Disciplinary Literacy and Inquiry: Teaching for Deeper Content Learning

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By relating disciplinary literacy with project-based inquiry, students learn the content of the disciplines and the processes that experts undertake to create knowledge.

"Give the pupils something to do, not something to learn; and the doing is of such a nature as to demand thinking...; learning naturally results" (Dewey, 1916/2004, p. 148). One hundred years ago, Dewey highlighted the virtues of learning by doing. In contemporary classrooms, learning by doing is heralded as the gold standard as a means for student engagement. Additionally, disciplinary literacy is gaining momentum among educators as they continue to find productive avenues to support deep content learning among their students.

In this article, we discuss the merits of disciplinary literacy and inquiry as two approaches to learning. Then, we describe how we have connected these two approaches in a model that relates disciplinary literacy in four areas—English language arts (ELA), science, history and social studies, and mathematics—to phases of a specific inquiry process, which we refer to as project-based inquiry (PBI). After describing the model, we provide an in-depth example of how Ms. Bolden applied the model in her 10th-grade biology class. Finally, we illustrate how relating disciplinary literacy with PBI creates an instructional space for deeper content learning to occur.

A Disciplinary Literacy Approach to Learning

The literacy field frames disciplinary literacy as a highly complex instructional approach that differentiates literacies by content domain (Fang & Coatoam, 2013; Moje, 2008; Shanahan, Shanahan, & Misischia, 2011). The Carnegie Council on Advancing Adolescent Literacy (2010) advocated for content area teachers to provide access to and support for reading print texts associated with their discipline. The council's report highlights disciplinary literacy as an appropriate instructional approach for adolescent literacy for struggling and advanced readers alike (Lee & Spratley, 2010).

Disciplinary literacy has been defined as "*the use of reading, reasoning, investigating, speaking, and writing required to learn and form complex content knowledge appropriate to a particular discipline*" (McConachie & Petrosky, 2010, p. 16). Building disciplinary knowledge is intertwined with the literacy practices of a particular discipline. By coupling content with domain-specific literacy practices, students engage in the same process used by disciplinary experts (e.g., literary critics, scientists, historians, mathematicians). Constructing disciplinary knowledge through disciplinary literacy allows students to learn both the process and the content of a discipline (Moje, 2008). What this means for students is that they can be apprenticed into the language and ways of knowing within a discipline and among the disciplines.

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A PBI Approach to Learning

A primary goal of inquiry is to engage students in authentic, intellectual work (Dewey, 1927; Newmann, Bryk, & Nagaoka, 2001). A well-known pedagogical approach that facilitates this type of student engagement is project-based learning (Boss & Krauss, 2007; Larmer, Ross, & Mergendoller, 2009). Because there are varied descriptions of project-based learning, empirical studies documenting its effectiveness are sparse (David, 2008). In the most comprehensive review of project-based learning to date, Thomas (2000) reviewed several experimental studies that compared high school students using project-based learning with a control group, and found significant effects in the areas of problem solving and decision making. Additionally, Holm (2011) found significant effects for project-based learning in the areas of content knowledge and information literacy.

In an attempt to be explicit, we use a specific type of project-based learning: PBI. We use it to create a shared language and process for teachers and students to use as they engage in inquiry. The PBI approach consists of five phases, which begin with posing a compelling question rooted in the disciplines and ends with an opportunity for students to share, publish, and act on the answer to their question. The aim of PBI is for students to engage in deeper learning (Huberman, Bitter, Anthony, & O'Day, 2014). Central tenets of deeper learning include real-world orientation, critical thinking, student choice, student-directed learning, collaboration, effective communication, and deep content knowledge.

Hiller (first author) has been honing the PBI process described in this article for over a decade. She designed the process as a pedagogical approach with literacy teachers in her new literacies and media classes as a way for them to work in teams to construct a collaborative inquiry project. During this time, the PBI model evolved as Hiller collaborated with Don Leu and other researchers at various levels in diverse instructional settings, including teacher institutes (Spires et al., 2009), middle-grade classrooms (Spires, Hervey, Morris, & Stelpflug, 2012), and our graduate education program at North Carolina State University (Manfra & Spires, 2013; Spires, Hervey, & Watson, 2013).

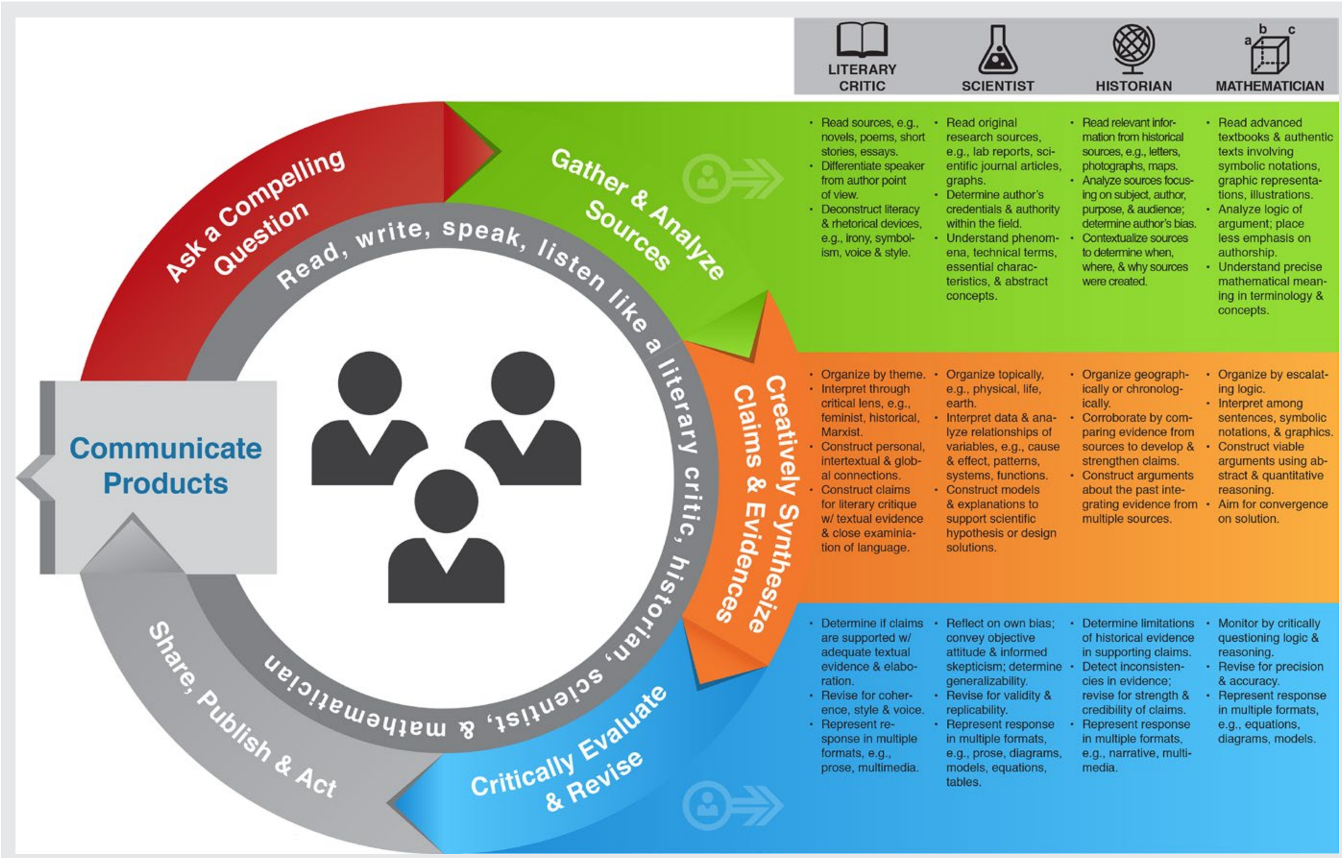
A Model for Relating Disciplinary Literacy to PBI

For the past two years, we have connected our PBI model with disciplinary literacy approaches as the instructional centerpiece for our massive online open course (MOOC) Disciplinary Literacy for Deeper Learning (Spires, Kerkhoff, Graham, & Lee 2014) using design-based research principles (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003). We drew theoretically from learning as apprenticeship, in which teachers were socialized on how to apply their disciplinary literacy knowledge within the PBI process (McConachie & Petrosky, 2010; Moje, 2007). Preliminary research on the MOOC learning environment is promising (Spires, Graham, & Kerkhoff, 2015), with 90% of the participants agreeing that the MOOC content enabled them to personalize their learning to create meaningful disciplinary literacy experiences for their students.

In particular, with respect to the PBI model, participants found it to be a practical framework for relating inquiry to disciplinary-specific literacy approaches. One participant shared, "The process of developing my inquiry-based disciplinary literacy project was the most valuable aspect of the course, providing me with something I could take back to my PLC [professional learning community] and share with my colleagues for further tweaking" (Spires et al., 2015, p. 8). Some participants reported developing a deeper understanding of disciplinary literacy practices and applying those practices in their inquiry lessons with students. One participant highlighted, "I have changed the way I read a text and the approach I use to read a text with the students. Also, the questions I ask to stir their thinking are different" (p. 8). Additionally, we have conducted face-to-face workshops in which teachers applied the model to their content area to develop and implement inquiry lessons with disciplinary literacy practices. Teachers respond positively to the model and point to its explicit nature, as well as noting that the process we have them engage in is beneficial for classroom application. Future research will focus on in-depth case studies of how the teachers apply the model to their instruction so we can understand in a more nuanced way what challenges teachers face.

The model used in the MOOC that connects PBI to disciplinary literacy practices is featured in Figure 1, with its five phases: (1) ask a compelling question, (2) gather and analyze sources, (3) creatively synthesize claims and evidences, (4) critically evaluate and revise, and (5) share, publish, and act (Spires et al., 2014). In the following section, we describe each phase of the PBI process. For the three middle phases, which are often the most intellectually challenging for students, we differentiate the literacy practices among four disciplines—ELA, science, history and social studies, and mathematics—based on a review of the literature. Our goal is to illustrate for the reader how the literacy practices may differ by discipline as teachers and students move through the PBI process.

Figure 1
Relating Disciplinary Literacy to Project-Based Inquiry



Note. From *Relating Inquiry to Disciplinary Literacy: A Pedagogical Approach* (p. 2), by H.A. Spires, S.N. Kerkhoff, A.C.K. Graham, and J.K. Lee, 2014, Raleigh: Friday Institute of Educational Innovation, North Carolina State University. Copyright 2014 by the Friday Institute of Educational Innovation, North Carolina State University. Reprinted with permission.

Ask a Compelling Question

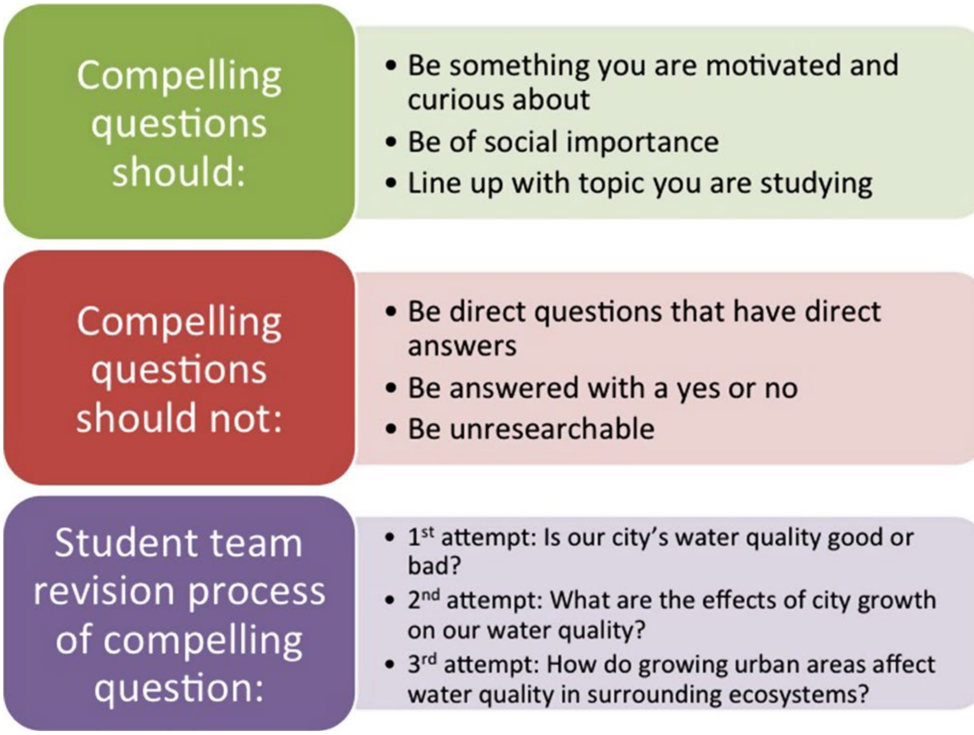
Asking a question that piques curiosity and compels students to seek an answer is key to high-quality inquiry. Provocative, open-ended questions are best for PBI. In part, compelling questions emerge from students' interests. Questions should be relevant to students' lives and of social importance, which often can be the most gripping aspect of inquiry learning. We suggest that questions should be student generated but also encourage teachers to facilitate the design process so the questions are of high quality. Students design a compelling question that often begins with *how* or *why*, resulting in creation of an original product. The question generation is supported by an instructional process that includes teacher modeling of what compelling questions do and do not look like, student teams brainstorming compelling questions based on criteria, teams sharing compelling questions for peer feedback, and teams revising until questions meet the criteria.

See Figure 2 for criteria and an example of how a 10th-grade student team in biology iteratively designed their question. The criteria for compelling questions are provided for students in the PBI rubric, and students are coached according to the rubric throughout the process. Pairing students who have similar interests is a great way to introduce collaboration skills as they conduct their inquiry. The questions should propel students to dig deeper as they construct answers.

Gather and Analyze Sources

After compelling questions are in place, teachers may provide minilessons on conducting Web searches productively, pointing out key sites pertaining to particular disciplines. Students then gather print and digital texts to collect information that addresses their questions, paying particular attention to the credibility and reliability of the sources (Leu et al., 2011). Although today's students have adapted to hyperlinks and nonlinear

Figure 2
Scaffold for Generating Compelling Questions



reading, research has suggested that they have not as readily adapted to the critical component essential for Internet research and comprehension (Coiro, 2003; Leu, Kinzer, Coiro, & Cammack, 2004). Additionally, we suggest that students should collect original data through surveys, interviews, or experiments.

Next, we explain how experts in four disciplines analyze sources during inquiry.

ELA. Assuming the role of literary critics, readers utilize expressive literacy, meaning that they appreciate how authors use language as a form of expression. Readers deconstruct figurative language and rhetorical devices to uncover various layers of meaning through irony, symbolism, style, voice, and structure. Not only must literary critics understand the underlying plot, but they must also construct an interpretation by going beyond the text as well (Rainey & Moje, 2012). The more layers of meaning that are evident, the higher the level of text complexity is. In ELA, readers differentiate the speaker from the author, whereas in the other three disciplines, the speaker is the author. Readers read closely to uncover themes or social commentaries and may construct differing interpretations of texts (Feldman, 1996; Galloway, Lawrence, & Moje, 2013).

Science. Scientists may choose texts based on the credibility of the author's institution (Shanahan et al., 2011). They gather texts to build background knowledge and to identify negative spaces in which to develop hypotheses. When reading, they must understand technical and quantitative terminology and move among prose, tables, diagrams, and figures (Hand et al., 2003; Lee & Spratley, 2010). The discourse of science is choosing language that signifies the degree of certainty, and is often very subtle. For example, scientists may use wording such as "preliminary results suggest that" to show lesser certainty and wording such as "the results confirm the cause" to exhibit more certainty. Readers in science pay attention to wording to interpret the author's findings (Norris & Phillips, 2003).

History and Social Studies. The SCIM-C (summarize, contextualize, infer, monitor, and corroborate) method is often used in history to describe how reading, writing, speaking, and listening like a historian is integrated with the inquiry process (Hicks, Doolittle, & Ewing, 2004). Based on Wineburg's (1991) seminal work, historians engage in what is referred to as source literacy. In history and social studies, who said it is as important as what is said. Readers source the text by identifying who is reporting and what biases the person may have, and contextualize by identifying the conditions surrounding events. Historians analyze to uncover an author's biases, intentions, and motivations, and corroborate information with additional texts to create a claim (Shanahan et al., 2011).

Mathematics. Reading like a mathematician is a complex process because it includes language density, numeric symbols, quantitative graphics, and little redundancy (Kenney, Hancewicz, Heuer, Metsisto, & Tuttle, 2005). Integral to mathematics is identifying patterns and breaking down technical syntax. In mathematics, the source of the information, be it a person or an institution, is not as important or relevant as the precision of the answer (Shanahan et al., 2011).

Creatively Synthesize Claims and Evidences

In this phase, students generate a series of claims related to their compelling question. Students must synthesize across multiple sources and integrate information across print and digital texts. For example, a historian might construct claims with photographic evidence and textual evidence. A scientist might build a model to support a hypothesis. As is emphasized in the Common Core State Standards (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010), students are required to justify claims with suitable evidence and be able to articulate their reasoning for such claims (Graff, 2003).

After generating and justifying claims, students engage in creative synthesis, a design process that results in an original representation of their research. The creative synthesis design process requires students to think in complex ways within the discipline through summarization, inferential reasoning, and novel connections while designing final learning products. DeSchryver (2012) suggested that "creative synthesis is largely the application of the creative process to reading and synthesizing Web text(s)" (p. 155). Based on the discipline and the project, students may write an academic paper or produce a multimodal text. For example, they may choose to design a website on Weebly or a video using Animoto to represent their newly constructed knowledge. With multimodal production, students must select images that illustrate the concept for their website or video in addition to writing content. Ideally, resources are organized in a manner that promotes quality learning outcomes intellectually, aesthetically, and technically (Spires, Hervey, et al., 2012). In our multimodal world, it is not sufficient for students to simply produce new knowledge; they must be able to represent that knowledge in a visually appealing manner through the appropriate use of technology.

ELA. Different readers may have different interpretations of a literary text (Lee & Spratley, 2010). One reason is that readers must decode words and then encode meaning based on their experiences (Smagorinsky, 2015). The most important part in producing a persuasive and viable interpretation of a text is supplying evidence to support one's claims, which can be drawn from three different sources: the self, the text, and literary criticism (Feldman, 1996). Close reading in ELA can be used to evaluate the author's craft and develop an emotional response to the literature (Park, 2013). Readers construct claims based on the ability to support with evidence from within the text. Synthesis may come in the form of pulling multiple quotes from one work or multiple works to support a claim.

Science. In synthesis, a reader is looking across many studies to validate theories and outcomes of scientific processes. Science students may read texts authentically to learn about others' inquiries about the natural world and creatively synthesize information to reach scientific consensus. Students can compare their first-hand experiments with previously published studies (Cervetti & Pearson, 2012). Synthesis of one's claims with other authors' claims leads to consensus and verification. In addition to synthesizing multiple texts when reading, students must be able to do so when writing, including representing data using multimedia (Yore, Bisanz, & Hand, 2003). Scientists construct models and write explanations to support their hypotheses.

History and Social Studies. Historians integrate evidence from historical sources to create a reasoned argument about the past. Historians read multiple accounts of historical events and look across sources to verify which aspects of the event are consistent across the different oral and written accounts (Reisman, 2012). Historians and scientists use two different terms, *corroboration* and *synthesis*, to explain a similar process with nuanced differences: Corroboration confirms, whereas synthesis combines.

Mathematics. When reading, mathematicians identify patterns, represent findings visually, verify their answers, and explain their reasoning (Hillman, 2014). Being quantitatively literate assumes that students can think mathematically, which is not the same as being able to calculate numbers (Piatek-Jimenez, Marcinek, Phelps, & Dias, 2012). As students practice reading, writing, and thinking like mathematicians, they learn to appropriately navigate the language demands of the discipline. Ultimately, students' language facilitation promotes deeper conceptualization of mathematics (Lee & Spratley, 2010).

Critically Evaluate and Revise

The next phase in the iterative PBI cycle is critically evaluate and revise. Students evaluate their arguments and revise by reworking their logic or adding evidence where needed. For example, a literary critic might look for disproving evidence in a story and revise for stronger claims. A mathematician might question the precision of terminology used and revise for clarity. In addition to self-evaluation, we suggest that peers and external experts should be included in the evaluation phase. All three levels of evaluation should be based on the same rubric with intellectual and aesthetic targets that are valued in the discipline and key to the teacher's instructional goals. As with the compelling question, the rubric may be teacher generated, student generated, or developed in collaboration. Students revise their products after each round of evaluation using formative feedback strategically within the design process.

ELA. In the ELA classroom, students revise their writing in two ways. One, they evaluate the strength of the evidence that they have provided and revise accordingly. Two, they make stylistic decisions—revising for word choice, sentence structure, and so forth—to match their voice with the expectations of the audience (Smagorinsky, 2015).

Science. Scientists evaluate the value of a text primarily on the explanation of methods (Cervetti & Pearson, 2012). They evaluate procedures, analyses, and claims based on completeness and consistency in tandem (Norris & Phillips, 2003). An emphasis is placed on revising for validity and replicability.

History and Social Studies. As mentioned previously, creating claims in history is an iterative process. Historians are constantly monitoring new evidence and comparing it against their claims. They also monitor their own biases and assumptions. When historians locate inconsistencies, they revise their claims to increase credibility (Shanahan et al., 2011).

Mathematics. A mathematician critically questions logic and revises for precision and conciseness (Hillman, 2014). Mathematicians want precision and certainty, with the goal of a single, defendable answer, whereas science aims for convergence to agree on a solution. Therefore, mathematicians must revise for word choice to convey the precise operation or relationship (Shanahan et al., 2011).

Share, Publish, and Act

As a culminating activity of the PBI process, students share their products of learning with classmates, family, and an extended community in a showcase and by publishing on social media (e.g., Twitter, Instagram, Vine). Students can post book reviews on Goodreads (https://www.goodreads.com) or share their lab results on Figshare (https://figshare.com). By sharing their inquiry products on social media, students can engage authentic audiences, intellectually and personally, beyond school. At the same time, social media publishing brings their out-of-school literacies into the classroom. For example, by placing the product online, students open themselves up to diverse audiences who bring multiple perspectives with which students may dialogue. Having students share their inquiry products with larger audiences often motivates them to put forth extra effort, supporting them in the development of new literacy identities (Jewitt, 2008). Moreover, the outcome of the inquiry process is for students to put their new knowledge in action through advocacy and community service projects.

Relating Disciplinary Literacy to PBI in Ms. Bolden's Science Class: A Sample Lesson

In this science class, 10th-grade biology, Ms. Bolden taught a PBI on water ecology in which students were to analyze a sample from a school pond, go through the PBI process using disciplinary literacy practices from science, and create a public service announcement (PSA) to draw attention to a local water quality issue. (See Figure 3 for Ms. Bolden's PBI planning template.) Ms. Bolden's learning scaffolds and student products are viewable online at waterecology.weebly.com.

To build background knowledge and spark interest, Ms. Bolden conducted an introductory lesson on water ecology, which included having students test the pH levels in the school pond and interpret findings. Next, she had students organize in teams of four to begin developing a compelling question in the area of water ecology. Ms. Bolden conducted a minilesson on how to design a compelling question and then provid-

Figure 3
Ms. Bolden's Project-Based Inquiry Planning Template

Learning outcomes for the grade 10 biology unit "Water Ecology"	Inquiry phase	Disciplinary literacy practices	Learning scaffolds	Student products
• Analyze the ecology of a local water source • Support findings with student-gathered data and external evidence • Create public awareness of a local water ecology issue	Build background knowledge	• Introduce students to water quality measures • Test the pH level of the school pond • Interpret the pH-level data	• TARGET lab advanced organizer • TARGET lab rubric	• TARGET lab report
	Ask a compelling question	• Each student group develops a compelling question to guide further investigation of a local water ecology issue	• Minilesson on what makes a question compelling • Compelling question themes • Question stems	• Compelling question explanation minivideo
	Gather and analyze sources	• Read original research sources • Determine the author's credentials • Understand phenomena and technical terms	• Curated Quip website • Minilesson on credible sources	• Annotated bibliography of three to five sources
	Creatively synthesize	• Organize topically • Interpret data and analyze relationships of variables • Construct models and explanations to support scientific design solutions	• Argumentation sentence stems • Claims & Evidences Sheet advanced organizer • Water ecology PSA storyboard	• Claims and Evidences sheet • Water ecology PSA storyboard
	Critically evaluate and revise	• Reflect on one's own bias; convey an objective attitude and informed skepticism; determine generalizability • Revise for validity and replicability • Represent the response in multiple formats	• Reasoning, Revise, Review Routine • Three-level evaluation process: self, peer, external expert	• Reasoning, Revise, Review Routine handout
	Share, publish, and act	• Share PSA through showcase and social media	• Rehearse presentations for showcase	• Water Ecology PSA using Animoto

Note. PSA = public service announcement.

ed themes and question stems to guide students. They were able to apply information that they had learned in the introductory lesson to think about their compelling questions. For example, when team 1 revisited their pond data, they discovered that the pH levels were slightly elevated. This prompted the group to want to further investigate the effects of alkalinity on the Upper Neuse River ecosystem, of which the pond is a part. After several iterations, they settled on the compelling question: "How does water pollution affect the ecosystem of the Upper Neuse River?"

As team 1 gathered and analyzed sources to address their question, Ms. Bolden directed them to a curated Quip website that had credible and noncredible resources related to water quality. She conducted a minilesson on how to determine the author's credentials and analyze the credibility of sources. Students continued to gather sources independently to create an annotated bibliography. As students encountered technical terms (e.g., *dissolved oxygen*, *eutrophication*, *polychlorinated biphenyl* [PCB]), they used context clues, secondary resources, and online tools to understand how the terms related to their compelling question.

Next, team 1 began to creatively synthesize their data into claims about water pollutants in the Upper Neuse River ecosystem by interpreting data and analyzing relationships of variables. They determined that increased pH levels often indicate the presence of harmful chemicals, such as mercury and PCB, in the water. They came to understand that as pH levels become distanced from the neutral value (i.e., 7), the hatchability of animal eggs and overall habitability decreases. Ms. Bolden provided a Claims and Evidences sheet that helped students structure their information into well-formulated evidence-based paragraphs. (See Table 1 for a snapshot of student work on claims and evidences.) Even though she modeled how to use argumentation sentence stems (e.g., "X is important because ___," "Previous work on ___ by X and Y supports ___"), students had difficulty integrating this academic language into their written discourse. Ms. Bolden explained that this type of phraseology is part of a scientist's vernacular and helps him or her clearly communicate findings. After the team polished their Claims and Evidences sheet, they began to create a storyboard for a PSA to bring awareness to their water ecology issue.

As team 1 began to critically evaluate and revise their projects, they engaged in the three-level evaluation process using the predetermined rubric and the Reasoning, Revise, Review Routine. In addition to fine-tuning their argumentative language, students self-assessed and revised their Claims and Evidences sheets and the storyboard for their PSAs. Feedback was then given through a peer review process with another team in the class. Ms. Bolden tried to arrange for an expert from the city water department to review student products for quality, but an expert was not available. Instead, one of her students' parents who worked for an environmental consulting firm volunteered to provide feedback. Based on the feedback, team 1 revised their storyboard to better illustrate their claims and evidences. Finally, students designed their PSA using Animoto, which is a free online video-editing tool. Their final product is viewable online at https://www.youtube.com/watch?v=lgnoN1veHUg.

Students were excited to share their final products during their Water Ecology Showcase, which was held

Table 1
Examples of Student Work on Synthesizing Claims and Evidences in Ms. Bolden's 10th-Grade Biology Class

Project-based inquiry task	Student work examples	
Ask a compelling question	"How does water pollution affect the ecosystem of the Upper Neuse River?"	
State a claim	*Claim 1:* "Agricultural runoff and industrial pollution releases pollutants into the Upper Neuse River."	*Claim 2:* "Create new legislation to help regulate the pollution that these companies give off."
Support with evidence	"One of the leading causes of water pollution in the Upper Neuse River is agricultural runoff. Pollutants found in the Upper Neuse River include microplastics, nitrogen and phosphorus, waste, and polychlorinated biphenyl (PCB). According to University of North Carolina's Environmental Finance Center, excessive nitrogen and phosphorus concentrations are affecting the water quality and killing many fish. Nitrogen and phosphorus are being swept into rivers through runoff. This is the leading causing of eutrophication, which is algal growth caused by excessive nutrients. It creates a green shade on the surface of the river and kills almost all the species of animals in the river. In addition to runoff, The North Carolina Office of Environmental Education states that, "Fertilizers and animal waste—washed from lawns, urban developed areas, farm fields and animal operations, particularly swine operations contribute to waste pollution in the Upper Neuse River Basin." An example of a pollutant is PCB..."	"During the Nixon administration, the United States created an organization to help protect the nation's environment. This department of the government was named the Environmental Protection Agency, or EPA for short. When the department was originally created, they created many successful acts and regulations such as the Safe Water Drinking Act which has kept our drinking water safe from excessive pollution in the forms of pesticides, chemicals, asbestos, Mercury, and PCB. Other acts, such as the Clean Water Act, have been enacted by the EPA with tremendous success since their initiation making it unlawful to purposefully dump pollutants from a point source location without having received a proper permit. However in recent years, lobbying groups have been fighting in Washington to weaken regulations and create loopholes in the law. This has lead to an increase in dumping and pollution in North Carolina from point source and nonpoint source pollution which has led to catastrophic results. Eutrophication, increase in mercury and pH levels, and even more issues are all because of the sudden increase in pollution due to corrupt corporations..."

Note. Complete examples can be viewed online at waterecology.weebly.com/synthesize.html.

in the school auditorium. Students and teachers from other classes, parents, and members of the community were invited to learn about water quality issues that were affecting their local community. Each team introduced their compelling question, presented their PSA video, and fielded questions from the audience. To keep the conversation going, students shared their videos online through social media.

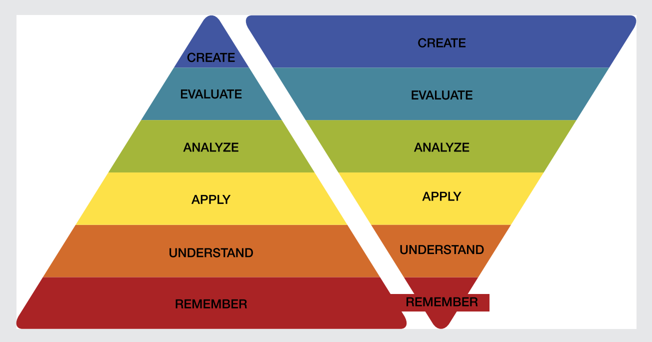
Disciplinary Literacy for Deeper Learning

Situated in real-world problems, such as water ecology, PBI utilizes the depth and complexity of disciplinary thinking. Our experiences and teacher feedback to date suggest that the value of our model is that it makes explicit the phases of an inquiry process and aligns the most challenging phases with specific literacy practices in four disciplines. The process requires students to access not only social skills but also an array of cognitive skills situated within disciplines. The revised Bloom's taxonomy (Anderson & Krathwohl, 2001) is a useful tool to mark the varying intellectual processes that are used during PBI, with creativity being the ultimate objective. Figure 4, depicting the inverted taxonomy, signifies that more time should be devoted to the act of creation, with the other processes in the model (i.e., remembering, understanding, applying) supporting higher levels of thinking (Spires, Wiebe, Young, Hollebrands, & Lee, 2012). Spending more time on creating aligns with 21st-century learning, where students are designing and generating products of learning rather than only consuming and remembering information.

Situated in the disciplines, students learn ELA, science, history and social studies, and mathematics by doing ELA, science, history and social studies, and mathematics. When students address real-world problems that interest them, they are more likely to interact with information inquisitively and curiously, leading to authentic learning outcomes. We value disciplinary depth because deep disciplinary knowledge is a prerequisite for addressing complex issues.

The inquiry cycle is recursive in that when students share their work with others, more questions for investigation may arise. In addition, although all of the phases should be included in the inquiry cycle, they do not necessarily occur in a linear fashion. For example, after critically evaluating, students may need to revise their compelling question or gather more sources. In fact, as students create interplay between analyzing sources and synthesizing claims, opportunities are formed for deeper learning and complex understanding. By including ongoing assessment throughout the process and a three-level evaluation after the products are created, the students engage in an iterative design process with important scaffolding incorporated throughout the duration of the project.

Figure 4
Revised Bloom's Taxonomy (left) and Inverted Revised Bloom's Taxonomy (right)



Note. This figure is a snapshot of *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives*, by L.W. Anderson and D.R. Krathwohl, 2001, New York, NY: Longman; and "Toward a New Learning Ecology: Professional Development in 1:1 Learning Environments," by H.A. Spires, E. Wiebe, C. Young, K. Hollebrands, and J. Lee, 2012, *CITE Journal*, *12*(2), 232–254 (reprinted white paper from Raleigh, NC: Friday Institute for Educational Innovation, North Carolina State University).

TAKE ACTION!

1. Provide instruction on how to create a compelling question for investigation in your discipline.
2. Create a flowchart for students to help them locate credible and reliable sources.
3. Have students partner with peers from a different country to integrate global learning with your disciplinary literacy PBI.
4. As part of the inquiry process, model a close reading of a short, worthy disciplinary text. Have students videotape themselves conducting their own close readings to reflect on their disciplinary ways of thinking.
5. Bring in disciplinary experts (face-to-face or virtually) to critically evaluate students' learning products based on a predetermined rubric and to provide constructive feedback for students' revisions.
6. Celebrate learning by inviting family, friends, and the community to a showcase of student products. Share a common hashtag and have a Twitter chat.

Conclusion

By relating disciplinary literacy to PBI with intentionality, teachers guide students to learn the content of the disciplines and the processes that experts undertake to create knowledge. Thus, students have opportunities to construct new knowledge by employing the content knowledge and disciplinary literacy practices used by literary critics, scientists, historians, and mathematicians. From our experience with this model, making the intuitive practices of the disciplines explicit within an inquiry process opens up a rich context for deeper learning among teachers and students.

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MORE TO EXPLORE

- Jetton, T.L., & Shanahan, C. (2012). *Adolescent literacy in the academic disciplines: General principles and practical strategies*. New York, NY: Guilford.
- Zygouris-Coe, V.I. (2015). *Teaching discipline-specific literacies in grades 6–12: Preparing students for college, career, and workforce demands*. New York, NY: Routledge.
- Disciplinary Literacy for Deeper Learning is a free open online course for preservice and inservice teachers, focusing on grades 4–12: mooc-ed.org.