

A Lesson to Unlock Preservice Science Teachers' Expert Reading Strategies

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Abstract

New standards for K-12 science education task science teacher educators with providing preservice teachers strong preparation that will help them to embrace their role as teachers of science literacy (National Research Council, 2012). Even though there is a growing trend for teacher preparation programs to offer literacy courses that focus on reading in the content areas, often they do not provide aspiring science teachers the science-specific tools needed to teach reading in secondary science contexts. This article addresses the question, “How can we, as science teacher educators, prepare our teacher candidates to teach reading in the context of science?” We designed an initial literacy lesson to help preservice teachers enrolled in two science methods courses to unpack their content knowledge about literacy in science. Our hope was that by unlocking their personal strategies they would be better positioned for engaging in conversations about literacy. We found that using this initial literacy lesson provided our preservice teachers with a solid foundation for engaging in conversations about how to scaffold student reading. This lesson also provided preservice teachers an opportunity to collaboratively develop a common beginner’s repertoire of reading strategies that we subsequently used as a building block for designing activities and lessons that engage middle and high school students in big science ideas and understanding real-world phenomena through reading a variety of kinds of science texts.

Introduction

According to literacy researchers, different disciplines demonstrate both social and cognitive practices that embody distinct ways group members use reading and writing within their discipline (Buehl, 2011; Goldman & Bisanz, 2002; Heller & Greenleaf, 2007). The Framework for K-12 Science Education (NRC, 2012), Next Generation Science Standards (NGSS Lead States, 2013) and Common Core State Standards (Council of Chief State School Officers, 2010) all specify that literacy—the ability to read in the context of science—is an essential scientific practice. These recent national reform documents emphasize that by the time students graduate from high school they should be able to analyze, evaluate, and synthesize information from scientific texts (Council of Chief State School Officers, 2010; NGSS Lead States, 2013; National Research Council, 2012). Thus, it comes as no surprise that science teachers must incorporate literacy into their curriculum and instruction. In the wake of these reforms, the expectation that students will have more opportunities to engage with scientific

texts is now firmly in place. However, this vision of ‘literacy for all students’ (Carnegie Council on Advancing Adolescent Literacy, 2010) can only be achieved to the extent secondary science teachers are able or inclined to meet this goal (Cohen & Ball, 1990).

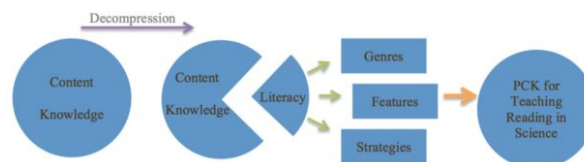
In response to this call for literacy, experienced secondary science teachers we talked to expressed that they feel they “have a responsibility to work on literacy” but do not know how to go about teaching and incorporating reading in their instruction. Unfortunately, the majority of otherwise competent or even expert teachers do not have the knowledge or training to teach literacy skills required to engage students with science texts (Norris & Phillips, 2003; National Research Council, 2012). Secondary science teachers are largely unprepared because their teacher preparation programs included little or no coursework focused on literacy. Even though there is a growing trend for teacher preparation programs to offer literacy courses that focus on reading in the content areas, often they still do not provide aspiring science teachers the science-specific tools needed to teach reading in secondary science contexts. One inservice teacher we spoke with commented that while she had taken a literacy course in graduate school it “really didn’t help me at all because it was too general and disconnected from the kind of reading you have to do in science.” Her sense that strategies introduced in her graduate school preservice coursework were too generic is not surprising given that science texts require content specific approaches and an understanding about how to read and engage with various disciplinary-specific genres (Carnegie Council on Advancing Adolescent Literacy, 2010; Lee & Spratley, 2010). This raises the question, “How can we, as science teacher educators, prepare our teacher candidates to teach reading in the context of science?”

Instead of depending on general content area courses designed for preservice teachers regardless of discipline or specialty, science teacher educators need to design lessons for secondary science methods courses that target how to teach reading as an integral and integrated component of 6th-12th grade science curricula. Fortunately, preservice science teachers are not walking into science methods classes as blank slates. They enter with extensive science content expertise and are generally proficient or advanced readers of scientific texts. The challenge for science teacher educators is that even though preservice secondary teachers know how to read and make meaning of texts within their discipline, it is difficult for individuals to leverage well-developed personal strategies for reading a variety of science texts in their planning and instruction to support struggling readers (Carnegie Council on Advancing Adolescent Literacy, 2010; Norris & Phillips, 2003). If reading is to play a more prominent role in secondary science, preservice teachers need help in making tacit knowledge about how to read common genres of science texts, such as popular science texts, textbooks, and primary scientific literature, explicit so they can use this knowledge as a foundation for learning how to teach middle school and high school students to read and make sense of science texts.

Context & Framing

The context for this study was a one semester secondary science methods course we taught at our respective institutions to a mix of undergraduate, post-baccalaureate, and masters students. We co-designed and taught a sequence of seminar sessions on how to use literacy activities, specifically reading different genres of science texts, to meaningfully help students learn science. This paper describes the first session in the sequence. We framed the design of the lesson using Ball & Bass's (2000) notion of decompression. This is the perspective that as individuals learn to teach they need to unpack, and make visible the connections between the integral whole of their content knowledge so that it is accessible to develop pedagogical content knowledge (Shulman, 1986) In this particular case the knowledge and skills necessary to use literacy strategies to teach reading in the context of science (Figure 1). Why is unpacking preservice teachers content knowledge about science reading strategies important? Unless one's content expertise is the study of reading, the act of reading can seem or intuitively be thought "a simple process" in which "text can seem transparent" (Norris & Phillips, 2003, p. 226). Helping preservice teachers identify their existing "expert" knowledge of how to read science texts—and preparing them to design lessons that productively incorporate literacy activities into their science instruction—is foundational for developing strategies to teach middle school and high school students how to read science texts.

Figure 1 (Click on image to enlarge). As preservice secondary science teachers decompress their content knowledge about literacy and their personal reading strategies they develop PCK for teaching reading in science.



Lesson Design

In order to unpack preservice teachers' genre specific strategies, we designed a structured introductory literacy activity that would:

- Help preservice teachers identify existing personal reading strategies for reading science texts
- Compare personal reading strategies with other preservice teachers
- Identify general and science genre specific reading strategies
- Engage preservice teachers in a dialogue about text features of different genres of science texts
- Brainstorm ideas about when and why teachers would want to use different genres of science texts in instruction
- Provide a foundation for designing lesson plans that include literacy activities that support ambitious science teaching practices—eliciting student ideas, supporting ongoing changes in student thinking, and pressing for evidence-based explanations (Windschitl, Thompson, Braaten, & Stroupe, 2012).

Specifically, we asked our preservice teachers to read three common genres of science texts—a newspaper article (popular science text), a science textbook (science text for education), and a scientific journal article (primary scientific literature)—that a science teacher might have their students read in class (Goldman & Bisanz, 2002). Relatively short texts about the same content—global climate change—were purposefully selected. Each student was given a packet of the readings that they were welcome to write on. We instructed preservice teachers to read each article with the goal of making sense of the text. They were given 10 minutes to read each text. How they spent this time, including what order they read the different texts, was left up to them.

After reading all of the texts, we made the preservice teachers aware of our purpose. We did not seek to assess them on their understanding of the content within each text. Instead, we wanted to make visible the strategies they used to read each type of text. Before we debriefed as a group, we asked each preservice teacher to respond in writing to the following questions for each genre of text:

- What did you do as you read the text?
- How did you make sense of the text?
- How did you interact with the text?
- Why did you approach the text in this way?

Asking preservice teachers to notice strategies encouraged them to make visible the latent expert knowledge they use to analyze the texts (Sherin, Jacobs, & Philipp, 2011). After students individually responded to the prompts on how they read each of the three texts, we split them into small groups of 3-4 to identify and record the reading strategies used to make sense of each text type. This activity was followed by a whole class discussion about reading order, reading strategies, and patterns in reading approaches across the three genres of science text: a newspaper article, a science textbook, and a journal article. Our preservice teachers' discussion and written reflections revealed that they did indeed have both general and subject specific approaches to reading different kinds of science texts.

Reading the Newspaper Article

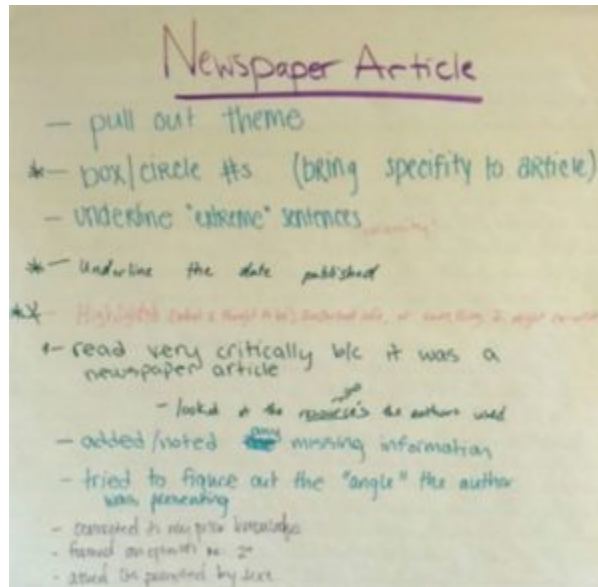
Popular texts, such as newspapers, magazines, online sites, trade books, and longer nonfiction science texts, take complex scientific information and phenomena and simplify it for the public—generally for the purpose of raising awareness and increasing understanding of important issues that are relevant to and impact citizens' everyday lives (Goldman & Bisanz, 2002). The newspaper article our preservice teachers read introduced international efforts to draft a world climate policy to limit global warming to 2°C by drastically cutting down on fossil fuel emissions to head off the negative impacts, such as rising sea-levels, of global warming (Gillis, 2014).

The discussion kicked off with one preservice teacher noting that the “writing was very straightforward” so it was not necessary to take notes as compared to engagement with the textbook or journal article. Another echoed this sentiment commenting that she read it like a story with a “main thread...which I grasped and everything else revolved around”. Several made remarks that were consistent with the objective of this text genre such as, “I wasn’t really ever exposed to the 2°C global climate change goals before so I felt I had to keep ready to gain more insight as to what it is and why it is important” and “science is controversial—one group may agree and another group may disagree”.

It was clear from the discussion that preservice teachers had a deep, established, and readily accessible understanding of the structure and purpose of a scientific newspaper article and that these pre-existing orientations to this genre shaped how they read the text (Figure 2). Strategies our preservice teachers used to read the newspaper article included:

- Using the title to identify who/what/when
- Using the first sentence to identify the tone
- Identifying the writer’s position and identifying bias
- Identifying stakeholders and different opinions with respect to the issue
- Evaluating the credibility of the source
- Identifying evidence, notably by locating quotations from scientists
- Skimming for the main idea and ignoring the “fluff”

Figure 2 (Click on image to enlarge). Preservice teachers’ strategies for reading newspaper articles.



Reading the Textbook

Science textbooks, the mainstay of secondary science, are expository which means they are written to inform, describe, explain or define patterns, and to help students construct meanings about science information (Goldman & Bisanz, 2002). Even though the objective of textbooks is to scaffold student learning, students often find them difficult reading because of content density, complex text structures, domain specific vocabulary, multimodal representations, lack of relevance to students' lives and prior knowledge (Lee & Spratley, 2010). The textbook reading on global climate change detailed specific consequences of global warming including warmer temperatures, more severe weather events, melting ice and snow, rising sea levels, and human health (Edelson et al., 2005).

As preservice teachers reflected on and discussed how they read the science textbook we observed a high degree of commonality across the approaches utilized. Most notably, conversation centered on text features that organize information in the text. For example, one preservice teacher shared that he "figured that a textbook would give the big ideas in the title and probably within the first couple of lines of the section so this helped me to get to the point faster, it helped me understand with less reading". Similarly another said "I first flipped through the text [and] read all of the headings and subheadings" upon which other students elaborated that "the headings and subheadings are great clues as to what the text is talking about" and that headings and subheadings helped to "identify the main idea of each section".

As with the newspaper article, the discussion of the textbook reading revealed that our preservice teachers have well developed strategies for reading science textbooks. Their strategies included:

- Reading the title to identify the focus of the entire reading
- Reading headings and subheadings to determine the main idea of each section
- Asking how the section relates to the title
- Asking how each section is connected to the sections before and after
- Reading for the main idea
- Reading first/last sentences of each paragraph
- Making a distinction between main idea(s) and evidence
- Skimming for unfamiliar science words, bolded vocabulary and associated definitions

Reading the Journal Article

Goldman and Bisanz (2002) point to the research report, such as a journal article, as the primary text genre used by scientists. Research reports are of particular interest because they are vehicles through which scientists present a scientific argument for consumption, evaluation, and response by their peers. Publication, circulation, evaluation, and response serves as a mechanism for providing information about research, making claims, and generating new scientific knowledge. According to Phillips & Norris (2009) journal articles present arguments about the need for conducting research, enduring or emerging methodology, analysis and provisions against alternative explanations—all in the service of supporting interpretation of authors' findings. Generally, these types of texts are infrequently used in the science classroom. The journal article we asked our preservice teachers to read presented an index for when temperature will increase beyond historic levels yielding worldwide shifts in climate (Mora et al., 2013).

Preservice teachers agreed that of the three texts the journal article was hands down the most difficult to read and understand. Even though they struggled with this article they had no trouble articulating how they read this text. As with the other two text types, preservice teachers used specific text features of journal articles to scaffold their reading. One shared that she “usually start[s] with the abstract of a journal article because it tends to give some sort of summary of the whole article.” Another built on this by saying that the “abstract is a good summary of key points.” In addition to the abstract, preservice teachers focused on reading the “intro and conclusion because they highlight scientist’s argument and claims,” as well as on “tables and figures because they provide evidence visually.” There was also widespread agreement with one preservice teacher that if the goal is to understand the article, it was fine to “skim the methods [because]...taking the time to read the methods portion would not provide me with the important information to understand the context.”

The discussion of the journal article reading uncovered that our preservice teachers have well developed strategies for reading scientific texts. Their strategies included:

- Reading abstract, introduction and conclusion for summary of argument and primary findings
- Reading discussion for explanation of findings
- Looking at graphs, tables and figures for evidence supporting claim
- Skipping or skimming methods
- Asking do I understand what this article is about
- Reflecting on whether I can tell someone what this article is about

Reading Across the Science Texts

We noticed that in addition to the genre specific strategies outlined above, preservice teachers talked about how—as they read with the goal of making sense of the texts—almost all indicated that they annotated the text in some fashion. When we collected and analyzed preservice teachers’ annotated texts, we observed that they had underlined, highlighted, and jotted down questions or comments directly on the text. When they reflected on their textual reading practices, they indicated that they marked-up the text because they planned to re-read the texts and that annotating and highlighting specific features (headings, main ideas, or writing questions), would facilitate their future re-skimming of the texts and allow them to focus on only re-reading the most relevant sections or re-engaging with the most salient information in the article (Mawyer & Johnson, 2017). It seems that preservice teachers engaged in a meta-dialogue with the text that would allow for the most effective and efficient interaction with the text to maximize understanding.

Preservice Teachers’ Ideas for Scaffolding Literacy

After students discussed the various texts and worked together to identify patterns and commonalities in how they read the three texts, we asked them to talk about implications of their personal strategies for reading different types of science texts for their own teaching. One of the preservice teachers commented that going into the activity she did not really think that she had any specific strategies for reading science texts and “felt uncomfortable and overwhelmed about the prospect of teaching literacy” and that the activity helped her to see that she “had more experience with literacy” than she originally thought. We noticed that in both of our classes the literacy activity our preservice secondary teachers engaged in and their subsequent small group discussions allowed them to think deeply about how to concretely support literacy. They were able to work together to develop ideas about how they could build on the reading strategies they identified in our class to design their own lessons and curriculum in order to integrate literacy activities into their teaching practice. Specifically we observed students leveraging their personal strategies into supports that could be helpful to students before, during, and after they directly interact with the text (Table 1).

Table 1 (Click on image to enlarge)

Preservice Teachers’ Ideas for Scaffolding Literacy for Different Types of Science Texts

Type of text	Implications for Classroom Use
Textbook	<i>Before:</i> • Give context! [case study/article/video/pictures] • Note important sentences/words in each section • Model 1 paragraph - talk through what you notice • Identify questions you would like answered [KWL chart] • Collect initial ideas and misconceptions <i>During:</i> • Make an outline while reading, possibly require a set amount of details per paragraph <i>After:</i> • Was your question answered? [Revisit KWL chart]
Newspaper	<i>Before:</i> • Make predictions about the title • Make a recommendation to politicians • Note who wrote and published the article <i>During:</i> • Make predictions from facts and evidence as you read <i>After:</i> • Write a summary of the article • Make connections to prior readings/discussions • Present the sides
Journal Article	<i>Before:</i> • Break it down! ◦ Choose key pieces & graphs ◦ The challenge should be understanding the content, not the act of reading • Frontload with content & vocabulary → focus on evidence [Late in unit] • Read abstract to gain insight into what you are about to read. <i>During:</i> • Refer to graph(s) while reading; note what is not familiar <i>After:</i> • What did you learn about, what did you discover more about?

Formal lesson plans and classroom observations revealed that after this literacy lesson our preservice teachers began incorporating these three genres of science texts into their science instruction and put the strategies and supports they identified into practice. For example, one student adapted a journal article to make it easier for her students to read. She structured reading by giving her students the following instructions:

“You will mark the text, highlight words you do not know or feel that are important, write in the side columns thoughts/responses/ideas, and form a thesis summary. To form a thesis means to make a conclusive statement (claim) on what you read. You will support this claim by providing 3-5 key details.”

The observation that our preservice teachers started using science texts after this literacy session, suggested they had more confidence in engaging their own students with literacy activities in the science classroom.

Implications for Science Teacher Educators

The Framework specifies that preservice science teacher education needs to be aligned with the scientific practices. Furthermore, it tasks science teacher educators with providing preservice teachers strong preparation that will help them to embrace their role as teachers of science literacy (National Research Council, 2012). In response to this call we designed this initial literacy lesson to help preservice teachers enrolled in our science methods courses to unpack their content knowledge about literacy in science with the hope that by unlocking their personal strategies they would be better positioned for engaging in conversations about literacy. In the words of one preservice teacher this activity helped him realize that his reading strategies were “so intuitive that they were tacit” and that previously he never “consciously thought about the text and how I approach reading”.

Challenges in implementation

As noted earlier one challenge that arose during this lesson was that our preservice teachers struggled with reading the journal article. Often journal articles are quite lengthy so we purposefully selected the shortest article we could find about global climate change in the hope that they would be able to read it in its entirety in the allotted 10 minutes. As the lesson unfolded we realized that this particular article was exceptionally dense conceptually and included a large number of visual representations.

Suggestions for future implementation

As we tweak this lesson for future use we plan to select another article that is more typical of scientific journal articles. That said, the very rich conversation that we had around the difficulties surrounding reading this particular article led to productive lines of inquiry in subsequent literacy sessions. In particular, we used it as a jumping off point for talking about adapting primary literature (Philips & Norris, 2009) to make scientific journal articles accessible to middle and high school students. We also realized that we needed to include explicit instruction around scaffolding reading visual representations such as tables, graphs, and diagrams. Another modification that we are considering is assigning the three readings and written responses to the four prompts as homework. This would allow preservice teachers to read each text at their own pace and take away the artificial constraint of a time limit.

Conclusion

This lesson highlights that preservice teachers' actual familiarity with reading strategies and content specific literacy expertise is different from their initial self-perception that they know very little about literacy. The combination of genre specific and general reading strategies our preservice teachers used demonstrated that they use visual and symbolic cues in the text in combination with prior knowledge to construct new meaning from the text by utilizing comprehension strategies as they read. The fact that preservice teachers have these highly developed metacognitive strategies to pinpoint important ideas, make inferences, ask questions, utilize text structure, and monitor comprehension while reading highlights a high level expertise (Gomez & Gomez, 2006; Pearson, Roehler, Dole & Duffy, 1992; Yore, 1991, 2004; Yore & Shymansky, 1991).

We found that using this initial literacy lesson provided our preservice teachers with a solid foundation for engaging in conversations about how to scaffold student reading. This lesson provided preservice teachers an opportunity to collaboratively develop a common beginner's repertoire of reading strategies that we subsequently used as a building block for designing activities and lessons that engage middle and high school students in big science ideas and understanding real-world phenomena through reading a variety of kinds of science texts. Also, compared to previous years, we noticed that how these preservice teachers were able to design and scaffold reading with their students was objectively more sophisticated and would allow students to engage with the science in more meaningful ways.

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