investigate. Students' questions were often driven by available tools or instrumentation (i.e., feasibility and access to equipment) rather than by an analysis of what is known, unknown, and necessary to find out about the research topic. Students failed to consider how the evidence being collected would relate to their driving question or to particular predictions. Scardamalia and Bereiter (1992) observed that students in fifth and sixth grades tend to construct low-level, factual questions rather than questions that can meaningfully extend their knowledge of a topic. Students' feedback on their peers' questions also tends to be superficial and not particularly constructive (Scardamalia & Bereiter, 1992). Building adequate topic knowledge is critical to enable students to ask good questions. Krajcik et al. (1998) concluded that inquiry activities should provide sufficient time for students to explore and locate relevant background information in order to support them in evaluating the appropriateness of their questions and in generating specific hypotheses and predictions from those questions. However, even undergraduates have difficulty distinguishing descriptive and relational (causal) questions (Lawson et al., 2000), suggesting that knowledge of the types of questions one might ask about a research topic is important for effective inquiry, beyond simply learning more about the topic.

Supporting Students in Generating Questions

Because of the difficulties students experience with posing research questions, some scholars suggest that question generation should be constrained. Kuhn & Dean (2005) argued that using prompts or templates can help students to manipulate

or examine a single factor at a time, making their inquiries more manageable and more likely to yield appropriate causal inferences in later phases of inquiry. Constraining student questions in productive ways can help them to focus on important elements of the research question being investigated, such as relationships among key variables (Kuhn & Pease, 2008). However, it is important not to constrain students' questions too strictly, particularly in online contexts. Self-generated questions appear to facilitate better online inquiry performance relative to assigned or imposed research questions (e.g., Bilal, 2001, 2002; Dresang, 1999). This finding suggests that it is important for students to generate their own research questions, despite the associated challenges, to support students' engagement with inquiry activities. As noted above, students' questions are constrained by their prior knowledge of the research topic; therefore, encouraging students to access and build on their relevant knowledge prior to question generation can support better formation of research questions with a clear goal. Evidence also suggests that middle school students can develop and research workable, appropriately worded driving questions with appropriate instructional supports, such as making explicit connections between question generation and the overall purpose and goals of the inquiry task (Kuiper et al., 2009). Having a deeper sense of the purpose of a research question—to inquire about an aspect of the topic for which they lack adequate knowledge or evidence, to enrich their understanding, or to aid in solving a problem—might help students better formulate and revise their questions.

Questioning as a Metacognitive Inquiry Process

Others have characterized questioning as a central element of the research process (e.g., Burke, 2002; Moore, 1995). According to Burke (2002), students must engage in continuous questioning when learning how to "read" online texts, including such questions as *What do I want to know? For what purpose?* and *What do I need to find out to answer my questions?* This attention to purpose, or task-oriented relevance (Rouet & Britt, 2011), might help students avoid getting lost or disoriented when using the Web to gather information (cf. Kuiper et al., 2005). In this case, questioning serves a metacognitive or self-regulatory function that helps students regulate their behavior throughout the inquiry process. We return to a discussion of the metacognitive aspects of conducting inquiry in the final section of the literature review.

Analysis, Evaluation, and Synthesis of Multiple Sources

We have conceptualized the practice of research and inquiry as one involving the extended analysis, evaluation, and synthesis of multiple sources of information, including texts and documents. The integration of multiple resources poses some distinct challenges in contrast to reading and learning from single texts; we review current research on the skills required for multiple-text comprehension below.

Cognitive Models of Multiple-Document Reading Comprehension

Scholars have argued that reading and writing from multiple sources requires more complex skills than does single-text comprehension (e.g., Goldman, 2004). In the case of multiple sources, the distinct texts are written by different authors, often writing for different purposes; texts may contain different levels of cohesion, may contain different text structures, and may demand greater or fewer knowledge-based inferences of the reader (e.g., O'Reilly & McNamara, 2007). In addition, there are often no explicit links and connections across texts, so the reader has to infer them by recruiting prior knowledge and making cross-text comparisons (Britt & Aglinskas, 2002; Perfetti et al., 1999; Wineburg, 1991). Therefore, multiple source understanding may demand different and potentially deeper cognitive processing as compared to comprehension of single texts.

The Documents Model

Expert performance in comprehending multiple documents is characterized by building a coherent mental representation or *documents model* (Perfetti et al., 1999), which captures the content of the documents and relationships among their content (situation model) as well as information about the documents' sources (e.g., author, publication venue, date, or document type information; document nodes), which content was provided by sources (e.g., according to Jones, from the *New York Times*—source-content links), and the relationships among those sources (e.g., agrees with, disagrees with, responds to, refutes, reinforces, replicates; source-source links). However, this model characterizes how multiple sources

on a topic might be represented in memory (i.e., with important or distinctive content being more likely to be associated with or linked to source information). That is, it describes the nature of the product of multiple document comprehension rather than the cognitive processes that might be involved.

The MD-TRACE Model

In a major extension of the documents model framework, Rouet and Britt (2011) proposed the MD-TRACE model, which describes both the processes and products involved in constructing a documents model (Perfetti et al., 1999), particularly in the context of a specific task or assignment (e.g., writing a research paper from sources, writing an argument in favor of one causal explanation for an event, etc.). This model describes multiple document comprehension in the context of inquiry tasks as a process involving five steps. The following steps may be cycled through in an iterative fashion until all information needs and task goals are satisfied (Rouet & Britt, 2011):

1. creating (or updating) a mental model of the task and associated goals and criteria for successful task completion;
2. assessing information needs, based on the quantity and quality of one's prior knowledge about the topic, including asking questions that need to be answered;
3. interacting with documents, which involves
    a. locating and selecting relevant information resources,
    b. reading and comprehending the resources, constructing a mental model of their contents, and
    c. creating (or updating) a documents model encoding the relationships among multiple documents with respect to content and source-based links;
4. applying the information learned from sources to create (or update) the required task product or artifact (e.g., an argument in support of a particular position); and
5. evaluating the task product with respect to goals, requirements, and criteria for successful completion.

The MD-TRACE model treats task-based or goal-based relevance considerations as a central feature of interacting with multiple documents, consistent with a relevance framework (cf. McCrudden, Magliano, & Schraw, 2011). Research from this perspective has demonstrated that task goals or instructions for reading have an important influence on reading comprehension in that such goals help define what information is relevant to attend to (McCrudden, Magliano, & Schraw, 2010) with consequences for memory and recall (Pichert & Anderson, 1977). Goals for reading also impact the reader's standards for building a coherent understanding of the information (Linderholm & van den Broek, 2002; van den Broek, Lorch, Linderholm, & Gustafson, 2001). That is, task goals can influence what readers attend to during reading, which influences what they remember from the text, in addition to influencing the amount of effort that students exert in order to deeply understand text content, with reading to study leading to greater coherence-building processes than reading for entertainment (van den Broek et al., 2001). These relationships suggest that task goals have an important influence on readers' comprehension and learning from texts. The influence of task is especially important in multiple-text reading tasks.

Task-oriented reading as described in the MD-TRACE model is exemplified by activities such as reading in order to write a synthesis (Spivey & King, 1989) and is consistent with constructs such as online reading comprehension (Coiro & Kennedy, 2011), online inquiry (Hoffman et al., 2003; Wallace et al., 2000; Zhang & Quintana, 2012) and information problem solving (Brand-Gruwel et al., 2005; Moore, 1995; Raes, Schellens, de Wever, & Vanderhoven, 2012) as used in educational and information sciences literatures, where students' conception of the task they are engaged in, what information is needed to address that task, and how to go about obtaining, evaluating, and using that information figure in a range of models and frameworks. Despite this iterative reading and evaluation process, many students, including undergraduates, have a tendency to simplify complex and open-ended inquiry tasks, treating them as a task of seeking a single answer to a constrained question and looking for a single source that might straightforwardly reveal the desired answer (Wallace et al., 2000; Wiley et al., 2009). Full engagement in multiple-source inquiry tasks involves the use of multiple strategies; research on these strategies is described in the next section.

Strategies That Support Comprehension of Multiple Documents

Research has attempted to describe strategies that support successful comprehension and integration of multiple sources. For example, in a landmark study of historians' reading of multiple documents, Wineburg (1991) identified three heuristics

that expert historians used when making sense of a historical event: sourcing, corroboration, and contextualization. Sourcing involves attending to and evaluating the source of a document prior to reading the content, as well as using the source to help interpret the contents of a document, including evaluating authors' perspectives and biases and their influence on the presentation of ideas. Corroboration involves comparing information across two or more sources or comparing information between sources and one's prior knowledge, including comparing perspectives, identifying consistencies or discrepancies between perspectives, and identifying consistencies or discrepancies between the content of different documents. Corroboration is thought to be critical to strategic processes that support the creation of an integrated understanding of multiple sources (Bråten, Britt, Strømsø, & Rouet, 2011). For example, Kobayashi (2009) found that when undergraduates read a set of two texts that presented conflicting views on a topic, those students who spontaneously wrote notes that indicated the relationship between the two sources were more likely to demonstrate improved comprehension of the relationships between the texts (indicative of a more elaborated documents model; Perfetti et al., 1999). Further, spontaneous construction of notes that summarized the individual texts predicted recall of the arguments contained in the texts as well as cross-text comprehension, suggesting that prompting students to construct summaries of texts they encounter in their research will facilitate comprehension of relations across multiple, conflicting texts (Kobayashi, 2009). Thus, corroboration strategies can contribute to improved comprehension (Bråten, Britt, et al., 2011; see Gil, Bråten, Vidal-Abarca, & Strømsø, 2010a, 2010b). Contextualization involves situating a document within the sociohistorical context in which it was produced, including publication date. Contextualization is most important for historical inquiry (NCSS, 2013) and is related to considerations of perspective-taking and judgments of relevance.

Evaluating the Usefulness of Information

Discussions of relevance in multiple-document contexts often refers to the degree to which information is perceived to be useful for completing a particular task or achieving a goal, or task-based relevance (McCrudden et al., 2011; Rouet & Britt, 2011). But what factors comprise judgments of relevance? Evidence from factor analyses of adults' situation-based relevance judgments in online information-seeking tasks (Xu & Chen, 2006) indicates that relevance judgments of websites are primarily driven by judgments of topicality (whether the text is about the targeted topic) and novelty (whether the text provides novel information about the targeted topic). Reliability (i.e., accuracy, consistency with facts) and comprehensibility of the content were also significantly related to judgments of relevance, but to a lesser degree than topicality and novelty. These four factors or dimensions correspond to the Gricean maxims (Grice, 1975) of relation (be relevant), quantity (be informative but not too informative), quality (do not say things for which you have no evidence), and manner (communicate so that you are able to be understood). Topicality and novelty can be thought of together as roughly "informativeness," or the degree to which a source provides new, unique information that is about the topic of interest (Xu & Chen, 2006, p. 970).

However, when thinking about supporting students in developing their multiple-document inquiry skills, this notion of relevance must be extended from a conception of relevance as giving new information about a topic to one of task-based relevance, where the primary question learners should ask themselves is not *Is this information new to me?* but rather *Is this information useful for completing my task goals?* This potentially more complex conception of relevance cannot be achieved until a student first understands that relevant information must truly be about the topic rather than containing words that are associated with or correspond to words used in describing the topic (i.e., keyword overlap). Arguably, the conception of relevance as including both topically related and novel content—that is, contributing information that fills a knowledge gap or extends one's understanding—is an intermediate position between mere topical relevance and task-based relevance.

Evaluating the Reliability and Credibility of Information Sources

Although students have some success in evaluating relevance, evidence suggests that evaluation of the reliability of sources is more difficult for them, despite an early developing ability to evaluate information sources. Developmental cognitive research reveals that children as young as ages 3–4 can distinguish among reliable and unreliable sources (i.e., adults). When children reach age 3, they display a marked preference for trusting and seeking information from knowledgeable over ignorant informants; they also begin to recognize particular cues to the speaker's confidence (Baldwin & Moses, 2001). For example, in word-learning studies, 3-year-olds who are given a choice between a word-referent link from a knowledgeable speaker and one who explicitly states that he or she does not know yet still offers a guess as to the

word-referent link will reliably learn the word provided by the knowledgeable speaker (Koenig, Clement, & Harris, 2004; Koenig & Harris, 2005a, 2005b). While both 3- and 4-year-olds demonstrate better learning of words from knowledgeable as compared to ignorant speakers, 3-year-olds cannot distinguish between speakers' ignorance and uncertainty (Sabbagh & Baldwin, 2001). Various developments in children's interpersonal abilities or theory of mind (Flavell & Miller, 1998) are thought to contribute to the development of the ability to evaluate the reliability of sources as children grow throughout the preschool years, including skill in making interpersonal inferences (Baldwin & Moses, 2001). Thus, the prerequisite skills for evaluating the sources' accuracy and knowledge emerges from the development of social processes.

Evaluating the Credibility of Texts and Documents

While such findings indicate that children can learn to discriminate among sources in familiar oral contexts at an early age, critical attention to the characteristics of sources of text information, particularly in the case of digital documents, is unlikely to develop without instruction. Research on middle school students shows that they are unlikely to attend to the authority, expertise, or credibility of sources when evaluating their usefulness to a task (Braasch et al., 2009; Hirsh, 1999; Hoffman et al., 2003; Large & Beheshti, 2000). Students are not particularly likely to evaluate the accuracy of information obtained online (Hoffman et al., 2003), though some students acknowledge that the Internet introduces an element of uncertainty about the reliability of information. For example, a sixth-grade girl interviewed by Large and Beheshti (2000) remarked, "Anyone can put anything on the web whether it is true or not. . . . People writing books make mistakes too, but generally the idiots who want to have fun screwing people up put it on the web" (p. 1074). This is perhaps a cynical view from a sixth grader, but it reflects the idea that one must scrutinize the accuracy and the authors' motivations for posting information online.

Sixth-grade students might pay some attention to trustworthiness when evaluating sources online, but those evaluations are limited to the deployment of simplistic heuristics like considering the top level domain of a URL (e.g., .gov and .edu are trustworthy, while .com and .org are less trustworthy; Hoffman et al., 2003). Students generally overlook source features such as accuracy, trustworthiness, bias, and expertise. Notably, even undergraduates tend to overlook information bearing on source credibility, unless given explicit tasks or instructions to consider and apply this information to one's reading (Britt & Aglinskas, 2002; Rouet et al., 1996; Sparks & Rapp, 2011). Rather than relying on evidence of the sources' expertise or potential biases, college students often rely on an evaluation of whether the information is plausible or consistent with their prior knowledge and give no further scrutiny unless a violation is detected (Sparks, 2013).

It is clear that in the service of conducting research, students of all ages must not only comprehend, analyze, and evaluate text content, but they must also consider content in light of the characteristics of its source in order to appropriately build coherent understandings of important concepts by reconciling information from different sources (Braasch, Rouet, Vibert & Britt, 2012; Rouet & Britt, 2011). It may be the case that only higher-knowledge students are likely to engage in critical evaluation of sources in the absence of any specific prompting to do so (Goldman, Braasch, Wiley, Graesser, & Brodowinska, 2012). However, younger students can learn to attend to and evaluate source information with appropriate instruction. For example, a recent study found that fourth- and fifth-grade students learned to evaluate sources' expertise (i.e., *Which source knows more about this topic?*) with instruction that engaged the students in comparing the arguments of two sources that varied in their expertise (i.e., a research scientist or a local resident; Macedo-Rouet, Braasch, Britt, & Rouet, 2013). By requiring students to comparatively evaluate the expertise of sources in order to resolve inconsistencies in text contents, instruction can support students in development of sourcing skills. Another element of attention to sources involves appropriate citation methods; this issue is discussed in the following section describing the final phase in the inquiry process, communicating and presenting one's findings to an audience.

Communication and Presentation of Results

In this section, we describe research on writing from multiple sources, including tasks such as synthesizing the results of multiple sources and citing those sources while avoiding plagiarism.

Writing From Multiple Sources

While models of multiple-document comprehension suggest that "knowledge of the norms and conventions for communicating disciplinary content play an important role" (Goldman et al., 2011, p. 180) in how students apply

information to their task, these models do not explicitly address how genre or disciplinary conventions for writing influence one's task product or what components of students' writing skills might be recruited and required by multiple-source comprehension tasks, particularly when those tasks culminate in written arguments or explanations that respond to inquiry questions. Models from the reading comprehension perspective also fail to specify the types of written or multimedia products that students might be expected to create as evidence of their comprehension and integration of evidence from multiple sources. Beyond writing an argument essay (e.g., Britt & Rouet, 2012), students might be expected to integrate information from multiple sources in research papers, informational brochures, websites, blog entries, newspaper articles, critiques of research articles, annotated bibliographies, abstracts, memos, presentations, posters, and so on. Comprehension models do not provide much guidance with respect to evaluating students' skill in integrating information from sources with different modalities (e.g., integrating text and images, or text and graphs, or data tables); writing well-formed connected text in different genres (e.g., explanation vs. argument tasks); tailoring one's writing for different audiences (e.g., authority figures, community members, teachers, parents, peers, novices, experts, etc.), which requires a consideration of their presumed level of knowledge, interest, and perspective on the topic; or in incorporating references and appropriate citations to the work of others.

Citing and Incorporating the Work of Others

The practice of citation is critical for academic research, which seeks to build knowledge by extending, rethinking, and creatively synthesizing one's own work with the work of others to indicate the important influences on one's thinking and to give credit to the thinking of others (cf. Hyland, 1999). Horn (2001) reviewed several functions of citations in academic writing, including supporting the claim or conclusion one wishes to advance, showing alternatives or counter-evidence to one's conclusions, and giving recognition to the cited author(s). Importantly, Horn suggested that the use of citations to previous works helps the writer not only to connect one's ideas to the ideas of others but also to build a consensus around the validity and strength of a particular conclusion. For example, by citing important and seminal sources in a discipline to support one's conclusions, the writer attempts to communicate the validity of those conclusions from the perspective of that discipline or of a particular theoretical frame. As Latour and Woolgar (1986) put it, there is a credibility-building function of citations in that the objective of citations is to "persuade colleagues that they should . . . accept and borrow this assertion as an established matter of fact, preferably by citing the paper in which it appeared" (p. 81). Citation is therefore an important discourse-level skill that serves both conceptual and social functions; citations can build relationships among claims, evidence, and ideas, and they can also signal belief in the value of an author's work (as evidenced by use of citation-related metrics in academic promotion and tenure decisions). Citation can help claims of knowledge enter a disciplinary discourse, if conclusions or evidence is restated in certain, unqualified terms. Horn (2001) suggested that when writers remove hedges or qualifications from statements cited from other documents, they help that information to be gradually converted from tentative knowledge to knowledge that is generally accepted within a disciplinary community. However, scholars have a tendency to maintain the uncertainties present in original research when they cite it; evidence from linguistic analyses shows that writers retain hedges and qualifications made by the original authors over 60% of the time (Horn, 2001).

It is likely that students beginning to develop their inquiry skills will be less attentive to the nuances of representing the certainty of cited statements and will be likely to err on the side of interpreting and representing knowledge claims gathered from sources as certain, rather than tentative. As noted by Goldman and Scardamalia (2013), authors are sometimes explicit about why they are choosing to include or cite others' work in their own writing (Goldman & Rakestraw, 2000), but when texts lack explicit cues to the author's evaluations of other sources or findings, readers tend to assume that the author believes in the cited source's conclusion and evaluates it positively, consistent with Gricean maxims (Grice, 1975). Thus, the presence or absence of hedges, qualifications, and evaluations of embedded sources can influence readers' interpretation of and belief in the knowledge claims being put forward in ways that might not be explicitly evident to them (i.e., people have a tendency to assume that information is credible unless given indications otherwise, and so they might not notice that such evaluative or qualifying comments are absent). Interestingly, even at the highest levels of professional research practice, writers receive little guidance on how to structure citations or excerpts from other sources. As Horn observed, "[I]t is unfortunate that references on how to write a research article, such as style guides . . . or textbooks . . . usually describe only different format styles for a citation. References do not explain how the citation should be

worded in order to relate the older research to the current work" (p. 1088). Despite these challenges, it is important for students to develop citation skills and, at a more conceptual level, to develop an understanding of how and why one should go about incorporating information from other sources into one's own projects, which is arguably a more critical competency for successfully engaging in a research enterprise than being able to simply provide a list of well-formatted references.

Difficulties in Writing From Multiple Sources

Evidence suggests that students have difficulty with genres of writing that include citing and integrating sources, such as annotated bibliographies and literature reviews, which are commonly required assignments in college courses (Burstein, Elliot, & Molloy, in press). Understanding the elements of these assignments that pose difficulty for students can give some indication of the types of skills and prerequisites that might be addressed in K – 12 education, as emphasis shifts toward an increasing focus on engaging students in research from multiple sources (Coiro & Kennedy, 2011).

Synthesizing Information From Sources

Froese, Gantz, and Henry (1998) summarized issues that early undergraduates often experience when writing literature reviews, which require them to "analyze, evaluate, and creatively synthesize" the published work of others. Common difficulties that students encounter when constructing literature reviews in the social sciences include conceptual inadequacies, such as failing to examine or evaluate the details of a study's methodology or the quality of the evidence provided when reading and extracting information from texts; problems with inferring relationships among variables examined in other studies; misuse of sources, including a lack of knowledge of proper citation practices in the discipline and confusion between primary and secondary sources (see Froese, Boswell, Garcia, Koehn, & Nelson, 1995); difficulty critiquing or evaluating articles in literature reviews and a lack of certainty about whether to include their own opinions in their writing; problems with making relevant comparisons between articles, such as focusing on differences or comparisons between studies that were irrelevant or unhelpful for addressing their research question; failure to appropriately integrate information across sources by drawing intertextual connections — student's literature reviews tend to consist of "knowledge telling" (cf. Scardamalia & Bereiter, 1986, p. 792) in which they summarize articles in sequence rather than integrating them. Issues such as knowledge telling and failure to appropriately synthesize in one's writing are evident in the essays of middle school students as well, with a small proportion of students including synthesizing inferences in their responses to multiple-text inquiry tasks (Goldman et al., 2011).

Avoiding Plagiarism

Developing students' writing is also more likely to be hindered by language issues with respect to both production and comprehension. For example, middle school students tend to look for sources that are comprehensible to them, making it easier to translate or restate information from those texts into their own words (Large & Beheshti, 2000). Despite this criterion, which seems in some ways mindful of the idea that one must paraphrase or otherwise transform information drawn from sources before incorporating them into one's own work, evidence suggests that sixth-grade students believe that by simply retyping the text, rather than cutting and pasting, one avoids committing plagiarism. This reflects an apparent misunderstanding of the concept of plagiarism, which is constrained in part by students' limited vocabulary and topic knowledge. For example, Large & Beheshti (2000) found that some students were more likely to plagiarize from books because "the books use all the good words" (p. 1073), whereas they felt it somewhat easier to translate the more casual language present in some Web texts — particularly those designed for children — into their own words. Transformation of information from multiple sources into students' own language reflects greater conceptual understanding and is a goal of multiple-source integration tasks (Wiley & Voss, 1999).

Clearly, multiple-source comprehension and integration, which requires proficiency with a constellation of reading and writing skills, poses a challenge for students at varying developmental levels. In sum, the multifaceted process of inquiry poses a challenge for many students, as they must demonstrate proficiency with many different skills in order to successfully conduct an extended investigation. In the next section, we discuss the role of metacognition in coordinating multiple aspects of extended inquiry.

Strategic and Metacognitive Influences on Inquiry Skills

Coordinating and strategically deploying appropriate inquiry skills also requires metacognitive and self-regulation skills (Azevedo & Cromley, 2004; Edelson, 2002; White & Frederiksen, 2005). Metacognition can be defined as "one's knowledge concerning one's own cognitive processes or products or anything related to them" (Flavell, 1976, p. 232) and includes both knowledge and regulation of one's own thinking. The importance of metacognition in inquiry has been heavily underscored in approaches to inquiry learning, from the perspective of science education and the learning sciences.

Indeed, mounting empirical evidence shows that individual differences in metacognitive ability (e.g., Coiro & Dobler, 2007; Graesser et al., 2007; Griffin, Wiley, & Salas, 2013; Stadtler & Bromme, 2007, 2008), prior topic knowledge (e.g., Bråten, Strømsø, & Salmerón, 2011), or epistemic beliefs[1] (i.e., beliefs about the nature of knowledge and knowing; for a review, see Bråten, Britt, et al., 2011) can all affect students' performance on inquiry tasks. For example, epistemic beliefs have a demonstrable impact on students' engagement with multiple sources in the context of inquiry tasks. Individuals with an *absolutist* epistemology believe that assertions are facts about the world that can either be correct or incorrect, knowledge comes from external sources, and knowledge is certain (cf. Kuhn, Cheney, & Weinstock, 2000). Those with an *evaluativist* epistemology believe that assertions are judgments that can be evaluated using argument and evidence and that knowledge is generated by human minds and is fundamentally uncertain (Kuhn et al., 2000). In contrast to those with absolutist views, for whom information can be evaluated as correct or incorrect with respect to an external reality, students with an evaluativist epistemology, for whom information must be evaluated through critical thinking, are better able to integrate information from multiple sources in the context of online inquiry tasks (Barzilai & Zohar, 2012; Bråten, Strømsø, et al., 2011). It is important to anticipate and, if possible, account for the influence of such variables on students' assessment performance, particularly in summative contexts. In this section, we review research regarding students' difficulties with metacognitive processes in inquiry contexts and instructional strategies for overcoming those challenges.

Student Difficulties With Metacognition and Self-Regulation in Inquiry Tasks

Metacognitive aspects of inquiry from multiple sources, such as planning, monitoring, and evaluating the results of one's information-based problem solving, pose a challenge for learners of all ages, from children through adults (Walraven et al., 2008). Without strong metacognitive skills, students experience a number of issues with inquiry. In online contexts, some researchers have observed that fifth- and sixth-grade students have great difficulty monitoring the results of their online search processes, failing to record useful URLs or to keep a record of searches that had yielded success (Hirsh, 1999; Hoffman et al., 2003; Large & Beheshti, 2000). Instead, students often reconstructed or repeated their searches, which was particularly time-consuming (Bilal, 2001; Large & Beheshti, 2000) and unnecessary, leading to a significant amount of wasted time (Hoffman et al., 2003). Evidence from work in middle school science classrooms suggests that students do not systematically design and carry out procedures and often fail to plan or to effectively execute plans, forgetting what they have already accomplished (Edelson, 2002; Krajcik et al., 1998). These problems are largely metacognitive in nature; for example, according to Edelson (2002), students' problems include an "inability to recognize when they need to keep records, failure to plan and monitor their progress effectively, and difficulty reconciling conflicting evidence" (p. 113) when conducting scientific inquiry from multiple documents and technological resources.

Students' self-regulatory behaviors also differ from those of expert inquirers. For example, a think-aloud study of differences between the information-problem solving processes of first-year undergraduates and fifth-year graduate students (Brand-Gruwel et al., 2005) found that experts engaged in more frequent regulation of their information problem-solving processes, demonstrating more monitoring (paying attention to one's task performance) and steering behavior (deciding what activities must be performed, including planning and deciding what one should do next) than novices (Brand-Gruwel et al., 2005). These regulation activities are associated with effective and efficient use of problem-solving strategies in project-based learning environments (e.g., Land & Greene, 2000). However, Brand-Gruwel et al. (2005) did not find direct evidence that the graduate students' processes were more efficient per se. Interestingly, both experts and novices frequently used cut-and-paste features to incorporate direct excerpts from Internet texts in their written arguments, though experts were more likely to indicate the source of those excerpts, to make connections between the excerpts and their arguments, and to have overall better writing skills in terms of organization and writing style. It is likely, then, that greater use of self-regulatory strategies is associated with better inquiry performance.

Strategies to Support Metacognition in Inquiry Learning Environments

Research on technologically enhanced inquiry learning environments have demonstrated the value of metacognitive scaffolding in supporting students' inquiry learning in science domains (e.g., Eslinger, White, Frederiksen, & Brobst, 2008; Graesser et al., 2007; Linn, Clark, & Slotta, 2003; Quintana et al., 2004; White & Frederiksen, 1998; Wiley et al., 2009; Zhang & Quintana, 2012). In a review of inquiry learning environments, de Jong (2006) concluded that the most effective of these environments includes tools that scaffold the learning process; prespecified questions or hypotheses and background information on the topic; supports to help students plan and monitor their inquiry process, such as a sequence of assignments; or hints for completing open-ended task components efficiently. As an example, prompts that suggest particular experimentation strategies (e.g., try investigating only one variable at a time; Kuhn & Pease, 2008, p. 523) have been demonstrated to be useful in developing students' scientific experimentation skills—in particular, their learning of the control-for-variables strategy, which is critical in making appropriate causal inferences. Students often fail to apply this strategy without prompting, leading to inefficient and ineffective hypothesis-testing procedures (Kuhn & Pease, 2008).

Using Scaffolding to Automate Low-Level Tasks

Building in scaffolds that support students in the metacognitive elements of inquiry, such as planning, monitoring, and regulating their inquiry processes, can help to free up students' cognitive resources to engage more deeply with the tasks. Thus, in an assessment context, such supports can also provide more precise measurement of students' skills in subtasks where metacognitive deficits might substantially limit students' performance. Zhang and Quintana (2012) presented a recent example of using metacognitive scaffolding to support students' science inquiry learning. Given that students have a limited time in which to conduct inquiry tasks, which require the coordination of different types of knowledge and strategies at different phases, the authors suggested that time wasted with low-level activities detracts from the time devoted to higher order cognitive activities, such as reading and analyzing a set of resources that meet criteria for relevance and reliability. They developed and tested a technology-enhanced notebook tool that automated low-level but memory-intensive tasks (e.g., automatic URL bookmarking and recording of all search histories) but gave students prompts to read, evaluate, and engage strategically with text content. In an extended inquiry task with sixth-grade students, use of the digital notebook was associated with deeper engagement, a greater focus on high-level cognitive activities, more on-task behavior, and better planning and monitoring of inquiry progress compared to a comparison group that conducted online inquiry using a paper notebook to record and monitor their progress. This study suggests that metacognitive scaffolding can support students in conducting deeper inquiries.

Using Scaffolding to Build Understanding of Integrated Inquiry Process

Scaffolding can also support students in understanding the purpose for engaging in the various aspects of inquiry, which is important to the extent that students' understanding of the task they are engaging in constrains and motivates their interactions and engagement with multiple sources (cf. Rouet & Britt, 2011). When instructors make explicit connections between component tasks (e.g., evaluating the credibility of a Web source) and the ultimate project goals (e.g., producing an informative and reliable brochure about healthy eating), middle school students are better able to apply the critical reading skills they learned while constructing their final brochure (Kuiper et al., 2009). This finding suggests that while students struggle with some aspects of inquiry skills, quality instruction (in particular, instruction focused on getting students to understand the relevance of particular inquiry activities for achieving one's purposes or goals) can improve their understanding of the nature of inquiry and thus enhance performance.

Considering Individual Differences in Scaffolding Effectiveness

Providing support is likely to be even more critical for younger or less advanced students, who are more likely to have trouble in inquiry environments that provide minimal guidance or are too open-ended (e.g., Klahr & Nigam, 2004). Qualifying this, though, is research in science education indicating that individual differences such as prior topic knowledge and metacognitive skill influence the scaffolding's effectiveness, such that some learners are able to benefit more than others from certain types of scaffolding (e.g., Bulu & Pedersen, 2012; H.-S. Lee & Songer, 2004). A study of over 300

sixth-grade students using a scaffolded hypermedia learning environment found that students with high knowledge and metacognitive skill (i.e., students with ample mental resources to engage with task content and to monitor and regulate their own thinking) appear to benefit little from scaffolding, whereas students with low knowledge or metacognitive skill do seem to benefit from the use of scaffolds during complex problem-solving tasks (Bulu & Pedersen, 2012), though some scaffolds might be more effective for knowledgeable students (H.-S. Lee & Songer, 2004). The use of scaffolding, then, must be designed carefully with respect to the characteristics of the population that is intended for a particular instructional unit or assessment.

Knowing Why and When To Use Particular Strategies

It is important to note that merely providing metacognitive scaffolds to support inquiry does not ensure that students can take advantage of them. For example, Edelson (2002) described a design-based research project that introduced a tool called the Progress Portfolio in middle school classrooms to support the development of students' reflective inquiry skills, emphasizing metacognitive elements of inquiry. The Progress Portfolio software consisted of a data camera for capturing images of the computer screen as well as a portfolio for storing, organizing, and annotating those images. After introducing this tool, Edelson (2002)

> continued to observe that students either lack or fail to apply inquiry strategies that would allow them to take advantage of the storage, annotation, and organizational tools we provided. For example, they did not necessarily employ effective strategies for deciding what to record or they failed to look for previously stored resources when they might have helped them. (p. 111)

Thus, simply learning about particular strategies is insufficient to ensure the development of critical thinking and scientific reasoning skills. Students must also develop what Kuhn calls *metastrategic competence*—the ability to reflect on one's knowledge of specific strategies, to organize and manage this knowledge, and to deploy strategies according to one's goals (Kuhn & Dean, 2005; Kuhn & Pease, 2008). That is, students need to develop not only strategies for engaging in inquiry but also the knowledge of why and in what circumstances particular strategies might be appropriate. Understanding why and when to use particular strategies increases the likelihood that a strategy will be deployed appropriately to solve problems; therefore, scaffolding is more likely to be effective to the extent that it can support the development of both strategic and metastrategic knowledge and skills. This kind of scaffolding would be critical for any inquiry learning environment intended to provide lasting knowledge of various inquiry strategies and the way they are deployed in a coordinated fashion to achieve the central goals of inquiry and information gathering; analysis, evaluation, and synthesis; and communication and presentation of results.

Summary

We presented a review of literature relevant to developing a framework of research and inquiry as a key practice in ELA. Consideration of these issues is important in developing designs for assessment tasks intended to provide evidence of students' inquiry skills; therefore, the work reviewed can inform the development of designs for scenario-based assessments that require students to perform a series of progressively more challenging research activities. The use of scaffolds in a scenario-based assessment can also provide more information about test takers, potentially allowing more precision in estimating students' proficiency with particular inquiry skills, which can support targeted instruction of skills in which students have specific difficulties. In the next section, we describe a set of hypothesized learning progressions for research and inquiry that are intended to support the design of such assessments.

Research and Inquiry Learning Progressions

The preceding analysis of research and inquiry as a key practice has resulted in a set of hypothesized developmental progressions, or learning progressions (Heritage, 2008) representing the skills needed to conduct research, with a particular focus on inquiry involving multiple sources (cf. Goldman et al., 2011; Rouet & Britt, 2011). In this section of the paper, we present learning progressions for a number of skills identified as part of our analysis of the key practice conducting

research and inquiry, as described previously. First, we briefly describe the structure of the CBAL ELA competency model (Deane et al., 2015; O'Reilly & Sheehan, 2009; Sabatini et al., 2013). Next, we present definitions of nine key skills associated with the practice of research and inquiry and describe how they are organized with respect to the ELA competency model as well as the phases of inquiry defined in Figure 1. Finally, we present detailed learning progressions associated with each of the nine skills; these learning progressions are presented in tables to provide precise specifications of how student skills might be expected to develop over time. This level of specification is intended to support both assessment development and instruction.

The CBAL English Language Arts Competency Model

The CBAL ELA competency model (Deane et al., 2013; Deane et al., 2015; O'Reilly & Sheehan, 2009; Sabatini et al., 2013) provides several lenses through which to analyze literacy practices, including five modes of cognitive representations and three types of cognitive processes. We apply each of these dimensions in turn to the analysis of the key practice, conducting research and inquiry.

Modes of Cognitive Representation

The CBAL ELA competency model suggests that students need to be able to represent ideas in the social, conceptual, discourse, verbal, and print modes. Each of these types of mental representations is defined briefly.

- *Social mode* refers to representations of people and their communicative purposes and requires students to think of reading and writing as social actions. This mode involves the understanding that all sources and authors have a particular point of view and that this perspective shapes how they understand or present information. Social representations depend heavily on an underlying theory of mind or social cognitive capacity.
- *Conceptual mode* involves the development of knowledge about the world in the form of mental models of concepts and phenomena. Conceptual reasoning involves access to prior knowledge, which is associated with comprehension, inference, logical reasoning, and argumentation. Conceptual representations also involve decisions about how to enrich one's existing knowledge through inquiry and decisions about how to represent information meaningfully. Conducting research and inquiry involves mainly a combination of social and conceptual representations (i.e., relations among ideas and the sources of those ideas).
- *Discourse mode* involves attention to the purposes and forms of texts and other documents. Here, the representations focus on text structure and function, such as the purpose of headings, indices, and other organization functions; ability to make inferences when navigating texts with hyperlinks; and appropriate methods of citing and incorporating information from sources into one's writing. Students' comparison of the structures and functions of multiple documents (e.g., analyses of document type or format) also require discourse-level representations. Therefore, discourse representations are also important for locating and comparatively evaluating information during research.
- *Verbal mode* represents the structure and meaning communicated by language; in the context of research and inquiry, this mode concerns the development and use of specialized vocabulary. These skills are in focus in another key practice, building and sharing knowledge, which emphasizes skills in learning text content and building vocabulary knowledge that are considered prerequisite for engagement in research and inquiry (O'Reilly et al., 2015). Therefore, we do not address the verbal mode in detail.
- *Print mode* involves representations of spelling and writing conventions. Mastery of print conventions often occurs in the early grades, but extended writing as required for the communication phase of research and inquiry necessarily builds on fluency with decoding and transcription skills. For a detailed analysis of the print mode, see Feng, Sabatini, Deane, Sands, and Foley (2015).

According to this analysis, the key practice, conducting research and inquiry, primarily requires knowledge and skills in social, conceptual, and discourse modes. For each of the nine research and inquiry skills, we identify the mode of representation that is most pertinent; these classifications are presented as a part of the skill definitions presented in a later section.

Table 1 Skill Definitions for the Key Practice Conducting Research and Inquiry

Phase	Skill	Definition	Mode
Inquiry and information gathering	Asking guiding questions	Pose and investigate focused questions to explore and build consolidated knowledge of a topic and use this knowledge to answer inquiry questions.	Conceptual
	Testing hypotheses	Engage in hypothesis-testing procedures to evaluate the degree to which data supports one hypothesis over another and explain connections between results and causal explanations for phenomena.	Conceptual
	Locating sources	Set goals and plans for locating useful information resources, differentiate among types of resources, and execute appropriate search strategies to obtain relevant information.	Discourse
Analysis, evaluation, and synthesis	Reconciling perspectives	Identify authors' perspectives, motivations, and biases; use knowledge of authors' perspectives to interpret and evaluate text content; and reconcile disagreements across texts by appealing to differences in perspectives.	Social
	Evaluating sources	Attend to and critically evaluate information as a function of source characteristics, including task relevance, reliability of content, credibility and expertise of authors, and usefulness for one's task.	Conceptual
	Integrating multiple formats	Recognize common information presented in different modalities and formats; recode information in different modalities; produce discussions that draw on multiple forms and formats of evidence.	Conceptual
	Comparing, contrasting, and organizing	Compare and contrast the discourse structure and content of multiple sources on a topic and organize information with respect to salient categories or goal-driven purposes.	Discourse
Communicating and presenting results	Synthesizing research results	Integrate and embed descriptions and evaluations of information drawn from multiple sources into a coherent synthesis to communicate the results of one's inquiries to others and contribute to a developing body of knowledge about a topic.	Conceptual
	Citing and using sources	Understand and explain the use of sources to support claims; use sources selectively to support one's own purposes; and incorporate information drawn from sources in written texts, using summary, paraphrase, and quotation as appropriate.	Discourse

Note. Phase = phase of key practice; mode = Mode of representation from English language arts (ELA) competency model.

Modes of Cognitive Processing

The ELA competency model also distinguishes among three modes of cognitive processing, namely interpretive, expressive, and deliberative processes. Interpretive processes correspond to fluent reading, text comprehension, and evaluation of texts and documents. Expressive processes correspond to fluent written composition, spoken production, or use of other methods to communicate meaning to others. Finally, deliberative processes involve reflective and metacognitive processes that support critical evaluation and strategic decision making. Thus, each of the nine inquiry skills we identify as important to the key practice can be decomposed in terms of its application to reading, writing, and critical thinking processes. This analysis forms a critical part of the organization of the learning progression tables. Though these three cognitive processes are often coordinated in instruction, and in advanced practice, it is important to specify how each skill intersects with the various types of processes, particularly for the purpose of assessment and diagnosis of student difficulties (i.e., are

Table 2 Conducting Research and Inquiry: Learning Progressions Overview Table

Level	Asking guiding questions	Testing hypotheses	Evaluating sources	Integrating multiple formats	Synthesizing research results	Reconciling perspectives	Locating sources	Comparing, contrasting, and organizing	Using and citing sources
Mode	Conceptual					Social		Discourse	
Preliminary	Understands inquiry as a process of finding correct answers to questions	Generates plausible hypotheses and causal explanations for observed data	Evaluates sources on the basis of information quantity and accuracy	Identifies common information between two sources that differ in modality or format	Scans to identify and explain points of agreement/ disagreement between two sources	Identifies and explains an author's point of view and purpose for writing	Uses scanning, browsing, and linear reading patterns to locate exact matches to keywords	Identifies important similarities and differences in content and structure between two texts	Identifies and provides source information for texts when prompted
Foundational	Understands inquiry as a process of exploring a topic and constructing answers to driving questions	Distinguishes between theory and evidence; generates predictions and uses evidence to confirm or disconfirm predictions	Evaluates and uses sources based on topical relevance, novelty of content, visual appearance, or ease of access	Identifies and explains relationships among information modes or formats including unique information	Identifies the use and meaning of embedded sources and can explain relationships among several sources	Distinguishes among primary and secondary sources and identifies similar or different perspectives between accounts	Uses text organizers or structural features to locate and select relevant information for further analysis	Categorizes and organizes multiple texts on the basis of similarities and differences in content, mapping out shared and unique features of the texts	Identifies source attributions using textual cues; includes using informal citations in writing (e.g., "according to", "said")
Basic	Understands inquiry as a process of constructing answers to multiple focused questions through selective use of reliable resources	Executes systematic hypothesis-testing procedures and produces reports documenting hypotheses, predictions, evidence, and interpretation	Evaluates and uses sources based on judgments of reliability and credibility of the author and embeds these evaluations in extended written analyses	Transforms mutually relevant information from one mode to another, in order to aid comparison, integration, or problem solving	Builds coherent interpretations of multiple texts and their relations; writes discussions that cite and explain relationships among multiple texts	Understands notion of subjective bias; recognizes and evaluates how authors' biases and perspectives shape text structure and content	Plans and executes efficient searches for relevant information; uses note taking and record keeping to monitor search results	Classifies and analyzes texts according to features important for one's purposes and produces extended texts using compare/contrast as the organizing structure	Uses bibliographic strategies and provides full citations in writing; uses summary, paraphrase, and quotation as appropriate without plagiarizing

Table 2 Continued

Level	Asking guiding questions	Testing hypotheses	Evaluating sources	Integrating multiple formats	Synthesizing research results	Reconciling perspectives	Locating sources	Comparing, contrasting, and organizing	Using and citing sources
Mode	Conceptual					Social		Discourse	
Intermediate	Understands inquiry as a process of problem solving, using an understanding of the nature of the topic to construct and justify a solution	Constructs a mental model of a causal process from multiple sources and presents that model to others, using topical concepts and evidence to support a synthesis	Evaluates and uses sources based on their usefulness for particular tasks or purposes, including consideration of relevance and reliability given those purposes	Creates products that embed multiple modalities of information, translating the information into appropriate forms for one's purpose and audience	Writes analyses that review and critique multiple texts, identifying areas of consensus, disagreement, or gaps and unanswered questions in the literature	Builds a coherent causal model of events, reconciling differences among sources' content by appealing to the perspectives and context	Executes repeated searches, revising as appropriate; effectively monitors search process to avoid duplicating or repeating searches	Writes analyses of similarities and differences among texts that consider multiple levels of comparison or classification schemes, which may be embedded within a longer text to support one's purposes	Understands and articulates how multiple sources are used to support particular goals or purposes, in the work of others or in one's own written work
Advanced	Understands inquiry as a means of building knowledge which can be applied to answer questions and solve significant problems in a discipline	Produces extended arguments presenting competing hypotheses and data collection methods, analyzing whether evidence favors one hypothesis, and interpreting results given relevant theory or literature	Evaluates and uses sources based on multiple factors, including consideration of relevance and reliability as well as disciplinary or theoretical significance and methodological standards of evidence quality	Produces extended discussions that incorporate multiple modalities and formats, while considering the importance and interpretation of the information from a disciplinary perspective	Presents and supports an original synthesis reviewing and evaluating evidence from relevant literatures, and understands how the article contributes to and extends the current "state of knowledge"	Produces extended analyses of disputable events or situations, which consider effects of bias and perspective on the reliability of accounts, and provides an interpretation that best accounts for the evidence	Uses citation-searching and tracking strategies to uncover related literature and recognize important and seminal sources in a discipline	Applies analogical reasoning strategies to analyze, interpret, and produce extended texts that use comparison, allusion, allegory, or symbolism as elements in an exposition	Selectively draws on seminal and important sources in a discipline; contextualizes information drawn from sources to connect one's work to existing literature and to clarify its contribution to ongoing discourse on the subject

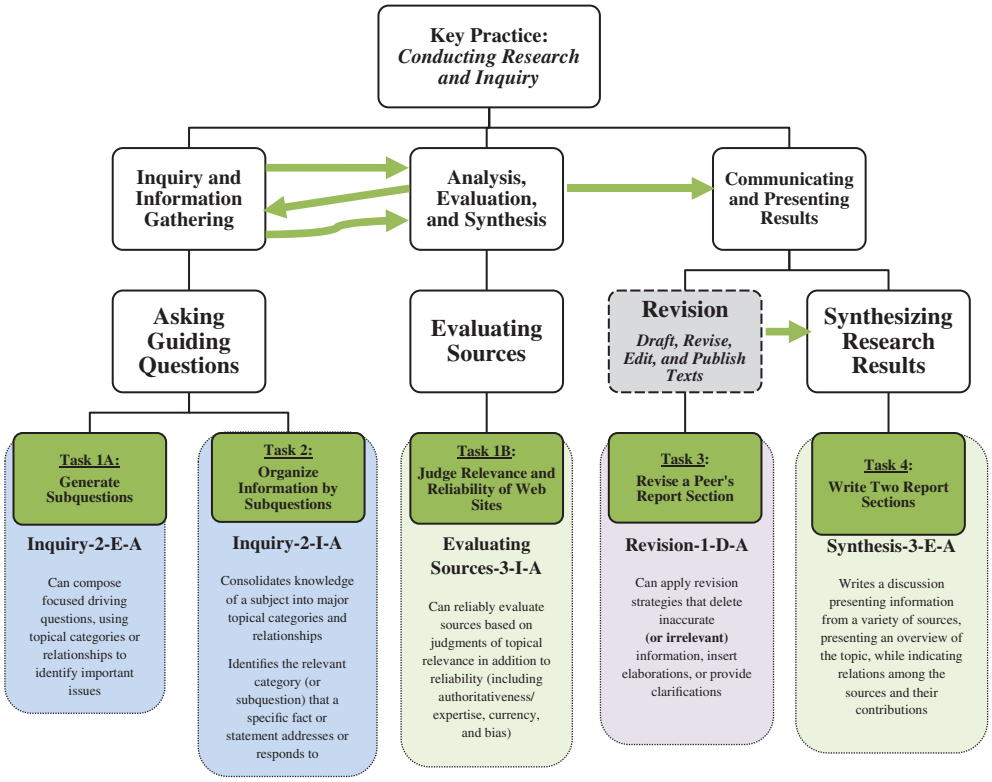

Figure 2 Mapping from the key practice conducting research and inquiry, to assessment structure, to learning progression level descriptors for the CBAL Invasive Plant Species summative form.

difficulties with citing sources due to trouble with writing skills or with students' ability to read and interpret the text). In the next section, we define these skills and outline a structure for the learning progressions, connected to the competency model dimensions described here.

Skills Required for Conducting Research and Inquiry

At the beginning of this paper, we identified three phases of the key practice, conducting research and inquiry: inquiry and information gathering; analysis, evaluation, and synthesis of multiple sources; and communication and presentation of results. On the basis of the literature reviewed previously, we present a set of nine skills that are critical for proficiency with research and inquiry in ELA. Specifically, we have postulated learning progressions for the following skills: asking guiding questions; testing hypotheses; locating sources; reconciling perspectives; evaluating sources; integrating multiple formats; comparing, contrasting, and organizing; synthesizing research results; and citing and using sources.

In Table 1, we present a definition of each of these skills, organized within the context of the three phases of the key practice (see Figure 1). In the rightmost column, we also include the primary mode of representation that performance of the skill involves (i.e., discourse, conceptual, or social). Several of these skills and associated learning progressions are revised from the previous version of the CBAL ELA competency model (O'Reilly & Sheehan, 2009; Sabatini et al., 2013). In addition, we propose two new skills and hypothesized learning progressions, locating sources and evaluating sources, which represent two critical elements of inquiry in online environments (e.g., Bilal, 2001, Braasch et al., 2009; Wallace et al., 2000) that were not well represented the previous ELA competency model. The learning progressions associated with each inquiry skill are presented next.

Hypothesized Learning Progressions

In CBAL research, a learning progression is defined as a description of qualitative change in a student's level of sophistication for a key concept, process, strategy, practice, or habit of mind. Change in student standing on such a progression

Table 3 Hypothesized Learning Progression for Asking Guiding Questions

	Asking Guiding Questions (Inquiry and Information Gathering/Conceptual) *What do I already know? What do I need to know? What do I need to find out more about?*					
	Interpretive		Expressive		Deliberative	
	Achievement	Limitation	Achievement	Limitation	Achievement	Limitation
Preliminary	**Inquiry-1-I-A** Identifies questions that must be answered to satisfy an information need Identifies what information is needed in order to answer questions of interest by considering gaps in existing knowledge	**Inquiry-1-I-L** Ability to identify needed information is constrained by task understanding and topic knowledge; limited ability to identify multiple elements of required information	**Inquiry-1-E-A** Generates and responds to questions of interest by drawing on existing knowledge or available sources	**Inquiry-1-E-L** May have limited ability to explain one's answers or the importance of a question to a given topic; questions generated may be inappropriate for research tasks	**Inquiry-1-D-A** Formulates simple strategies for looking up or finding answers to questions (such as finding a confirming example or randomly browsing until an answer is found) Distinguishes relevant from irrelevant information; known from unknown information	**Inquiry-1-D-L** Inquiry is viewed as locating a specific, correct response rather than generating and justifying a response; may only successfully locate verbatim answers to queries
Foundational	**Inquiry-2-I-A** Consolidates knowledge of a subject into major topical categories and relationships Identifies the relevant category (or subquestion) that a specific fact or statement addresses or responds to	**Inquiry-2-I-L** May have difficulty explaining or justifying one's classifications or going beyond obvious or surface-level categories due to limited domain knowledge	**Inquiry-2-E-A** Composes focused driving questions, using topical categories or relationships to identify important issues Produces paragraph-length responses to inquiry questions	**Inquiry-2-E-L** Driving questions may be too narrow or overbroad; may have difficulty revising questions to the appropriate level of focus without support; responses may lack evidentiary backing	**Inquiry-2-D-A** Uses concept-mapping strategies to identify important topical categories or relationships, to identify gaps in knowledge, and to guide information gathering Distinguishes between driving questions and subquestions	**Inquiry-2-D-L** Inquiry is viewed as exploring a topic; may have a limited understanding of structural (vs. surface) relations among categories

Table 3 Continued

	Asking Guiding Questions (Inquiry and Information Gathering/Conceptual) *What do I already know? What do I need to know? What do I need to find out more about?*					
	Interpretive		Expressive		Deliberative	
	Achievement	Limitation	Achievement	Limitation	Achievement	Limitation
Basic	**Inquiry-3-I-A** Consolidates knowledge about a subject by using multiple question/answer relationships to fill gaps in existing knowledge	**Inquiry-3-I-L** Might have difficulty locating answers to some questions if language or format varies widely across question and source text; questions might not be most important to the topic	**Inquiry-3-E-A** Organizes and presents collected information in terms of multiple question/answer relationships, as in an FAQ-like question/answer structure, dialogue, or chat	**Inquiry-3-E-L** May have difficulty coordinating multiple levels of classification; may have limited ability to explain one's classifications according to one's purpose or goals	**Inquiry-3-D-A** Uses collection strategies in which topic knowledge is used to generate focused questions and subquestions, which are then used to decide what information to acquire and analyze Uses ranking strategies to evaluate the relative importance of questions	**Inquiry-3-D-L** Inquiry is viewed as answering multiple questions; task might be viewed as mere accumulation of facts; organization of questions is constrained by prior knowledge
Intermediate	**Inquiry-4-I-A** Consolidates information about a subject, even if organized in incompatible ways, by recognizing how it is relevant to other known and understood research questions and problems	**Inquiry-4-I-L** Might have difficulty making analogical mappings between problems, especially if mappings are at the level of deep structural similarities vs. surface level	**Inquiry-4-E-A** Organizes and presents collected information using a structure that emerges from consideration of the nature of the specific problem being described Produces extended expositions that present and justify a solution to an inquiry-based problem	**Inquiry-4-E-L** Explanations may include supporting details from text materials, but include little justification of how the information gathered contributes to an understanding of the inquiry problem	**Inquiry-4-D-A** Uses problem-solving strategies (including forward chaining, backward chaining, backtracking, and rethinking the problem) to identify and evaluate information that is necessary to achieve a solution	**Inquiry-4-D-L** Inquiry is viewed as problem solving; may be limited in ability to apply forward-facing problem-solving strategies given lack of knowledge of contexts in which solutions are appropriate
Advanced	**Inquiry-5-I-A** Consolidates information about a subject relative to the disciplinary frame provided by a specific literature or theory	**Inquiry-5-I-L** n/a	**Inquiry-5-E-A** Produces extended expositions describing the results of one's inquiries with explanations connected to a relevant disciplinary or theoretical frame	**Inquiry-5-E-L** n/a	**Inquiry-5-D-A** Uses literature review strategies to identify significant research problems or questions in a discipline and extracts information from multiple sources that answer those questions	**Inquiry-5-D-L** n/a

Table 4 Hypothesized Learning Progression for Testing Hypotheses

	Testing Hypotheses (Inquiry and Information Gathering/Conceptual) *What are the consequences of my ideas? Do they fit the facts? Are there other ways to conceptualize my subject?*					
	Interpretive		Expressive		Deliberative	
	Achievement	Limitation	Achievement	Limitation	Achievement	Limitation
Preliminary	**Hypothesis-1-I-A** Distinguishes between speculation, observed facts, and hypotheses	**Hypothesis-1-I-L** Has difficulty understanding how observed facts relate to (e.g., confirm or disconfirm) hypotheses	**Hypothesis-1-E-A** States simple sentence-length explanations that present a plausible cause for an observation	**Hypothesis-1-E-L** Explanations may confuse correlation and causation; unlikely to be able to explain the causal relationship	**Hypothesis-1-D-A** Deploys hypothesis-formation strategies in which one postulates a cause that could have led to observed facts	**Hypothesis-1-D-L** Suggested causes may not reflect accurate mental models of the relation between causes and observations
Foundational	**Hypothesis-2-I-A** Distinguishes between hypotheses and theories Distinguishes reasons to credit information (observation; authority, inference from previously accepted facts or theories)	**Hypothesis-2-I-L** May be unable to provide evidentiary support that distinguishes theories from hypotheses; has little appreciation of the epistemic status or reliability of different sources of data	**Hypothesis-2-E-A** Writes simple paragraph-length explanations that present a hypothesis, present predictions that follow from the hypothesis, and then provide evidence whether the predictions can be confirmed or disconfirmed	**Hypothesis-2-E-L** Hypotheses may lack appropriate structure, and evidence used to verify predictions is likely to be limited to what is available to students	**Hypothesis-2-D-A** Deploys confirmatory strategies in which one generates a prediction from a hypothesis and then runs some kind of simple test or fact check to see whether the prediction is confirmed	**Hypothesis-2-D-L** Extent of validation of the prediction is likely to be limited and subject to confirmation bias; likely to have difficulty integrating information that contradicts the hypothesis
Basic	**Hypothesis-3-I-A** Infers connections between different parts of a scientific text, identifying hypotheses and predictions, explaining the reason for particular procedures or protocols, and determining whether the results confirm or disconfirm the hypothesis	**Hypothesis-3-I-L** May have difficulty making inferences that go beyond a single text, or that integrate information from other sources (i.e., related literature)	**Hypothesis-3-E-A** Writes extended experimental reports and analyses that document evidence supporting a theory and provide enough information to allow another person to replicate the experiment	**Hypothesis-3-E-L** Reports are unlikely to be situated within a broader theory or model of the topic, rather consisting of knowledge-telling (i.e., listing verbatim what was done)	**Hypothesis-3-D-A** Follows protocol-based strategies that have well-defined procedures designed to control the conditions necessary to confirm or disconfirm a prediction and documents both what one did and what happened as a result	**Hypothesis-3-D-L** The procedures students engage in are likely to be limited by the availability of equipment or resources; investigations may not be quite appropriate tests of the hypotheses

Table 4 Continued

	Testing Hypotheses (Inquiry and Information Gathering/Conceptual) *What are the consequences of my ideas? Do they fit the facts? Are there other ways to conceptualize my subject?*					
	Interpretive		Expressive		Deliberative	
	Achievement	Limitation	Achievement	Limitation	Achievement	Limitation
Intermediate	**Hypothesis-4-I-A** Integrates information from a range of sources (direct observations, simulations, experiments, related literature, and textbooks) and in a variety of formats (including text, graphs, tables, video, and audio) to build a coherent mental model of a causal process	**Hypothesis-4-I-L** Understanding may be coherent but may overlook inconsistencies or caveats as a function of methodology or disciplinary constraints on reliability of data and resulting conclusions	**Hypothesis-4-E-A** Writes a theoretical synthesis describing key terms and concepts in a domain, explaining major causal processes and summarizing supporting experiments and evidence	**Hypothesis-4-E-L** May not effectively address counter-evidence or cases that disconfirm or violate one's conclusions; writing may not reflect full command of required text structures	**Hypothesis-4-D-A** Follows literature-search strategies in which one defines hypotheses that have been advanced and lines of research that have sought to confirm or disconfirm their predictions	**Hypothesis-4-D-L** May be unlikely to have developed the ability to determine what strategies are appropriate for achieving specific goals (i.e., whether a literature search or designing a new investigation is more appropriate)
Advanced	**Hypothesis-5-I-A** Recognizes anomalies and unexpected results reported in a scientific text, using one's knowledge of theory and literature to define appropriate expectations or predictions	**Hypothesis-5-I-L** n/a	**Hypothesis-5-E-A** Writes extended theoretical arguments considering alternative hypotheses and laying out the empirical evidence that would favor one hypothesis over the others	**Hypothesis-5-E-L** n/a	**Hypothesis-5-D-A** Follows hypothesis-testing strategies in which one defines alternative hypotheses that can each account for the facts and devises experiments and procedures that will make it possible to determine which hypothesis best fits the facts	**Hypothesis-5-D-L** n/a

Table 5 Hypothesized Learning Progression for Locating Sources

	Locating Sources (Inquiry and Information Gathering/Discourse) *How am I going to find out what I need to know? What types of resources will give necessary information? How will I locate and find these resources?*					
	Interpretive		Expressive		Deliberative	
	Achievement	Limitation	Achievement	Limitation	Achievement	Limitation
Preliminary	**Locate-1-I-A** Identifies words in a text that are related to a specific topic and can use this to locate necessary information on that topic	**Locate-1-I-L** Understanding of relevance is limited to verbatim/surface matching rather than a semantic relevance	**Locate-1-E-A** Generates topically relevant keywords or phrases that can be used to guide information search	**Locate-1-E-L** Keyword selection is constrained by topic vocabulary knowledge; may have difficulty generating multiple keywords	**Locate-1-D-A** Uses browsing or random walk strategies and scanning strategies to locate and skim sources about a topic	**Locate-1-D-L** Students' search strategies are not well planned or monitored, may be overly linear, or inefficient; unlikely to spend time reading texts closely
Foundational	**Locate-2-I-A** Identifies types of sources that are likely to contain needed information and selectively queries those sources for information Recognizes desired information by using subject directories, etc.	**Locate-2-I-L** Knowledge of different types of information sources is constrained by exposure to and understanding of different source types and limited metatextual knowledge (how texts are organized)	**Locate-2-E-A** Uses knowledge of topically related vocabulary to generate multiple possible keywords or phrases that can be used to guide information search Revises keywords or phrases when they prove ineffective	**Locate-2-E-L** Typing, spelling, and vocabulary skill constrain ability to find appropriate resources; will often repeat the same keywords across multiple searches	**Locate-2-D-A** Uses top-down strategies like table of contents, outlines, or site maps to locate information about an identified topic Uses note-taking strategies to keep track of search strategies that one has tried	**Locate-2-D-L** Use of top-down strategies may not be consistent until basic level; memory and cognitive load limitations affect ability to track one's search strategies; note taking may be limited or lack sufficient detail to retrieve the item again
Basic	**Locate-3-I-A** Can identify and use content information about text (titles and summaries) to make predictions of the relevance of a search result to a given query Can identify search queries that are likely to yield relevant results.	**Locate-3-I-L** May have difficulty coordinating multiple cues to the usefulness of information; predictions may be biased by surface features of text; misleading or nonliteral titles may pose difficulty	**Locate-3-E-A** Composes search queries that use Boolean logic to effectively constrain results Revises overly narrow or broad search queries to improve their effectiveness in retrieving relevant results	**Locate-3-E-L** May not appropriately use quotation marks or other delimiters to constrain search, even when presented with this strategy; may not efficiently and effectively revise search queries	**Locate-3-D-A** Uses top-down strategies like index lookup or directed search to locate relevant information efficiently Applies note-taking and record-keeping strategies to keep track of one's search processes and results, including sources one wishes to analyze further	**Locate-3-D-L** Selection of information is driven by topical relevance and may not effectively consider the usefulness of information for one's goals; may have difficulty inferring relevance of sources to questions if different terms or implicit language are used

Table 5 Continued

	Locating Sources (Inquiry and Information Gathering/Discourse) *How am I going to find out what I need to know? What types of resources will give necessary information? How will I locate and find these resources?*					
	Interpretive		Expressive		Deliberative	
	Achievement	Limitation	Achievement	Limitation	Achievement	Limitation
Intermediate	**Locate-4-I-A** Reliably identifies sources that address similar or related problems or questions Reliably identifies sources that will provide information relevant to achieving one's purposes or satisfying one's information needs	**Locate-4-I-L** Selection of sources takes into account text content but is unlikely to include consideration of reliability or of the reputation and position of sources within a deeper conceptual or theoretical framework	**Locate-4-E-A** Embeds descriptions of one's information-gathering processes in extended expositions that describe the results of one's research	**Locate-4-E-L** Information-seeking process may be unsystematic, or unconnected to a methodological approach; sources may have incomplete coverage of multiple methods or perspectives	**Locate-4-D-A** Follows literature-search strategies to identify sources that have addressed similar problems or questions Applies goal-driven filtering strategies to select information for further analysis if it is relevant to one's goals for information gathering	**Locate-4-D-L** May have difficulty identifying related literature due to failure to look beyond surface text features (e.g., titles) or difficulty inferring connections across sources that use different terms or vocabulary or that come from different disciplines
Advanced	**Locate-5-I-A** Reliably recognizes important and seminal sources within a disciplinary or theoretical perspective and interprets the conclusions of those sources in light of one's purposes or disciplinary perspectives	**Locate-5-I-L** n/a	**Locate-5-E-A** Describes and provides theoretical justification for one's methods for locating and selecting sources for a particular purpose, such as a systematic literature review or meta-analysis	**Locate-5-E-L** n/a	**Locate-5-D-A** Uses citation-searching and source-tracking strategies to locate important and seminal sources within a discipline or theoretical perspective and maps out information that is relevant and useful for one's purposes	**Locate-5-D-L** n/a

Table 6 Hypothesized Learning Progression for Evaluating Sources

Evaluating Sources (Analysis, Evaluation, and Synthesis/Conceptual) *Are my sources useful for my purposes? Are they relevant to my topic? Do they provide reliable information from credible sources?*						
	Interpretive		Expressive		Deliberative	
	Achievement	Limitation	Achievement	Limitation	Achievement	Limitation
Preliminary	**EvaluateSources-1-I-A** Evaluates sources on the basis of accuracy of the content and quantity of information	**EvaluateSources-1-I-L** May have little consideration of the relevance of information to one's goals; evaluations of accuracy are limited to obvious violations of prior knowledge	**EvaluateSources-1-E-A** Generates evaluative statements about sources' content, focusing on accuracy and information quantity	**EvaluateSources-1-E-L** May have limited ability to articulate the nature of the inaccuracy; evaluations default to a belief that adults and printed materials are authoritative sources until proven inaccurate	**EvaluateSources-1-D-A** Deploys evaluation strategies that validate information content from a source against one's prior knowledge or another reliable source	**EvaluateSources-1-D-L** Evaluations of accuracy may be affected by confirmation bias or epistemic beliefs (e.g., printed texts are accurate) and limited to obvious inaccuracies
Foundational	**EvaluateSources-2-I-A** Evaluates sources based on topical relevance and novelty/consistency of content relative to one's knowledge or other sources	**EvaluateSources-2-I-L** Judgments of relevance are based on the title or first page, with little actual reading; limited or inappropriate consideration of reliability	**EvaluateSources-2-E-A** Writes paragraph-length critiques of sources that consider the informativeness (topical relevance and novelty) and quality of the content	**EvaluateSources-2-E-L** Evaluations of relevance are limited to on/off topic, failing to consider the usefulness for one's goals; critiques of sources are driven by content rather than reliability and credibility of the source	**EvaluateSources-2-D-A** Deploys comparison strategies to evaluate two or more sources with respect to their relevance and content and uses this information to guide the choice of sources to examine more closely	**EvaluateSources-2-D-L** Selections of source are driven by a consideration of content, without taking into account source reliability; may select relevant but unreliable sources
Basic	**EvaluateSources-3-I-A** Can evaluate sources based on judgments of topical relevance (to the research question or topic) in addition to reliability and credibility (including authority/expertise, currency, and bias)	**EvaluateSources-3-I-L** Judgments of reliability may be based on superficial cues (.org, .com); may have difficulty explaining one's evaluations in the context of one's goals	**EvaluateSources-3-E-A** Embeds critiques of sources' relevance, reliability, and credibility in extended texts, using this information to interpret information drawn from the source	**EvaluateSources-3-E-L** Critiques include considerations of source reliability but evaluations may be simplistic rather than nuanced; evaluations of reliability may not be important given one's purposes	**EvaluateSources-3-D-A** Applies ranking strategies that differentiate sources by their relevance and reliability and credibility (including authority/expertise, currency, and bias) and can use this information to guide selection of sources to analyze further	**EvaluateSources-3-D-L** May have difficulty differentiating between sources that require coordinating multiple cues to reliability; relations among the sources being ranked are not well understood

Table 6 Continued

Evaluating Sources (Analysis, Evaluation, and Synthesis/Conceptual) *Are my sources useful for my purposes? Are they relevant to my topic? Do they provide reliable information from credible sources?*						
	Interpretive		Expressive		Deliberative	
	Achievement	Limitation	Achievement	Limitation	Achievement	Limitation
Intermediate	**EvaluateSources-4-I-A** Evaluates sources based on their usefulness for achieving particular tasks or purposes, including consideration of relevance and reliability given those purposes	**EvaluateSources-4-I-L** Evaluations of reliability and usefulness may be limited by failure to consider evaluative criteria important for a particular discipline or domain perspective	**EvaluateSources-4-E-A** Embeds analyses of sources' usefulness for particular tasks or purposes in extended texts, such as expositions or annotated bibliographies	**EvaluateSources-4-E-L** Consideration of source usefulness is based on one's own task criteria rather than criteria that would be applied within a particular discipline	**EvaluateSources-4-D-A** Can use mapping, graphing, or other organizational strategies to determine how multiple sources are related and then prioritize them for a particular task or purpose	**EvaluateSources-4-D-L** Organization takes into account usefulness but may lack consideration of the source features that are relevant to evaluating credibility in particular disciplines
Advanced	**EvaluateSources-5-I-A** Consistently evaluates the quality and usefulness of sources based on multiple factors, including consideration of relevance and reliability as well as disciplinary or theoretical significance and methodological standards	**EvaluateSources-5-I-L** n/a	**EvaluateSources-5-E-A** Writes extended reviews and critiques of sources by applying criteria of relevance, reliability, and quality from a disciplinary frame	**EvaluateSources-5-E-L** n/a	**EvaluateSources-5-D-A** Applies analytic and comparative strategies that evaluate sources along multiple dimensions that are relevant for a discipline (e.g., in history, consideration of context, date, perspectives, primary or secondary source, etc.; in science, use of citations and evidence, methodology, validity, and reliability of data)	**EvaluateSources-5-D-L** n/a

Table 7 Hypothesized Learning Progression for Reconciling Perspectives

	Reconciling Perspectives (Analysis, Evaluation, and Synthesis/Social) *Can I account for differences between my sources? How do their perspectives differ? What does the perspective and social context of the source say about its meaning?*					
	Interpretive		Expressive		Deliberative	
	Achievement	Limitation	Achievement	Limitation	Achievement	Limitation
Preliminary	**Perspective-1-I-A** Identifies an author's viewpoint and purpose for writing a text	**Perspective-1-I-L** May have difficulty inferring point of view and purpose when they are not explicitly stated; little attention to cues that reveal perspective or intent (e.g., intended audience or publication venue)	**Perspective-1-E-A** Explains in a sentence why an author wrote a particular text	**Perspective-1-E-L** May have difficulty detecting ulterior motives or hidden agendas behind texts, tending to consider texts as being informative despite the author's purpose	**Perspective-1-D-A** Distinguishes between the author's viewpoint and one's own	**Perspective-1-D-L** Understanding of viewpoint may be limited to familiar positions such as pro/con, like/dislike, and other emotional positions rather than intellectual or theoretical positions or perspectives
Foundational	**Perspective-2-I-A** Using formal features as cues, distinguishes between primary and secondary accounts of events Identifies similar events or actions being described across descriptions or accounts written from different perspectives	**Perspective-2-I-L** May have difficulty holding both perspectives at the same time, if accounts are viewed as either being true or false; unlikely to be able to account for or explain differences in perspectives	**Perspective-2-E-A** Prepares short factual reports that present the common, agreed-upon information across a set of accounts that differ in viewpoint and immediacy	**Perspective-2-E-L** Reports are likely to focus on surface rather than structural similarities between accounts; differences may be noted but not explained and may not be critical differences.	**Perspective-2-D-A** Deploys comparison strategies in which one examines multiple accounts of the same events and identifies shared and contrasting elements	**Perspective-2-D-L** Identification of contrasting elements will be more difficult and more likely limited to surface differences; meaningful discrepancies may be difficult to detect if not explicit (e.g., mentions/does not mention X)
Basic	**Perspective-3-I-A** Recognizes biased and loaded language In general, identifies aspects of a text that represent subjective (questionable) evaluations rather than objective (factual) descriptions	**Perspective-3-I-L** May simply discount biased or opinionated sources rather than interpreting the information content in light of the biases, deepening one's understanding of the topic	**Perspective-3-E-A** Prepares objective reviews of information sources, outlining both the information provided by the source and factors affecting its reliability	**Perspective-3-E-L** Unlikely to adequately explain how the reliability of the source affects interpretation of the content and implications for understanding the topic	**Perspective-3-D-A** Deploys evaluation strategies that consider how an author's perspective and/or bias has influenced the selection and presentation of information	**Perspective-3-D-L** Might have difficulty explaining how information is affected by perspective or bias in nuanced ways, assuming that all information is tainted by any indication of bias

Table 7 Continued

	Reconciling Perspectives (Analysis, Evaluation, and Synthesis/Social) *Can I account for differences between my sources? How do their perspectives differ? What does the perspective and social context of the source say about its meaning?*					
	Interpretive		Expressive		Deliberative	
	Achievement	Limitation	Achievement	Limitation	Achievement	Limitation
Intermediate	**Perspective-4-I-A** Integrates information provided by multiple sources to form an internally consistent (coherent) causal model of events that occurred	**Perspective-4-I-L** Causal models of events may overlook information that contradicts or conflicts with a particular interpretation, lacking nuance; evidence that does not fit this interpretation might be overlooked	**Perspective-4-E-A** Prepares objective reports that combine information from multiple perspectives, making selective use of sources in order to correct for the effects of bias and perspective	**Perspective-4-E-L** May selectively excerpt information from sources without considering how the information fits into a broader disciplinary context or mental model of the issue	**Perspective-4-D-A** Deploys evaluation strategies that examine primary sources and extract evidence that bears on their truthfulness and reliability; deploys evaluation strategies that analyze how secondary sources make use of information from primary sources	**Perspective-4-D-L** Evaluations may not incorporate considerations of rhetorical moves or reliance on authorities within a discipline; evaluations may be insensitive to the criteria which are most relevant given the discipline or context
Advanced	**Perspective-5-I-A** Consistently evaluates the veracity and reliability of accounts, taking into account a variety of factors, including immediacy of knowledge, previous reliability, bias, perspective, and consistency with the testimony of other reliable witnesses or sources	**Perspective-5-I-L** n/a	**Perspective-5-E-A** Prepares written analyses of historical events (or other disputable situations) that consider multiple sources, evaluate competing causal explanations, and determine what interpretation of the events best accounts for the available evidence	**Perspective-5-E-L** n/a	**Perspective-5-D-A** Deploys analytical strategies that map how different sources agree and disagree and trace possible causes for differences in perception of and reaction to the events described, including attention to disciplinary or theoretical frameworks	**Perspective-5-D-L** n/a

Table 8 Hypothesized Learning Progression for Integrating Multiple Formats

Integrating Multiple Formats (Analysis, Evaluation, and Synthesis/Conceptual) *How is this information represented in words, images, and data displays? How can I show this information differently?*						
	Interpretive		Expressive		Deliberative	
	Achievement	Limitation	Achievement	Limitation	Achievement	Limitation
Preliminary	**Integrate-1-I-A** Identifies common information between two representations of the same or similar concepts or ideas	**Integrate-1-I-L** Has difficulty identifying discrepant information; has difficulty identifying common information in the absence of explicit labels or cross-references	**Integrate-1-E-A** Produces short statements that describe how two representations illustrate or give information about the same concepts or ideas	**Integrate-1-E-L** Statements are likely to focus on the most evident similarities; these comparisons are not extended or developed in detail	**Integrate-1-D-A** Applies inference strategies to determine how one type of representation informs or extends the description of a concept represented in a different mode	**Integrate-1-D-L** Can infer relations between representations but has trouble articulating why a particular representation was selected or communicates information in the most appropriate way
Foundational	**Integrate-2-I-A** Identifies unique or discrepant information between two or more representations that present the same or related concepts or ideas	**Integrate-2-I-L** Discrepant information will be more difficult to detect if it must be inferred or goes beyond presence/absence of one aspect in the other representation; may not identify topically important discrepancies	**Integrate-2-E-A** Produces texts that compare two or more representations or descriptions of a concept, describing their common and unique features and how the unique features inform one's understanding of the topic	**Integrate-2-E-L** Unique features described may not be what is most important for understanding a topic; writings are not likely to include explanations that account for differences across representations	**Integrate-2-D-A** Applies comparison strategies that map out common and unique features of two or more representations and uses these to decide how to best communicate about a particular idea or concept	**Integrate-2-D-L** Decisions about how to communicate an idea or concept may not take into consideration the knowledge and values of an audience, but rather what is unique or interesting given the information described in a textual representation
Basic	**Integrate-3-I-A** Recognizes common information and mutual relevance between sources when information is presented in different modes, such as different communication mediums or different formats (text, graphics, multimedia) or is presented in very different words or categories	**Integrate-3-I-L** May have difficulty interpreting or understanding the reasons or justifications for using different presentation modes or language to present information	**Integrate-3-E-A** Produces notes and writings that transform and recast information drawn from sources in terms of familiar opinions, perspectives, categories, and language, to suit one's purposes	**Integrate-3-E-L** Notes may not include appropriate references or quotations; writings are oriented toward building one's own understanding rather than communicating this to an audience	**Integrate-3-D-A** Applies recoding strategies that translate information from one mode of representation to another and recast it to make information easier to process or problems easier to solve, depending on one's purposes	**Integrate-3-D-L** Translation of information may not take into account the authors' original intentions or the difference in one's own and the authors' purposes; translation is framed with one's own knowledge and perspectives rather than of one's audience

Table 8 Continued

	Integrating Multiple Formats (Analysis, Evaluation, and Synthesis/Conceptual) *How is this information represented in words, images, and data displays? How can I show this information differently?*					
	Interpretive		Expressive		Deliberative	
	Achievement	Limitation	Achievement	Limitation	Achievement	Limitation
Intermediate	**Integrate-4-I-A** Recognizes points of agreement and mutually shared knowledge even when the source documents are written from fundamentally different perspectives, goals, or communicative purposes	**Integrate-4-I-L** Builds a coherent synthesis, but may not have a conceptual understanding of how different disciplinary perspectives shape the presentation of information content	**Integrate-4-E-A** Produces reviews that recast information from sources in terms that express one's own perspectives and evaluations, while using terms and categories which are familiar to one's audience	**Integrate-4-E-L** Writings may lack the formal structure used in the disciplines, and may include little explanation of the complexities among different concepts	**Integrate-4-D-A** Applies recasting strategies that take an audience's knowledge and point of view into account and translate information into terms and categories appropriate for the audience	**Integrate-4-D-L** Transformation of information is done to suit one's own goals, without considering how the representations would be interpreted or valued within a disciplinary context
Advanced	**Integrate-5-I-A** Draws on a wide range of canonical source texts, including classic literature and important historical documents to provide points of reference when interpreting and recasting information from other texts	**Integrate-5-I-L** n/a	**Integrate-5-E-A** Produces discussions which consider and evaluate information from sources from multiple perspectives and formats which are valued in a discipline (e.g., integrating both quantitative and qualitative approaches)	**Integrate-5-E-L** n/a	**Integrate-5-D-A** Applies exemplar-based strategies in which one considers how information from sources would be viewed by a particular character, historical figure, or exponent of an influential theory or position	**Integrate-5-D-L** n/a

Table 9 Hypothesized Learning Progression for Comparing, Contrasting, and Organizing

Comparing, Contrasting, and Organizing (Analysis, Evaluation, and Synthesis/Discourse) *Do my sources agree? Where and how do they differ? How should I organize the information they provide?*						
	Interpretive		Expressive		Deliberative	
	Achievement	Limitation	Achievement	Limitation	Achievement	Limitation
Preliminary	**Compare-1-I-A** After reading two texts, decides whether they are very similar, somewhat alike, or different	**Compare-1-I-L** Analyses of similarities and differences between texts are likely to be driven by surface cues rather than deeper, semantic relations among text contents, without support or prompting to consider text content	**Compare-1-E-A** Lists similarities and differences between the content described in a pair of texts, as long as the features are salient for the type of text (events and characters for stories; major topics, key illustrations, or topic headings in expository text)	**Compare-1-E-L** Unlikely to generate less salient similarities and differences, and differences identified may not be the most important to the topic or theme	**Compare-1-D-A** Deploys sorting strategies in which similar material is grouped together, and generates simple descriptions for each category	**Compare-1-D-L** Limited to relatively explicit similarities and differences; greater attention to surface vs. deeper, structural relations among sources; descriptions may fail to capture conceptually important information
Foundational	**Compare-2-I-A** Integrates information from multiple texts on the same topic or theme and maps out shared and distinguishing features that capture how each text is related to the others	**Compare-2-I-L** Integration is limited to main ideas of texts and may have difficulty integrating information from texts with very different structures, genres, or rhetorical goals	**Compare-2-E-A** Creates elaborated descriptions of similarities and differences between texts written on the same topic (or which present the same story), highlighting similarities and differences in their treatment of common plots or themes	**Compare-2-E-L** Text may lack a coherent structure and connect little to deeper conceptual issues such as justifications or explanations for observed similarities and differences	**Compare-2-D-A** Deploys hierarchical sorting strategies in which he or she decides not only how texts agree or differ, but also distinguishes between major and minor features and gives priority to major features as he or she creates groups and subgroups of similar texts	**Compare-2-D-L** Major and minor features are likely to be limited to the texts' content or surface features and not take into account the authors' goals or intended audience
Basic	**Compare-3-I-A** Integrates information and identifies similarities and differences among texts with major surface differences, such as texts from different genres, texts written from different viewpoints, or texts that derive from fundamentally different cultures or time periods	**Compare-3-I-L** Integration overlooks subtle differences in interpretation that emerge as a function of document type, source, and context; focus on a common conclusion or idea rather than discrepancies	**Compare-3-E-A** Uses comparison and contrast as the fundamental organizing principle of an extended text and develops a comparison at length, considering multiple dimensions of similarity and difference	**Compare-3-E-L** May have limited command of text organization and structure, such that multiple comparisons are not organized in order of importance for understanding a topic	**Compare-3-D-A** Develops classification strategies for texts that focus on features that are important for an extrinsic purpose (such as defending a particular thesis or exploring a particular theme) even if the features in question are not primary organizing elements in the texts being analyzed	**Compare-3-D-L** Classification may be based on inappropriately excerpted or extracted information, failing to take into account how viewpoints shape interpretation of text features

Table 9 Continued

Comparing, Contrasting, and Organizing (Analysis, Evaluation, and Synthesis/Discourse) *Do my sources agree? Where and how do they differ? How should I organize the information they provide?*						
	Interpretive		Expressive		Deliberative	
	Achievement	Limitation	Achievement	Limitation	Achievement	Limitation
Intermediate	**Compare-4-I-A** Interprets similarities and differences among texts that require multiple levels of analysis (e.g., analyzing how a theme or a topic is treated both in primary and secondary sources, or how an idea is transformed when it is transferred or is reworked)	**Compare-4-I-L** The levels of analysis are driven by task goals and may not be those acknowledged as critical or canonical given a disciplinary or theoretical context	**Compare-4-E-A** Effectively embeds extended comparisons as elaborating elements within a longer text, selecting the comparison and its details to maximize its effectiveness given the purpose and audience	**Compare-4-E-L** Comparisons may be relatively concrete and may not extend to allusion involving more theoretical or abstract concepts	**Compare-4-D-A** Analyzes texts using mapping strategies in which one classification scheme is overlaid on another (e.g., a classification of how sources differ in their treatment of a theme is mapped onto a classification of how later works transform that theme)	**Compare-4-D-L** Classification schemes are likely to be limited to those that are relevant to current task goals and may not consider aspects of the problem from disciplinary or theoretical approaches within or outside of the target domain
Advanced	**Compare-5-I-A** Analyzes similarities and differences among texts in which one text can be viewed as the analogical key to another, as in cases of allegory and symbolism	**Compare-5-I-L** n/a	**Compare-5-E-A** Makes effective use of implied comparisons, such as allusions, and of framing elements, where the comparison is woven as a background element into an extended exposition organized on some other principle	**Compare-5-E-L** n/a	**Compare-5-D-A** Analyzes texts using analogical strategies in which structures derived from one domain are used as a key to elucidate another, less clearly understood set of concepts	**Compare-5-D-L** n/a

Table 10 Hypothesized Learning Progression for Synthesizing Research Results

Synthesizing Research Results (Communication and Presentation of Results/Conceptual) *What is the current state of discussion in the field? What can I contribute that is new? How can I present the information I have gathered?*						
	Interpretive		Expressive		Deliberative	
	Achievement	Limitation	Achievement	Limitation	Achievement	Limitation
Preliminary	**Synthesis-1-I-A** Identifies points in two texts (or different points in the same text) that agree with or contradict one another	**Synthesis-1-I-L** Has difficulty identifying points of agreement or disagreement that must be inferred vs. those that are more explicitly stated, with disagreements more difficult to identify	**Synthesis-1-E-A** Explains points on which two texts (or different points in the same text) agree or conflict	**Synthesis-1-E-L** Is limited to explaining explicit or obvious points of agreement or conflict; response may be list-like rather than well-integrated	**Synthesis-1-D-A** Applies document-scanning strategies to identify relevant information or to generate expectations to be applied when reading another text (e.g., based on Text 1, make a prediction of the content or position of Text 2)	**Synthesis-1-D-L** Judgment of relevance is limited to explicit keyword matches; expectations may be simplistic or stereotypical and driven by a limited understanding of the topic
Foundational	**Synthesis-2-I-A** Distinguishes statements and information that should be attributed to the author from those attributed to other sources, using textual cues and other indicators	**Synthesis-2-I-L** May have difficulty tracking which source holds which belief or perspective, or explaining relationships among embedded sources and the overall theme of the text	**Synthesis-2-E-A** Composes short texts that draw on information from multiple sources; can explain relationships among sources in appropriate language (quotes, responds to, builds on)	**Synthesis-2-E-L** Use of sources may be blocked or sequential rather than integrated; references or attributions to sources are likely to be absent or incomplete	**Synthesis-2-D-A** Applies mapping or graphing strategies to distinguish information reflecting different sources or points of view in a text (e.g., complete a graphic organizer that classifies information with respect to content and sources/perspectives)	**Synthesis-2-D-L** May have difficulty if the text contains few cues that indicate relationships among sources (i.e., lack of connectives or contextualized citations that attribute information to sources explicitly)
Basic	**Synthesis-3-I-A** Builds a coherent global interpretation of a text that distinguishes its unique contribution to an ongoing discussion, understanding its relations to other sources and concepts referenced in the text	**Synthesis-3-I-L** May have difficulty inferring unstated relationships to other sources and concepts, if links are not explicitly present in the text; may have a limited or superficial understanding of related discourse	**Synthesis-3-E-A** Writes a discussion presenting information from a variety of sources, presenting an overview of the topic, while indicating relations among the sources and what each source contributes to the discussion	**Synthesis-3-E-L** Relations among sources are likely to be at the level of content and may not include consideration of reliability; may resort to knowledge-telling of information obtained from each source	**Synthesis-3-D-A** Applies mapping or graphing strategies that capture key relations among a set of sources, including common and unique information content and relationships among sources	**Synthesis-3-D-L** May have difficulty identifying related literature due to failure to look beyond surface text features (e.g., titles); difficulty inferring connections across sources that use different terms or vocabulary

Table 10 Continued

Synthesizing Research Results (Communication and Presentation of Results/Conceptual) *What is the current state of discussion in the field? What can I contribute that is new? How can I present the information I have gathered?*						
	Interpretive		Expressive		Deliberative	
	Achievement	Limitation	Achievement	Limitation	Achievement	Limitation
Intermediate	**Synthesis-4-I-A** Identifies areas of consensus, disagreements, gaps needing to be filled, implications, or other issues that emerge from a specific literature on a topic	**Synthesis-4-I-L** Identification of overlaps, gaps, and discrepancies is likely to be limited to content explicitly available in the materials, with little consideration of whether they are important or meaningful in a disciplinary context	**Synthesis-4-E-A** Writes an extended analysis that reviews multiple sources on a topic and presents critical evaluations of the sources discussed, including using source information to inform one's interpretation of content	**Synthesis-4-E-L** Information is framed with respect to task goals, but text interpretations may not consider the broader disciplinary or theoretical context of the sources consulted; unlikely to address threats or alternative interpretations	**Synthesis-4-D-A** Applies generalization and organization strategies to synthesize information from a variety of texts into a coherent framework and organize it for exposition	**Synthesis-4-D-L** May demonstrate a tendency to overgeneralize in the direction of one's conclusion, overlooking information that is inconsistent or problematic; organization and structure may be limited to established templates rather than by important aspects for the topic or discipline
Advanced	**Synthesis-5-I-A** Identifies the contribution that a research article makes to the ongoing discussion in a literature, including the novel content or arguments, and evaluating how it contributes to the current "state of knowledge" on the topic	**Synthesis-5-I-L** n/a	**Synthesis-5-E-A** Writes research articles that present and support an original synthesis based on a thorough review and critical evaluation of evidence from relevant literatures	**Synthesis-5-E-L** n/a	**Synthesis-5-D-A** Applies critical reasoning strategies to identify and analyze key issues and assumptions shared by a set of texts and to generate proposals, claims, or arguments based on that analysis	**Synthesis-5-D-L** n/a

Table 11 Hypothesized Learning Progression for Citing and Using Sources

	Citing and Using Sources (Communication and Presentation of Results/Discourse) *What information should I include? How should I embed it in my text? How should I document where this information comes from?*					
	Interpretive		Expressive		Deliberative	
	Achievement	Limitation	Achievement	Limitation	Achievement	Limitation
Preliminary	**CitingSources-1-I-A** Understands the idea of a source Identifies source information within a text	**CitingSources-1-I-L** Little ability to distinguish among formal aspects of source information (e.g., author name, position, publication venue, date) or properties of different sources	**CitingSources-1-E-A** Provides sources for information when prompted	**CitingSources-1-E-L** Likely to rely on single rather than multiple sources, with little consideration of sources' reliability or quality	**CitingSources-1-D-A** Answers questions by scanning or questioning sources that may have the desired information	**CitingSources-1-D-L** Ability to locate relevant answers is constrained by topic knowledge and vocabulary; relies heavily on verbatim keyword overlap and explicit answers to questions
Foundational	**CitingSources-2-I-A** Interprets information by taking into account what is known about the source from which it was drawn	**CitingSources-2-I-L** Likely to have difficulty coordinating multiple cues to source reliability (e.g., author, publication venue, date) in one's interpretation without support or prompting; interpretations are simplistic (for/against) rather than nuanced	**CitingSources-2-E-A** Categorizes and orders notes from sources to arrange material for presentation Writes short texts that draw on notes from sources, including source attributions	**CitingSources-2-E-L** Categorization is constrained by understanding of the topic domain in question; source attributions are likely to be informal or implicit; may have difficulty appropriately using summary, paraphrase, and quotation.	**CitingSources-2-D-A** Uses note-taking strategies to record information from sources for later rereading and use	**CitingSources-2-D-L** Notes may be unsystematic, with difficulty making distinctions between the author's ideas and one's own interpretations; may have difficulty identifying and recording important events, details, or source characteristics, and difficulty tracking the origins of information.
Basic	**CitingSources-3-I-A** Identifies the use and meaning of embedded sources in texts Distinguishes statements that should be cited (e.g., observations, authority, research results) from those that can be considered common knowledge	**CitingSources-3-I-L** Explanations for embedded sources are not likely to appeal to the purpose of the text or disciplinary considerations; may mistake information common across two text sources as "common knowledge" or err on citing everything	**CitingSources-3-E-A** Embeds excerpts from sources in longer texts, appropriately using summary, paraphrase, and quotations while avoiding plagiarism Revises excerpts from sources to avoid plagiarism	**CitingSources-3-E-L** May have difficulty providing appropriate context for excerpts from sources, indicating how the excerpted information contributes to and supports one's own purposes; little evidence of integration and synthesis of ideas across multiple sources	**CitingSources-3-D-A** Uses bibliographic strategies to maintain lists of sources and keep track of quotations, paraphrases, personal responses, and opinions about specific points in source texts	**CitingSources-3-D-L** Notes are systematic but lack consideration of relationships between or among sources or related concepts; notes or comments may not reflect consideration of whether the information is useful for one's purposes

Table 11 Continued

Citing and Using Sources (Communication and Presentation of Results/Discourse) *What information should I include? How should I embed it in my text? How should I document where this information comes from?*						
	Interpretive		Expressive		Deliberative	
	Achievement	Limitation	Achievement	Limitation	Achievement	Limitation
Intermediate	**CitingSources-4-I-A** Identifies and evaluates sources cited in a text with respect to their role in supporting the authors' purpose for writing	**CitingSources-4-I-L** Has a limited ability to evaluate the broader purpose of use of sources (e.g., to connect to a disciplinary community, or to address an important issue in a field), mostly evaluating whether information supports the authors' conclusions	**CitingSources-4-E-A** Incorporates and revises information drawn from source texts so that it fully fits into and supports one's own ideas and purposes	**CitingSources-4-E-L** May misconstrue information in the direction of one's purpose when the text as a whole does not support that interpretation, due to selective reading or excerpting; may not provide appropriate context or disciplinary grounding for the excerpted information	**CitingSources-4-D-A** Uses interpretive note-taking strategies to contextualize source information with respect to its relationships with other sources and concepts	**CitingSources-4-D-L** Notes or comments may not reflect consideration of the importance of sources in light of a particular discipline, theory, or approach; interpretations are constrained by one's own purposes for writing and may overlook broader aims of the original source text
Advanced	**CitingSources-5-I-A** Evaluates sources cited in a text in light of their position in a disciplinary context (e.g., prestige of authors, dominance of the perspective presented, authority of the publication venue, etc.)	**CitingSources-5-I-L** n/a	**CitingSources-5-E-A** Contextualizes information drawn from source texts to make its significance clear in a relevant disciplinary and theoretical context	**CitingSources-5-E-L** n/a	**CitingSources-5-D-A** Deploys citation-tracking strategies to uncover related literatures and recognize important and seminal sources in a discipline and can prioritize these for inclusion in one's writing	**CitingSources-5-D-L** n/a

may be due to a variety of factors, including maturation and instruction. Each progression is presumed to be modal—to hold for most, but not all, students. Finally, it is provisional, subject to empirical verification and theoretical challenge (Deane, Sabatini, & O'Reilly, 2011). Some of the descriptions are grounded strongly in empirical literature, while others are extrapolated from available evidence when research is thin. All descriptions are considered to be hypotheses that are open to empirical verification or falsification.

To organize the qualitative changes along a developmental continuum, we label the hypothesized learning progressions for research and inquiry with respect to five levels, namely, preliminary, foundational, basic, intermediate, and advanced. These labels are used relative to a scale of how well students are able to conduct research in the interpretive, expressive, and deliberative modes. For example, a student at the preliminary level is learning the beginning moves that are required for inquiry but uses relatively simple methods for evaluating texts and sources and has a limited capacity to integrate information from multiple texts. At the basic level, students can draw conclusions from multiple sources that incorporate information about sources' reliability and other characteristics but may only present one-sided information when constructing their own arguments. A student at the advanced level conducts inquiry with relative fluency, using proficient metacognitive and self-regulation skills to develop integrated knowledge and construct extended analyses of important problems and issues within specific fields of study.

These levels describe a modal pattern of development in students' knowledge, skills, and abilities in the practice of research and inquiry. Not all students will go through all the levels in the same order or reach the advanced level at a certain grade. However, for the purposes of developing ELA assessments, it is necessary to specify the range of grade levels for which certain competencies may be relevant, acknowledging that instruction in inquiry often does not begin until middle school and that the research reviewed above suggests many deficits in even undergraduates' research skills. We propose the following alignment as a general guideline:

- Preliminary: Kindergarten to third grade (early elementary)
- Foundational: Fourth to sixth grade (upper elementary)
- Basic: Seventh to ninth grades (middle school)
- Intermediate: 10th to 12th grades (high school)
- Advanced: Undergraduate (college ready and beyond)

In Table 2, we present an overview of the progressions for each skill in the key practice model in parallel. This table includes descriptions of key knowledge, skills, and abilities to illustrate how inquiry skills may develop in concert from preliminary to advanced (i.e., collapsing across these processing modes). Tables 3 through 11 present the hypothesized learning progressions for each of the nine skills, presented as the intersections among the five levels of development (from preliminary to advanced) and the varieties of reading-focused (interpretive), writing-focused (expressive), and strategic or metacognitive (deliberative) processes. Thus, the basic structure of each progression is a 3×5 table, describing the primary aspects of proficiency with the skill for each level and each mode of thought (e.g., evaluating sources→preliminary→interpretive). Within each of these 15 cells, we differentiate between an achievement, a statement of what students are expected to achieve at this level, and a description of the critical limitations of students' skill (with the exception of the advanced level, where it is assumed there are no limitations on students' performance of inquiry tasks).

As noted above, the learning progressions presented in the following tables are provisional and subject to empirical validation and revision. To the extent that these learning progressions reflect the scope of the domain and a normative development pattern, this competency model can support the development of assessments of research and inquiry skills. The progressions might also yield suggestions for particular instructional moves or interventions that might be used to help students progress to the next level of skill proficiency (Deane, 2011; Deane, Sabatini, et al., 2011).

Mapping from Key Practice to Assessment Design

Specifying a model of the key practice, conducting research and inquiry, as defined previously affords a range of possibilities for task types and sequences that might be incorporated into a scenario-based assessment of research and inquiry skills. The flexibility of the model defined here is useful, given the complex and multifaceted nature of inquiry and the need for assessment developers to make principled decisions regarding the skills that will be measured in the assessment and the tasks and situations that provide evidence of those skills. In this section, we provide an illustration of how the

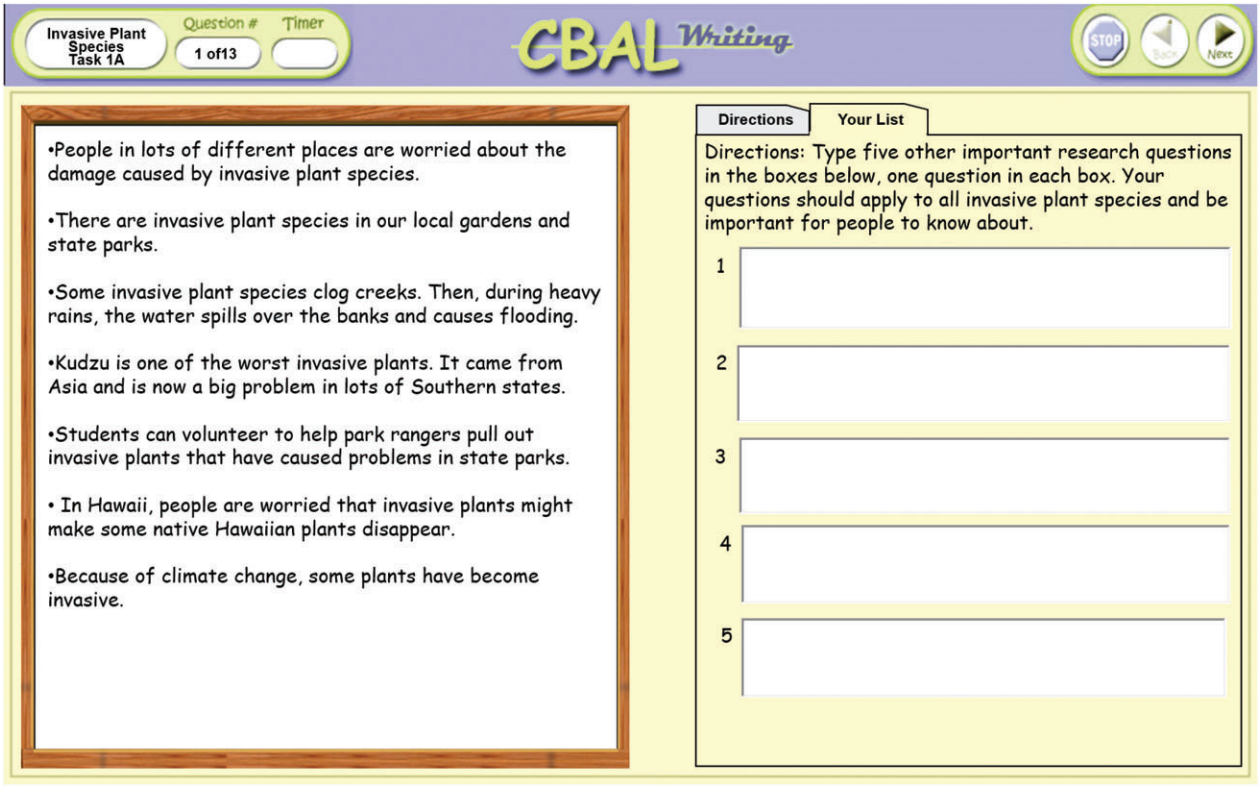

Figure 3 Screenshot of constructed-response items in Task 1A (Asking Guiding Questions — Generate Subquestions).

model of conducting research and inquiry as a key practice in ELA can be used to organize a sequence of assessment tasks and items within the context of a scenario-based assessment. The example assessment described below is intended to illustrate the utility of the activity diagram (Figure 1) as a framework for designing a scenario that requires a combination of inquiry activities organized in a sequence that is consistent with our definition of the key practice. While the activity diagram could be used to support very different instantiations of the research and inquiry process depending on one's goals, we provide one example of how the practice provides a coherent framework for aligning competency models, learning progressions, and task designs. Specifically, we illustrate how the high-level sequence of activities as defined in the key practice is instantiated in particular assessment goals, which are tied to specific performance descriptions from the learning progressions for targeted skills. Selection of measurement targets helps to define the extent to which a particular scenario design will generalize across contexts; that is, tasks can be selected and prioritized so that the overall assessment samples a range of targeted skills in a principled way.

Figure 2 presents an analysis of one CBAL summative assessment, Invasive Plant Species, in terms of the key practice of research and inquiry, organizing the main assessment tasks with respect to the major phase of the key practice and aligning each task with a performance description from the revised learning progressions (Tables 3 – 11). The mapping of learning progression descriptions to specific item and task types is illustrated in Figures 3 – 7. In Figure 2, the assessment tasks are represented by green boxes, and green arrows illustrate the sequence of activities across various subgoals of conducting inquiry.

In this assessment, students are presented with a scenario in which they will work with a simulated team to produce a brochure about invasive plant species to be distributed at an upcoming environmental science fair. Students are presented with some background information about the topic and then engage in a series of five tasks that provide evidence of inquiry skills, including generating research questions, evaluating the relevance and reliability of Web sites, organizing information by research question, revising part of the pamphlet written by a team member, and drafting two sections of the pamphlet based on information gathered and assembled in the previous tasks. As students complete the five tasks in this scenario, they first cycle between the phases of inquiry and information gathering and analysis, evaluation, and synthesis (Tasks 1A, 1B, and 2) before moving on to the phase of communicating and presenting results in the final two

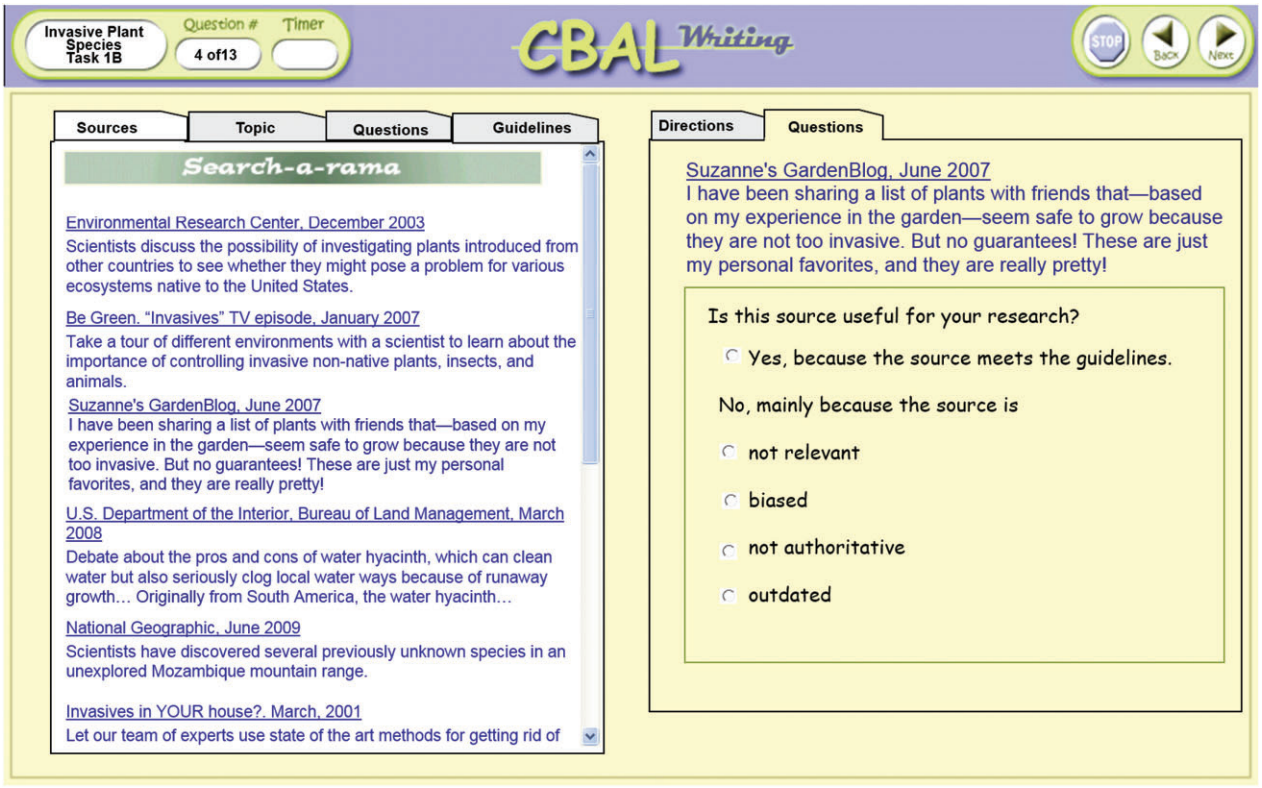

Figure 4 Screenshot of selected-response items in Task 1B (Evaluating Sources).

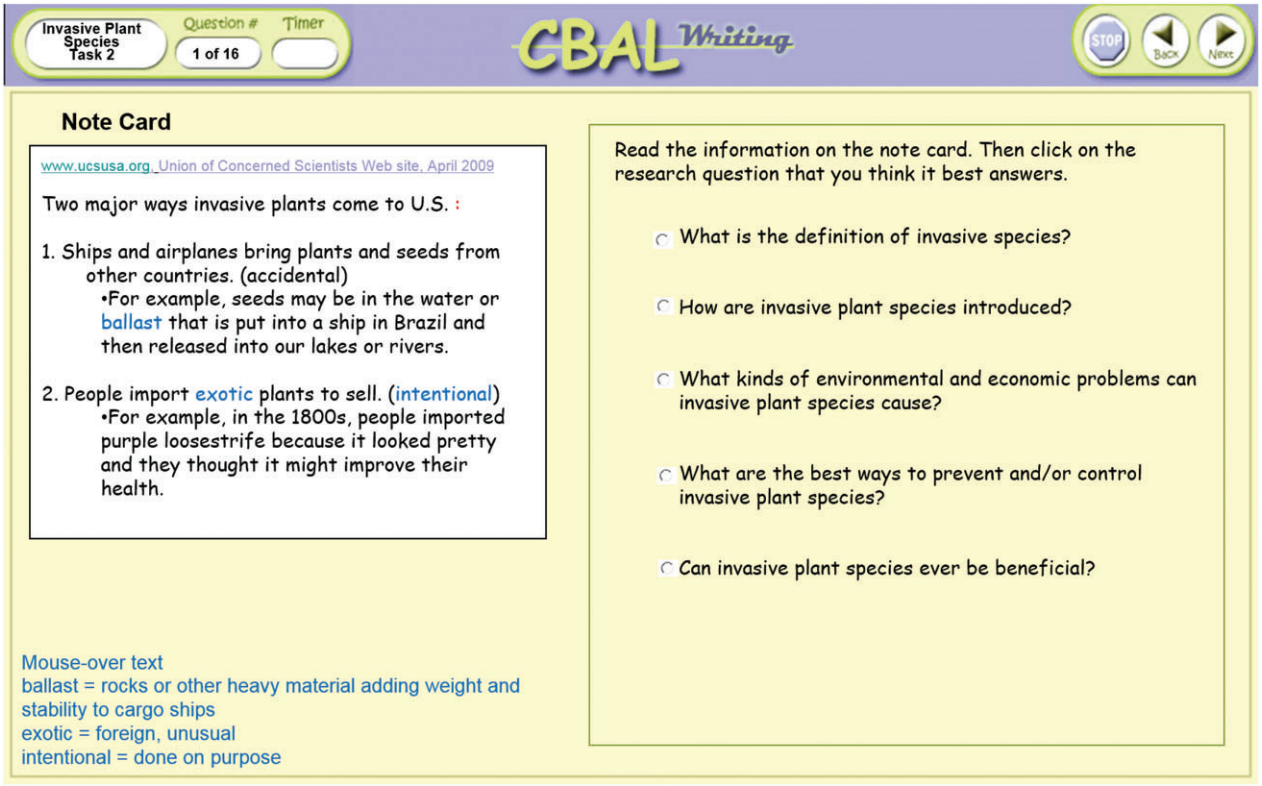

Figure 5 Screenshot of selected-response item in Task 2 (Asking Guiding Questions—Organize Information by Subquestion).

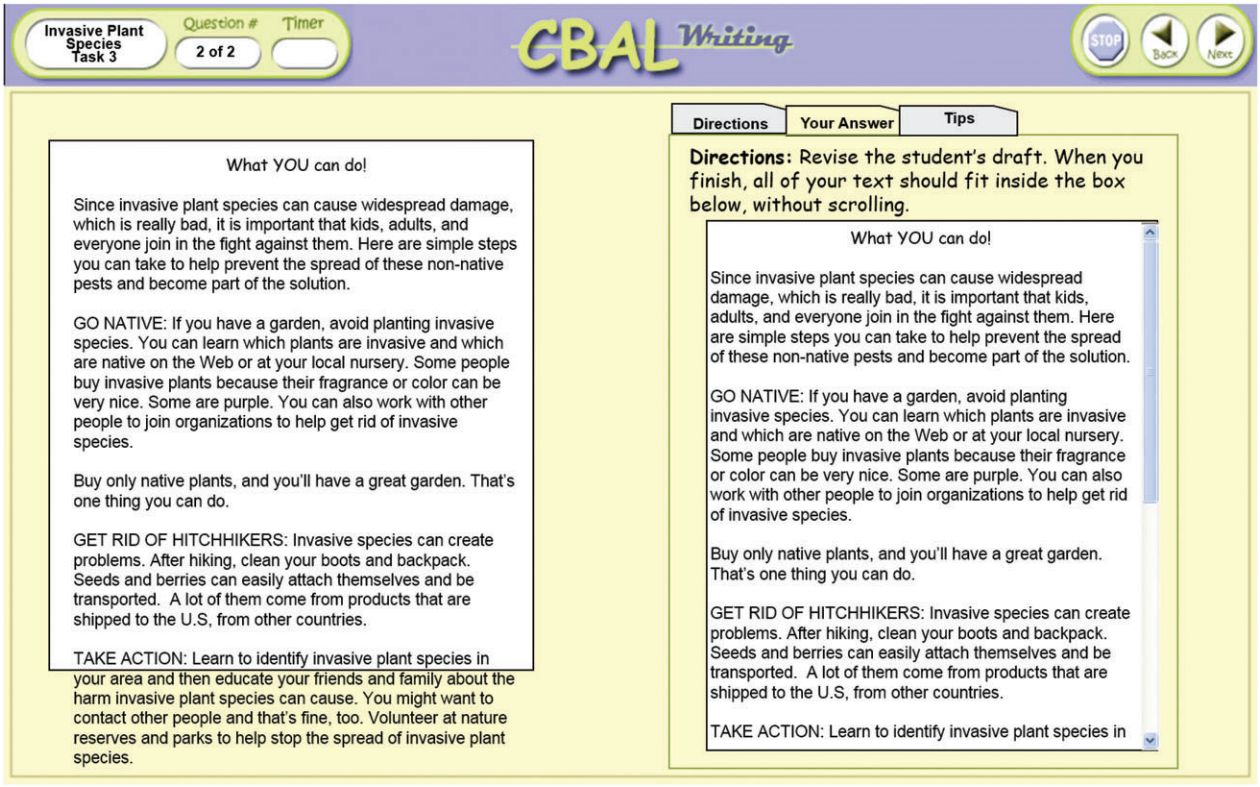

Figure 6 Screenshot of constructed-response item in Task 3 (Revision—Draft, Revise, Edit, and Publish Texts).

tasks (Tasks 3 and 4).[2] This design represents a relatively straightforward mapping onto the major activities of the key practice, in that each assessment task corresponds to only one targeted skill, but more complex designs are possible. The scenario measures learning progression levels ranging from preliminary to basic proficiency, which is an appropriate range of difficulty for middle school students (Deane, Fowles, et al., 2011). Taken together, this example serves to illustrate one way in which the key practice and associated learning progressions can be instantiated in a scenario-based assessment task that affords measurement of distinct, but complementary skills, organized in a way that is consistent with real-world contexts in which those skills might be applied (i.e., in the context of the practice of conducting inquiry).

Conclusion

The CBAL ELA competency model is organized around 11 key practices that take the form of activity systems derived from sociocognitive theory as well as theory in literacy and the learning sciences more generally. Each key practice is described in terms of a coordinated set of activities or phases. This paper defines and elaborates one of those key practices, conducting research and inquiry, decomposing it into three phases. The first phase, inquiry and information gathering, concerns activities related to developing and planning investigations, including understanding the task, defining research questions, and identifying sources of information or data collection methods that may yield answers to those questions. The second phase, analyzing, synthesizing, and evaluating, requires a collection of cognitive processes related to close reading, comparison and contrast, and integration of information presented in multiple distinct sources, which may include information that varies in terms of author, credibility, presentation format, complexity, and so on; the ability to skillfully build meaning from multiple sources while taking into account their reliability and credibility is the focus of this phase. The third phase, communication and presentation of results, involves skills related to citing and writing from sources, including appropriate use of bibliographic techniques, and effective incorporation of others' texts into one's own written products. Together, these three phases form the basis of our model of engagement in the key practice of conducting research and inquiry in ELA.

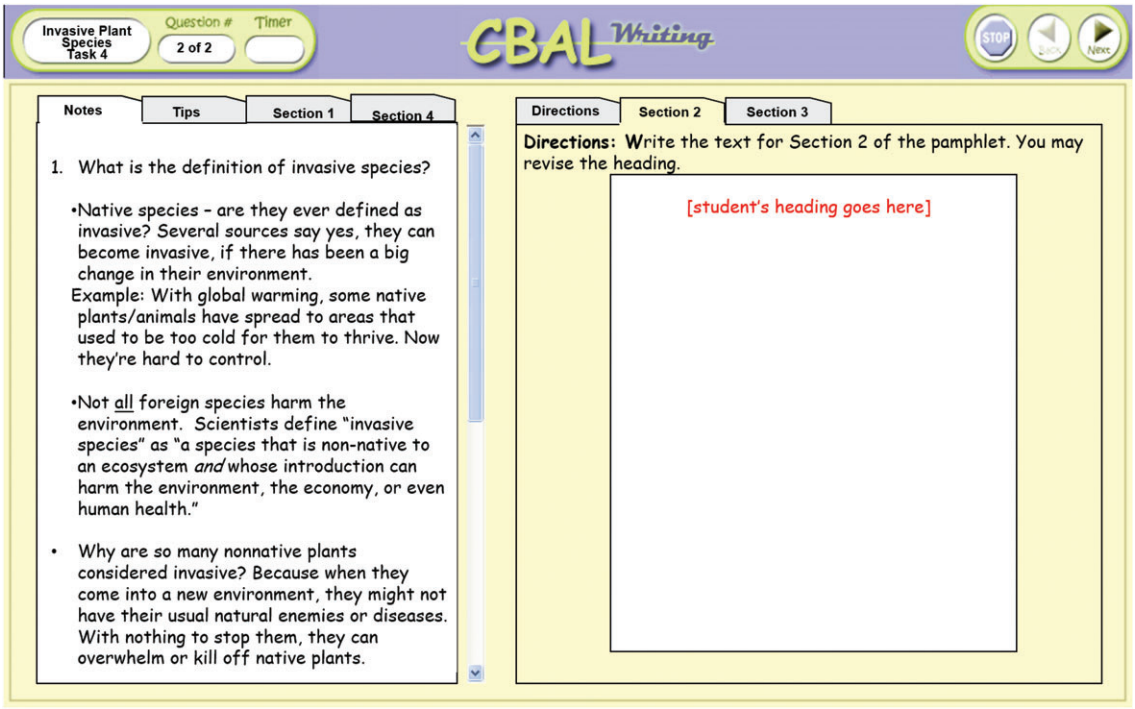

Figure 7 Screenshot of constructed-response item in Task 4 (Synthesizing Research Results).

Each phase is further specified as a set of learning progressions that correspond to key skills associated with the practice. The purpose of the progressions is to characterize qualitative shifts in students' abilities as they develop from novice to more expert levels, on the basis of current theory and empirical work related to those skills. The progressions can be used to guide assessment development and to support teachers in making evidence-based instructional decisions. Here, we presented detailed specifications for learning progressions, and in the final section of the paper, we illustrated how these learning progressions might be organized with respect to the phases of the key practice in the context of an example assessment design for measuring middle school inquiry skills in ELA. This work represents an important step in supporting the assessment of students' skill in building knowledge by synthesizing multiple sources.

Further work is needed in order to validate the hypothesized learning progressions presented here in terms of their ability to accurately capture and describe the developmental sequence by which research and inquiry skills develop; we are currently developing a set of items aligned to various levels of the learning progression for evaluating sources in order to test specific hypotheses about how these skills develop and the extent to which there are dependency relationships among certain aspects of source evaluation (i.e., relevance and reliability judgment). In addition, research that evaluates the instructional utility of the key practice, associated learning progressions, and scenario-based tasks must be conducted in order to determine the extent to which practicing teachers can make use of the learning progressions and assessment results to improve instruction, and to what extent they need support in doing so. This work will contribute to our understanding of how research and inquiry skills develop over time, and how these critical 21st century skills can be supported with appropriate instruction.

Notes

1 These student-level characteristics are consistent with O'Reilly and Sabatini's (2013) conception of *performance moderators*, individual differences that might affect performance on an assessment but which are considered separate from the construct being measured.

2 Notably, though, the pamphlet revision task (Task 3) measures students' skill in revision, which is part of the key practice of draft, revise, edit, and publish texts, rather than a skill that is specific to inquiry. In terms of the conducting research and inquiry key practice, revision of others' work would fall under the subgoal of communicating and presenting results, so a link to the skill of revision is represented under this phase of inquiry with a gray box in Figure 2.

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