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An Investigation of Literacy Practices in High School Science Classrooms

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ABSTRACT

This study reports findings from an exploration of the literacy practices of 10 high school science teachers. Based on observations of teachers' instruction, we report teachers' use of text, evidence-based vocabulary and comprehension practices, and grouping practices. Based on interviews with teachers, we also report teachers' perceptions regarding their role in implementing literacy instruction and the alignment of these perceptions with their practices. In total, we observed for 3,167 min across teachers. Coding of observations revealed that teachers rarely used expository text and implemented a minimal amount of vocabulary and comprehension strategy instruction. They used a variety of grouping practices but most often utilized whole-class instruction and independent work. Coding of interviews revealed that teachers supported the idea of integrating text and literacy instructional practices into their lessons but perceived a wide range of barriers to implementing these practices. We provide implications and directions for future research.

An observation study of reading practices in high school science classrooms

Many students in the United States continue to struggle with reading, and ultimately acquiring content, into the secondary grades. The 2013 Nation's Report Card reported that a high percentage of students (64%) in the United States are ranked below proficient in reading at the conclusion of high school, representing a decline in performance compared to previous years (National Center for Education Statistics, 2014). Given continued evidence of poor achievement, researchers and policymakers have advocated that content-area literacy instruction should be central to instruction in the core content areas in which use of expository text is critical to increasing student learning (Kaldenberg, Watt, & Therrien, 2015). Ideally, when literacy instruction is integrated into content-area instruction, students will not only improve their reading ability but also gain access to content knowledge through reading, one of the most efficient ways of doing this when one is equipped with the necessary skills (Biancarosa & Snow, 2006). The need for *all* teachers to be prepared to integrate evidence-based literacy practices into instruction is undeniably important (Heller & Greenleaf, 2007).

Science education

One content area that deserves attention in regard to content-area literacy instruction is science. Science education in particular has received nationwide attention because of poor achievement in science across the United States. For example, less than one third of students in eighth and 12th grades scored at or above proficient in science on the National Assessment of Educational Progress (National Center for Education Statistics, 2014). In addition, the EDFacts/Consolidated Performance

Report for the 2012–2013 school year revealed that only 60% of students were proficient on state science assessments. Recent initiatives (e.g., Change the Equation Organization, 2011) and new nationwide science standards (e.g., Next Generation Science Standards, 2013), adopted in response to this problem, aim to increase capacity in science, technology, engineering, and mathematics fields by creating a highly skilled science, technology, engineering, and mathematics workforce (Therrien, Hughes, & Hand, 2011). The Next Generation Science Standards were written to align with the Common Core State Standards (CCSS; CCSS, 2010; National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010). These standards affirm that reading in science is an important skill that requires, for example, the ability to read and synthesize complex information and use textual evidence to make arguments.

Scientific literacy

A common understanding of scientific literacy includes, in sum, an understanding of the content of science, its applications, and its use in problem solving and the ability to think critically about it (DeBoer, 2000; National Research Council, 1996; No Child Left Behind, 2002; Organisation for Economic Co-operation and Development, 2003; Villanueva & Hand, 2011). Science educators have not traditionally emphasized the role of text and literacy instruction in science instruction and have therefore not seen it as a priority in helping students become scientifically literate (see Yore, Craig, & Maguire, 1998). In fact, traditional science instruction has historically been characterized as inquiry based, commonly referred to as a *constructivist* or an *oracy-based* approach (Norris & Phillips, 2003; Scruggs & Mastropieri, 2007). Indeed, although researchers have asserted that some science knowledge and skills are more suitably learned through these experimental, inquiry-based activities (see Brigham, Scruggs, & Mastropieri, 1992; Kamil et al., 2008; Mastropieri & Scruggs, 1994; Scruggs, Mastropieri, & Bakken, 1993), other researchers contend that such instruction only goes so far, especially for struggling learners. Consequently, these researchers assert that there is a need for science content knowledge to be acquired through reading expository text, which, they espouse, carries essential content that cannot always be conveyed in another manner (Bean, Zigmond, & Hartman, 1994; Kaldenberg et al., 2015; Moin, Magiera, & Zigmond, 2009; Norris & Phillips, 2003; Tishman & Perkins, 1997).

Norris and Phillips (2003), for example, contended that literacy in its “fundamental sense” is critical to achieving scientific literacy. They, along with others (see Villanueva & Hand, 2011), have purported the importance of using text and instruction in strategies to support the use of that text as a key element of science literacy instruction. The authors suggested that when it is accepted that

the primary access to scientific knowledge is through reading of text, then it is easy to see that in learning how to read such texts a great deal will be learned about both substantive science content and the epistemology of science. (p. 237)

We next define the nature of content-area literacy and general expectations and challenges for students and teachers with regard to this instruction. We subsequently discuss considerations and challenges of content-area literacy in science.

Content-area literacy instruction

Integrating literacy instruction into secondary content instruction is necessary, as mastering early literacy does not guarantee that students will move effortlessly into proficiency with text at the secondary level (Snow & Moje, 2010). In successful content classrooms, teachers teach content knowledge in tandem with language and literacy practices (Baumann, Edwards, Boland, Olejnik, & Kame'enui, 2003; Lee & Spratley, 2010). This does not mean that these teachers should take on the challenges of teaching the most foundational skills to their struggling readers; this should be the responsibility of a specialist. Instead, common practices recommended by authors of several reports on adolescent literacy regarding thinking and reasoning about content-area text are

applicable to all content areas (Bulgren, Graner, & Deshler, 2013). There are also strategies that can be considered unique to each discipline given different reasoning processes and presentation of material (Heller & Greenleaf, 2007; Lee & Spratley, 2010; Shanahan & Shanahan, 2008). Authors of several meta-analyses and reports on adolescent reading comprehension research (Biancarosa & Snow, 2006; Edmonds et al., 2009; Flynn, Marquis, Paquet, Peeke, & Aubry, 2012; Kamil et al., 2008; Lee & Spratley, 2010) have recommended that *all* content areas include the following instruction to improve comprehension of text: building background knowledge, teaching key vocabulary words and concepts, teaching students to ask and answer different types of questions, summarizing and generating main idea statements, engaging in extended discussions of text and vocabulary words, and using graphic organizers.

Furthermore, in addition to *what* strategies are taught to support text use and content acquisition, it is also important to consider aspects of *how* teachers deliver this instruction. Delivery of instruction should include explicit modeling, guided, and independent practice (Archer & Hughes, 2011; Solis, Miciak, Vaughn, & Fletcher, 2014). This is especially critical at the secondary level, where teachers may have students with intensive learning and behavioral needs in their classes (Vaughn, Wanzek, Murray, & Roberts, 2012). In this case, teachers can intensify the delivery of instruction by providing frequent opportunities for student response and feedback in many ways, including utilization of a variety of grouping structures such as the use of partners or small-group instruction (Wexler, Reed, Pyle, Mitchell, & Barton, 2015). Using whole-group instruction and independent work generally deprives students of opportunities to practice and receive immediate, corrective feedback.

Expectations and challenges for students

The recent focus on rigorous content-area literacy expectations is manifested in the CCSS. These standards pose expectations for students to not only read text with automaticity but also use sophisticated reasoning to acquire and synthesize information (Zygouris-Coe, 2012). This poses a considerable challenge for many adolescents, especially those who struggle with reading.

Text difficulty

One reason why students struggle with these expectations is that many students have difficulty accessing the very tool, namely, expository text, that they are expected to use to acquire content knowledge (Berkeley, King-Sears, Hott, & Bradley-Black, 2012; McCrudden, Schraw, Hartley, & Kenneth, 2004). Several characteristics of expository text pose significant conceptual demands for students (Gajria, Jitendra, Sood, & Sacks, 2007; Sáenz & Fuchs, 2002). In contrast to the more predictable story structure in narrative text, expository text includes an array of text structures (e.g., cause-effect), making it less considerate and therefore more difficult to read for understanding (Sáenz & Fuchs, 2002). Expository text is also conceptually dense, meaning that concepts may be presented in a disorganized manner using syntactic sophistication with no built-in supports (e.g., illustrations; Gersten, Fuchs, Williams, & Baker, 2001). This too can limit the cohesiveness of the text and ultimately impede comprehension (Reed & Kershaw-Herrera, 2015). Furthermore, although vocabulary knowledge is critical for reading comprehension and all content areas have a plethora of critical discipline-specific vocabulary embedded in it (Cunningham & Stanovich, 1997; Lee & Spratley, 2010; Stahl & Nagy, 2006), new technical vocabulary is often presented in expository text but is rarely supported within the text itself (e.g., no definitions; Berkeley et al., 2012). Finally, comprehending content-area expository text requires prior knowledge to make inferences; however, prior knowledge is something that poor readers frequently lack (Carr & Thompson, 1996).

Lack of explicit instruction

To help students navigate challenging expository text, teachers need to provide explicit instruction to enhance comprehension and vocabulary, including direct instruction in key concepts before reading (e.g., providing background knowledge) and strategies (e.g., using context clues) that students can use

to support acquisition of that content or unknown vocabulary when reading text independently (Scruggs & Mastropieri, 2007; Seifert & Espin, 2012; H. L. Swanson & Deshler, 2003). It is especially critical that content-area teachers provide this instruction given that 60% of students with disabilities, many of whom are struggling readers, spend 80% or more of the school day in the general education setting (Newman, 2006; U.S. Department of Education, 2011).

Unfortunately, although there is a paucity of literacy observation research in secondary content-area classrooms (E. A. Swanson, 2008), the evidence that exists from previously conducted observation studies (e.g., Ness, 2009; E. Swanson et al., 2015) reveals that secondary teachers are implementing comprehension and vocabulary practices to differing degrees, missing key opportunities to provide literacy instruction, and often designing lessons that circumvent the use of text all together. For example, from 137 observations of vocabulary and reading comprehension practices implemented in secondary social studies and English language arts (ELA) classrooms, E. Swanson et al. (2015) reported that although more than half of the class periods observed contained some type of vocabulary instruction, the most common vocabulary instruction included presenting definitions with limited context clue and morphology instruction. Furthermore, teachers frequently provided prior knowledge building activities, but this consumed a large amount of class time and was of low quality. Even more concerning is that less than 15% of the observed time included engaged text reading across both content areas and comprehension strategy instruction was rare, likely because of the lack of text reading in classes. With the current increased emphasis on the use of expository text to acquire content knowledge, avoiding the use of text and strategy instruction to support comprehension of that text is clearly problematic. By bypassing text use, teachers sacrifice students' exposure to content, vocabulary, and text reading and comprehension strategy practice (Gelzheiser & Meyers, 1991; Hairrell et al., 2011; O'Sullivan, Ysseldyke, Christenson, & Thurlow, 1990). In sum, students' literacy abilities are not always commensurate with the increased demands for educational achievement. In addition, challenges such as text difficulty and a lack of explicit instruction are often evident in the content-area setting, serving to increase the gap between student ability and classroom instruction.

Expectations and challenges for content-area teachers

Inherent in these demanding literacy expectations is the idea that every teacher is considered to be a teacher of literacy skills (Reeves, Robertson, & Taylor, 2011). This can be especially difficult for secondary content-area teachers who must accommodate typically achieving as well as an increasing number of struggling learners in their classrooms, as noted previously. In addition, many content-area teachers report additional concerns, including feeling unprepared to help their struggling readers because they do not have the time, training, or support or feeling that teaching reading skills is not even their responsibility (Heller & Greenleaf, 2007; Ness, 2009). Some teachers have even disclosed feeling unsure that struggling readers will even be able to acquire the higher order thinking skills necessary to learn content through complex expository text (Bulgren et al., 2006).

Meeting content-area literacy instruction needs in science

Implementing content-area literacy instruction in science shares some of the same challenges as implementing similar instruction across all content areas. First, and most notable, the majority of struggling readers take mainstream general education science classes (Ehren, Lenz, & Deshler, 2004; Kaldenberg et al., 2015), which requires content-area science teachers to be well versed in integrating evidence-based strategies and pedagogical practices to support learners at different levels. Second, many science textbooks are poorly organized and often do not incorporate essential information to support comprehension of the text (Bakken & Whedon, 2002; Dornisch, Sperling, & Zeruth, 2011; Mason & Hedin, 2011; Scruggs & Mastropieri, 2007). Texts are also typically written at a high school or higher readability level and contain technical, multisyllabic vocabulary (Fang, 2006). Assuming that science teachers are incorporating the use of text at all into their instruction,

this makes acquiring science content knowledge even more difficult for adolescents, and particularly for students who struggle with reading and comprehending text (Cawley, Hayden, Cade, & Baker-Kroczyński, 2002; Parmar, Deluca, & Janczak, 1994; Shepard & Adjogah, 1994).

Purpose and research questions

Considering the status of many adolescents' current reading ability and expectations to learn science content through the use of text (e.g., CCSS, 2010; Therrien et al., 2011), the primary aim of this study was to investigate the types and frequency of text teachers use in their lessons and the types and frequency of literacy and pedagogical practices being implemented to support instruction. For the purpose of this initial exploratory study, we chose to document the use of strategies that authors of previous reports on adolescent literacy research (i.e., Kamil et al., 2008) have recommended that *all* content-area teachers incorporate into instruction as opposed to what some might describe as more discipline-specific literacy practices (e.g., reading mathematical tables; i.e., Lee & Spratley, 2010, pp. 4–6). Although we acknowledge that additional discipline-specific literacy strategies may exist, we saw this as a first step with regard to investigating the practices we know that all content-area teachers should be incorporating into their instruction. Documenting the use or lack of use of these practices can greatly inform the field regarding teacher education needs in this area. Note that we sought to extend E. Swanson et al.'s (2015) literacy observation study of secondary ELA and social studies classrooms by also investigating text reading, vocabulary and comprehension practices, and grouping structures used in *science* classrooms. We extend the observation study of comprehension practices in secondary science classrooms by Ness (2009) by also investigating vocabulary, text reading, and grouping practices in this same content area.

Furthermore, despite the fact that a growing number of students struggle with reading in general education science classes, and the need for these students to be able to read and understand increasingly difficult expository text, science teachers may feel that they do not possess adequate skills or that it is not within the scope of their role to integrate literacy instruction into their content-area instruction (Hall, 2005; Ness, 2009; Seifert & Espin, 2012). To guide future professional development (PD) efforts for those teachers working in science content-area classes, a secondary aim of this study was to explore the perceptions and beliefs of the observed teachers in regard to their role in providing literacy instruction for students, particularly struggling readers, in their science classes. Using this information, we sought to identify the extent to which the teachers' beliefs aligned with their practices.

Method

To address our primary aim, we conducted observations in the classrooms of 10 high school biology teachers. Observations can provide understanding and evidence in regard to how policies and practices are being implemented in typical classroom settings (E. A. Swanson, 2008). To address our secondary aim, we interviewed all teachers in the study to extend our understanding of the findings (Creswell & Plano Clark, 2009).

Setting

The study took place in six high schools within one semiurban school district in a Mid-Atlantic state in the United States. The state where the study took place was one of the first states to adopt the CCSS, and the standards had been adopted 4 years prior to the implementation of this study. The state also required two literacy courses for teacher certification. The district provided a curriculum calendar so that all science teachers followed a similar schedule and pace. This school district served 127 schools and approximately 80,000 students and had a moderate 4-year high school completion rate of 85.6%. At the time of the study, the school district served a diverse body of students (i.e., 59.12% White, 20.31% African American, 10.84% Hispanic, 3.55% Asian American, 5.57%

reported more than one race, and less than 1% reported American Indian or Hawaiian/Pacific Islander). At the high school level in this district, 5.7% of students received 504 services, fewer than 5% were identified as limited in English proficiency, and 8.5% qualified for special education services. Of all of the high school students in the district, 26.4% received free and reduced-price meal services.

Teacher participants

Ten high school biology teachers participated in the current study. Four teachers taught regular-level biology, four taught honors biology, one taught Advanced Placement biology, and one teacher taught a sheltered class for English language learner (ELL) students. All 10 teachers were professionally licensed to teach, and eight were licensed in science specifically. Five teachers reported participation in at least one literacy- and at least one CCSS-focused PD. Nine teachers reported their highest degree obtained. Six of these teachers held master's degrees and three held bachelor's degrees. Nine teachers reported how long they had been teaching science content. Of these nine teachers, one had been teaching science content for fewer than 2 years, five had been teaching science content between 5 and 10 years, and three had been teaching science content for more than 10 years. Nine teachers reported their ages at the time of the study. Of these nine teachers, one was younger than 29 years old, six were between 30 and 39 years old, and two were between 40 and 49 years old. Eight of the teachers observed were female, and two were male. Seven teachers were White, two were Asian, and one teacher did not report ethnicity.

Student participants

Across the 10 classrooms observed, we collected parent consent and student assent from 198 students. The sample included students in ninth through 12th grades. Out of all 198 participants, 8.58% were receiving special education services, 9.6% were receiving 504 services, and 10.61% were identified as ELLs. Regardless of these classifications, we considered students within these classes to be at risk for reading difficulties if they scored less than the 25th percentile rank on a researcher-administered standardized assessment, the Test of Silent Reading Efficiency and Comprehension (Wagner, Torgesen, Rashotte, & Pearson, 2010), which we administered prior to conducting any observations. This cutpoint was selected because the authors of this assessment interpret students scoring in this range as below-average, poor, or very poor readers. A total of 34% of all participating students were considered at risk for reading difficulties according to our classification on the Test of Silent Reading Efficiency and Comprehension, though the number of students varied across classrooms (see Table 1).

Table 1. Student demographics.

Teacher ID	IEP	504	ELL	Grade				At risk in reading ^a	Percentage of class at risk
				9	10	11	12		
1	0	0	0	22	0	0	0	0	0
2	0	0	0	25	0	0	0	0	0
3	7	2	0	0	10	1	0	10	90.9
6	0	0	0	13	9	0	0	3	13.6
7	1	0	4	19	1	0	0	6	31.6
8	1	8	0	20	0	0	0	17	89.5
11	2	6	0	3	17	3	0	10	43.5
13	0	1	0	0	0	6	12	2	11.1
15	0	2	0	0	19	0	0	4	25
17	3	0	17	4	7	5	1	16	100
Total	14	19	21	107	63	15	13	68	
Percentage of total sample	7	10	11	54	32	8	7	34	

Note. ID = identifier; IEP = individualized education plan; ELL = English language learner.

^aAt-risk status determined by a Test of Silent Reading Efficiency and Comprehension pretest score below the 25th percentile.

Data sources

We developed an observation tool to capture literacy and grouping practices in the observed classrooms. The tool was adapted from the Writing and Reading Observation Tool (Bryant et al., 2013), an observation tool designed for secondary literacy settings. These targeted observable practices reflected evidence-based practices that we would expect to see integrated across content-area classes (see Kamil et al., 2008). Our code sheet captured text reading practices, instances of comprehension strategy instruction, background knowledge building, vocabulary instruction, and grouping practices. See Table 2 for a copy of the codebook, which defined each practice. A copy of the observation tool (code sheet) that aligns with this codebook is available on request from the first author. The observation tool was divided into 1-min increments, and a partial interval recording method was used for coding. If a teacher displayed a target practice at any point in the interval, the behavior was coded as occurring at least once in that interval. For example, if a teacher defined a word at any time during a given minute interval we coded that interval as definition/example. In addition, we coded the type of student grouping (e.g., whole class) and type of text being used (e.g., worksheet) for every minute interval observed.

Table 2. Descriptions of codes on the observation instrument.

Code	Description
Text reading practices	
Worksheet activity	Short sentences or paragraphs with or without questions; teacher gives students cloze notes to complete
Lab/activities procedures/directions	List of directions or procedures to follow to complete an activity or lab
Textbook/expository passage	Multiparagraph text from a textbook or a handout
PowerPoint/overhead text	A PowerPoint slide with minimal text that the teacher draws attention to or asks the students to read; worksheet or notes displayed
Electronic text	Websites, online modules; any connected text, including short sentences or a short paragraph
Comprehension strategy instruction	
Preview	Teacher/students preview the materials by reviewing title, headings, and graphics; must link to text
Ask and answer questions while reading	Teacher prompts students to ask questions while reading; must link to text
Main idea/summarization	Teacher asks students to explain the main idea or to summarize the passage; must link to text
BK building	
BK: picture/object	Teacher/students draw a picture or use an object to label or convey word meaning or a science concept
BK: video	Teacher/students make connections between content and BK by demonstrating a vocabulary word or concept through a small experiment/activity or video
Vocabulary instruction	
Definition/example	Teacher/students provide or review a definition; teacher cues students to utilize reference tools (dictionary, thesaurus) to obtain a word meaning; teacher/students use examples/nonexamples to explain a word meaning
ELL support—translation/cognate	Teacher/students use a translation of a word; teacher/students make connections with a word that is similar across two languages
Morphological/structural analysis	Teacher/students model or explain how to use morphology to understand word meanings; explicit instruction in prefixes, suffixes, and roots and analysis of word parts
Contextual analysis	Teacher/students model or explain how to use context clues to understand word meanings; explicit instruction in context clues
Graphic organizers/semantic maps	Teacher uses graphic organizers to scaffold complex concepts/words
Grouping	
Independent	Students working on their own
Pairs	Two students work together
Small group	Three or more students work together
Whole class	Entire class together

Note. BK = background knowledge; ELL = English language learner.

Procedure

Data were collected over 3 months in one spring semester. Each teacher was observed during the same randomly chosen class period for each observation. Teachers were notified of each observation date in advance, although some rescheduling occurred per teacher request because of school schedule changes. Every effort was made to evenly disperse the observations over the data collection period. At least 10 days of instruction occurred between observations.

Observer training

Four graduate-level research assistants (RAs; three doctoral-level and one master's student) who had extensive experience in secondary schools and in conducting observation research served as data collectors. Prior to conducting the observations, RAs watched and coded a 20-min video segment of biology instruction previously recorded for the sole use of training observers. The RAs familiarized themselves with the previously developed observation tool that contained terms and operational definitions for the observable practices. The team coded the video together and discussed areas of disagreement with the first author until a consensus was reached. Some operational definitions were adjusted at this time to provide clarity.

Interobserver agreement

Interobserver agreement was established after the observer training was completed. The second and third authors established two master code sheets to serve as the gold standard against which the other observers' codes were compared (Gwet, 2001; E. Swanson et al., 2015). First, the second and third authors independently coded two additional previously recorded videos and achieved 98% and 97% agreement with each other on Videos 2 and 3, respectively. Percent agreement was calculated by dividing the total number of agreed occurrences by the total possible occurrences of practices for the timed segment. Second, they came to a consensus on disagreements and finalized a master code sheet for each video to which the other observers' codes were compared. The remaining RAs subsequently independently coded Videos 2 and 3. The RAs achieved at least 90% agreement on each master video code sheet before coding in the field. To prevent observer drift, the research team met biweekly to discuss and provide clarification when questions arose.

Phase I: Classroom observations

A single RA, who had been randomly assigned a priori, observed and simultaneously coded each observed lesson using a live coding scheme. The observations commenced with the scheduled bell. Observation times ranged from 23 to 90 min. Times varied because of a variety of unscheduled interruptions (e.g., fire drills). The RA had a recorded timer that prompted the start of each new minute interval. Four observations were completed for each teacher ($N=10$), for a total of 40 observations.

Phase II: Teacher interviews

After all classroom observations were complete, semistructured teacher interviews were conducted with each teacher by either an RA or the first author for approximately 45 min. Interviewers conducted the interviews using several predetermined, open-ended questions and then followed up as necessary with additional clarifying questions (see Table 3 for a sample of the interview questions). First teachers were asked general questions about their role in implementing literacy practices and meeting expectations of newly adopted standards (e.g., What do you perceive your role to be in meeting literacy CCSS standards?). After asking teachers about their perceptions of their role in and use of these practices, the interviewers explained how we conceptualized each of the codes and asked the teachers to predict how much time they spent on these activities during their class (i.e., If you had to predict what percentage of time you spend incorporating explicit vocabulary and comprehension strategy

Table 3. Sample of teacher interview questions.

Question category	Question
Perceptions of CCSS	As you may or may not be aware Maryland has adopted CCSS. What do you perceive your role to be in meeting literacy CCSS standards? With the adoption of these standards, all teachers are now responsible for literacy instruction such as direct and explicit vocab and comprehension strategy instruction with an emphasis on using these strategies to help students comprehend expository text to acquire content knowledge. How do you feel about these expectations? Do you have struggling readers in your classes? Do you think this instruction can help those students and/or all students to access the content knowledge you are responsible for teaching?
Before showing data	We conceptualized vocab and comprehension strategy instruction to reflect the following evidence-based practices [show codebook]. Note that we recorded each practice being implemented on our code sheet every 1-minute interval of every observation. If you had to predict what percentage of time you spend incorporating explicit vocab and comprehension strategy instruction as we just defined it, how much would it be?
After showing data	These graphs represent the overall percentage of time implementing each of these strategies across 10 classrooms and over 3,000 minutes of observations. So, for example, definitions and examples were used by teachers 6% of the total time we observed. What is your interpretation of this? What do you think the implications are?

Note. CCSS = Common Core State Standards; vocab = vocabulary.

instruction as we just defined it—how much would it be?). Next interviewers showed and explained to each teacher the aggregated results of our observations using a bar graph. Following the examination of our observation results, we asked the teachers how they interpreted the results and what they felt the implications of these findings might be for their students. All teacher interviews were audio recorded and later transcribed for coding.

Data analysis

Phase I: Classroom observations

After all classroom observations were completed, the percentage of 1-min intervals in which each practice was observed was determined. The number of intervals in which each code was observed was totaled across the 40 observations. Next the number of intervals in which each code was observed was divided by the total minutes observed to create a proportion of 1-min intervals in which each practice was observed. These proportions were then converted into percentages by multiplying by 100. Thus, the final results can be interpreted as the percentage of time each practice was observed across all 1-min intervals observed, and thus observed time can be interpreted to be at the 1-min interval unit of analysis.

Phase II: Teacher interviews

Qualitative data were analyzed for patterns using Dedoose, a qualitative data analysis software tool. Prevalent themes and emerging issues were identified via thematic coding (Harry, Sturges, & Klingner, 2005; Wolcott, 1994). After audiotaped interviews were transcribed, two RAs independently read the interview transcripts and identified related chunks (Wexler et al., 2015). The RAs continually adjusted the category definitions in consultation with the first author to develop a set of comparisons that helped us begin to identify themes (LeCompte & Schensul, 1999). This procedure helped us interpret teachers' perceptions in regard to integrating literacy instruction in their classrooms and how these aligned with the results from the classroom observations.

Results

Phase I: Classroom observations

A total of 3,167 min of literacy practices in science instruction were coded in a total of 40 classroom observations (i.e., four observations per 10 teachers). Observed lessons ranged from 23 to 90 min,

Table 4. Percentage of 1-min intervals in which practice occurred.

Code	%
Text reading practices	
Worksheet activity	42.09
Lab/activities procedures/directions	14.94
Textbook/expository passage	2.21
PowerPoint/overhead text	8.24
Electronic text	15.79
Comprehension strategy instruction	
Preview	0.09
Ask and answer questions while reading	0.76
Main idea/summarization	0.60
BK building	
BK: picture/object	15.91
BK: video	15.98
Vocabulary instruction	
Definition/example	6.57
ELL support—translation/cognate	0.79
Morphological/structural analysis	1.14
Contextual analysis	0.06
Graphic organizer/semantic maps	5.55
Grouping	
Independent	35.65
Pairs	23.90
Small group	18.57
Whole class	48.72

Note. BK = background knowledge; ELL = English language learner.

with an average observation length of 79.18 min. We next present the percentage of 1-min intervals we observed for each practice, reported as a percentage of observed time. See Table 4 and Figure 1 for displays of all descriptive data.

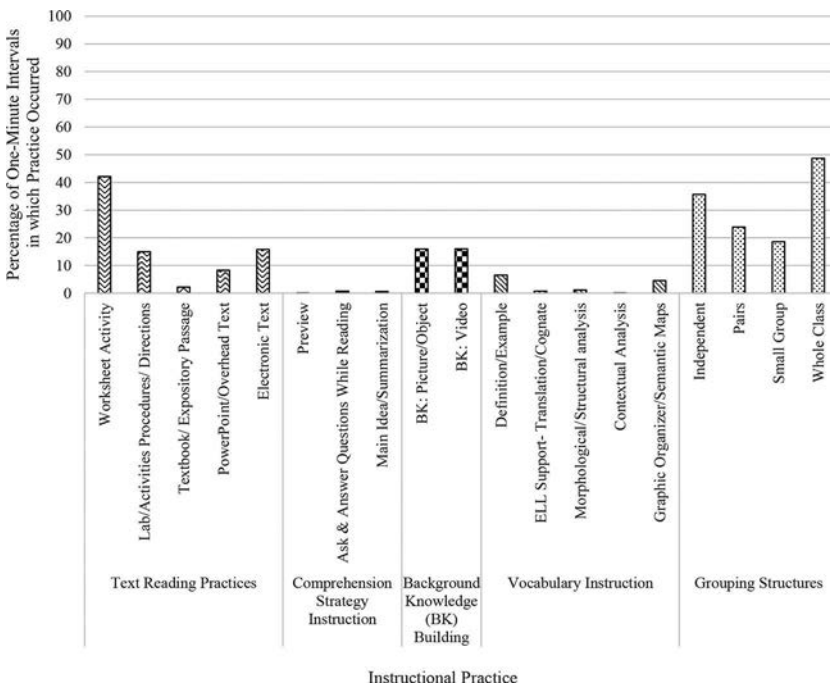


Figure 1. Use of instructional practices graphic display. ELL = English language learner.

Text reading practices

Observations revealed that teachers rarely used multiparagraph expository text as a part of their classroom instruction. Note that for the purpose of this study, we defined worksheets and any type of electronic text as text that could contain some connected text, such as short sentences or a paragraph, but not multiparagraph text. Teachers most commonly utilized worksheets 42.09% of the time. In addition, teachers used electronic texts (i.e., websites and online modules) and lab activities/procedures 15.8% and 14.9% of the observed time, respectively. PowerPoint presentations were evident 8.2% of the time we observed. Teachers engaged students in multiparagraph expository text reading 2.2% of the observed time.

Comprehension strategy instruction

Teachers essentially integrated no comprehension strategy instruction into their instruction. Observers coded these practices as an occurrence if the practice was observed in conjunction with direct use of text. The research team observed each of the strategies (i.e., preview, asking/answering questions, main idea/summarization) for less than 1% of the observed time.

Background knowledge building

Of all evidence-based practices designed to enhance reading comprehension, the most frequently observed practice was background knowledge building. Teachers were observed implementing background knowledge building practices in the form of providing students with pictures/objects or videos 16% of the observed time for each practice. We acknowledge that providing pictures/objects or videos does not represent a comprehensive list of how teachers can provide background knowledge (Neuman, Kaefer, & Pinkham, 2014). We also acknowledge that some people may consider previewing to be a form of background knowledge building. For the purpose of this article, we categorized previewing under comprehension instruction, as noted previously.

Vocabulary instruction

Of all of the vocabulary practices that we observed, we most commonly observed was teachers providing students with definitions/examples. The research team observed this practice 6.6% of the observed time. Despite the fact that 11% of the sample were ELLs, we observed the practice of providing students with ELL support strategies (e.g., cognate instruction) less than 1% of the time. Teachers used graphic organizers/semantic maps to scaffold complex concepts/words 4.6% of the observed time. Furthermore, we essentially did not observe strategy instruction designed to enhance students' ability to become more independent word learners. For example, we only observed morphological/structural analysis instruction 1.1% of the observed time and contextual analysis instruction less than 1% of the observed time.

Grouping practices

The most commonly utilized grouping practice was whole-class instruction. The research team observed this practice 48.7% of the observed time. We observed independent practice 35.7% of the observed time. Finally, teachers utilized partner work and small-group instruction 23.9% and 18.6% of the observed time, respectively.

Phase II: Teacher interviews

We conducted interviews with all observed teachers to glean further information about their perceptions of their role in the implementation and use of evidence-based literacy practices. We were also interested in determining the extent to which their beliefs and current practices aligned. Themes for each category and example quotes from teachers are displayed in [Table 5](#).

Table 5. Interview themes and example quotes.

Theme	Example quote
Use of text	
Aware of importance	"It's everybody's responsibility to improve our students' literacy ... pushing our students to read more technical readings."
Many reasons why facilitating text reading ability is essential	"The biology high school assessment is heavy in reading, very heavy in reading. They [students] read a lot of informational text [in the test]."
Barriers in regard to integrating text	"Quite frankly, the amount of material we are expected to cram into a unit really doesn't allow for—let's take a half an hour in this class to scaffold this reading."
Students are more visual learners	"We don't ever use the book ... we'll try and have a picture because they are such visual learners."
Literacy strategy instruction	
Awareness of importance but only time for short-term strategies	"There are different strategies that we use, and I think it does help the student in the short term ... but you still have a struggling reader and you're just trying to get them passed along."
Strategy instruction is something students do at home	"We do a lot of that for homework. Take it home and read it, answer the questions, summarize it."
Vocabulary knowledge is essential, but teachers do not provide independent word learning strategies	"They're always asking us what words mean. I tell them, 'You need to know this word,' and I say it. I use it a thousand times in class. We'll sometimes make them write down definitions and look up words."
Grouping practices	
Using a variety of grouping strategies purposefully	"Yeah. Overall it's 50%. That's what we, or I shoot for in my classroom, is some part whole class, some part pairs or independent work or small group, so it's a little bit of all of those."
Misbehavior challenges	"After a while it just gets to be easier to get more learning done when you're not fighting with that behavior.... you're fighting with that behavior less when you're not doing those separate small-group activities."

Use of text

We asked teachers about the importance of, use of, and their role in integrating text into their instruction. All 10 science teachers reported that they were aware of and valued the use of text as an instructional tool to improve science literacy. More than half of the teachers provided another reason why the use of text is important: test preparation. One teacher remarked, "The biology high school assessment is heavy in reading, very heavy in reading. They [students] read a lot of informational text [in the test]."

When we showed teachers the observation data revealing little use of text across teachers, they all cited several barriers in regard to actually integrating text into their instruction, including the challenge of using what they perceived to be a complicated text and a lack of time with simultaneous pressure to cover large amounts of content. Furthermore, although teachers initially indicated the belief that text was an important instructional tool, two teachers explained that their students were actually more visual learners who did not necessarily benefit from assignments that relied on the text. All teachers acknowledged that they had received PD consisting of an overview of the CCSS and its inherent expectations that expository text be used as an instructional tool. Four teachers, however, explained that although they had received an overview of the CCSS expectations, they had not received guidance on *how* to address these standards.

Literacy strategy instruction

We asked all teachers to reflect on their role and current practices in regard to implementing literacy strategy instruction (i.e., comprehension, background knowledge building, vocabulary instruction). All teachers indicated an awareness that students typically need some type of strategy instruction to become independent learners; however, after seeing the observation data, four teachers explicitly stated that they only had time to provide instruction on short-term strategies designed to provide a Bandaid to get students through the content. Four of the teachers provided examples that revealed

that their conceptualization of strategy instruction included something students do independently at home for practice.

Teachers agreed that vocabulary knowledge is essential in science; however, seven teachers indicated that they provided direct instruction in vocabulary knowledge, namely, definition instruction, but not independent word learning strategies. After seeing the observation data, all teachers indicated disappointment in the lack of vocabulary instruction and reiterated how many critical vocabulary words students needed to learn.

Grouping practices

We asked teachers about their perceptions of the use of different grouping practices in their instruction. Seven of the 10 teachers we interviewed reported that they felt that they were implementing a variety of grouping structures, and five of these seven teachers added that they were grouping students in a purposeful manner. After seeing the observation data that revealed that the most common grouping structures included whole-class and independent work, four teachers cited a fear of misbehavior as a reason for not letting students work together.

Discussion

Given that this study took place in a state that requires two literacy courses during preservice training and is 4 years into the adoption of the CCSS, we were interested in investigating teachers' literacy and instructional practices that may enhance learning for struggling readers in high school science classrooms. We were also interested in exploring science teachers' perceptions regarding their role in implementing literacy instruction, their use of evidence-based literacy practices, and the overall alignment of these beliefs with their practices.

Text reading practices

Many science researchers and policymakers are currently emphasizing the use of expository text as a primary vehicle to improve science literacy (i.e., Villanueva & Hand, 2011). It is encouraging that all teachers in this study supported the use of expository text as an instructional tool for improving science literacy in general and aiding in specific goals, such as preparing students for the state test. It is noteworthy that teachers in the previously conducted Ness (2009) study also cited test preparation as a concern but were focused solely on a content coverage approach, whereas the teachers in the current study recognized literacy instruction and practice with science text as a critical pathway to improving student achievement on state tests. Considering the current emphasis on reading for understanding with expository text and the teachers' acknowledgment about participating in PD designed to provide an overview of the CCSS, we suggest that teachers' awareness and acceptance of their role in integrating text use into their lessons may be at least partly due to the focus on literacy across the state.

Although teachers indicated awareness and acceptance of their role in using expository text as an instructional tool, this did not align with the practices we observed. We were especially concerned that out of five different text types, teachers used worksheets that typically contained short sentences for the largest portion of time during their lessons and multiparagraph expository text, contained in actual textbooks or separate passages, the least amount of time in the lessons we observed—only 2.2% of the observed time. Our results align with E. Swanson et al.'s (2015) recent observation study in ELA and social studies classrooms in which they also demonstrated that students were rarely engaged in multiparagraph text reading. Although many researchers continue to explore issues related to the use of textbooks and expository text (Berkeley et al., 2012) with the assumption that secondary teachers are using this type of text, results from previous studies as well as the current study do not support this assumption.

After we revealed our findings regarding the type and frequency of text use we observed, the same teachers who initially acknowledged the importance of text use in facilitating learning provided a variety of reasons for their lack of text use in the observed lessons (e.g., uncertainty about how to help their struggling readers with the text). Determining ways to help teachers structure their lessons to account for these challenges is critical. Teachers' acknowledgment of the importance of text use may indicate a potential point of entry for future PD efforts.

Literacy strategy instruction

We also investigated teachers' use of practices to enhance vocabulary knowledge and comprehension of text. This included explicit instruction in strategies students can use to become more independent readers (e.g., main idea strategy instruction) and the provision of background knowledge to enhance understanding of key vocabulary or concepts.

Comprehension strategy instruction

In a recent meta-analysis of 20 studies investigating the effect of vocabulary and comprehension interventions on reading comprehension of science text among students with disabilities, Kaldenberg et al. (2015) reported that explicit vocabulary instruction and the use of multicomponent interventions can have a positive effect on comprehension for students with disabilities when they are reading science-related materials. Interventions targeted in both the studies included in this meta-analysis and the current study were interventions that focused on main idea instruction, self-questioning, the use of graphic organizers, and semantic mapping to learn and recall key vocabulary. Considering that Kaldenberg et al.'s results provided evidence that students can indeed benefit from comprehension strategy instruction with science text, we find it troubling that we observed virtually no strategy instruction designed to enhance comprehension. Ness (2009) reported similar patterns when she observed secondary science classrooms, although Ness and also E. Swanson et al. (2015) both revealed slightly more comprehension strategy instruction in social studies and ELA classes.

This lack of comprehension strategy instruction can likely be attributed to the lack of time students spent engaged with text, which is necessary for text-based comprehension strategy instruction to occur. An alternative explanation is that some teachers have a misunderstanding about what strategy instruction is and how to implement it effectively. When asked about strategy instruction, teachers indicated that they felt that strategy instruction was important but provided examples that revealed that their definition of strategy instruction included something students practiced at home (e.g., answering questions; see Table 5). As previously noted, it is important that students have explicit instruction in strategies to improve comprehension and learning as well as opportunities to practice and receive feedback. This type of instruction is compromised when teachers assign this type of practice for homework.

In summary, like the use of text as an instructional tool, teachers also indicated that students benefited from strategy instruction. Once again, however, their beliefs did not match their actions. Minimal strategy instruction was observed. In addition, teachers' perception that answering questions at home is an example of a strategy does not align with the common definition of comprehension strategy instruction (i.e., promoting students' active participation in the comprehension process through direct and explicit modeling, guided practice, and feedback on a particular strategy; Kamil et al., 2008).

Background knowledge building

Content-area teachers can build background knowledge with activities that do not require a lot of text use and reading (Lee & Spratley, 2010). Although background knowledge building is especially essential for enhancing the comprehension of students who struggle with reading and/or who are ELLs (Gersten, Baker, Smith-Johnson, Dimino, & Peterson, 2006; Recht & Leslie, 1988), spending an excessive amount of time on background knowledge building is not supported by best practice

(Boardman et al., 2008). We observed a considerable amount of background knowledge building, whether linked directly with text or not (i.e., viewing short videos). This finding aligns with the results of the study by E. Swanson et al. (2015) in ELA and social studies.

Vocabulary instruction

Vocabulary knowledge is also essential in science, a content area laden with technical information and discipline-specific terminology (Borsuk, 2010; Fang, 2006). Although the majority of the teachers agreed with this sentiment, we observed infrequent vocabulary instruction. The most common type of vocabulary instruction we observed was providing definitions or examples of words, which aligns with findings in the study by E. Swanson et al. (2015). Still, this occurred only 6.6% of the total observed time. Beyond that, we observed nominal use of graphic organizers/semantic maps to scaffold complex concepts or words.

Older students frequently encounter increasingly difficult and unfamiliar words in texts, especially content-area texts (Baumann et al., 2003), and it is even more important to provide multiple exposures to these words (Beck, McKeown, & Kucan, 2002). Furthermore, it is important to provide not only direct instruction in word meanings but also direct instruction in strategies that students can use to foster word meanings on their own (Boardman et al., 2008). This is essential in the general education setting, in which students are expected to be independent learners. And because teachers indicated that they save some of their assignments that include reading for homework, it is even more essential to provide students with instruction in independent word learning and comprehension strategies. Unfortunately, we observed virtually no strategy instruction (e.g., contextual analysis and morphological/structural analysis) to promote this type of independent learning. E. Swanson et al. (2015) also observed very little independent word learning strategy instruction.

Finally, despite the fact that it is essential to provide vocabulary instruction for ELLs (August, Carlo, Dressler, & Snow, 2005), we saw essentially no evidence-based vocabulary support for ELLs (e.g., cognate instruction). This is especially concerning considering our sample contained 11% ELLs, which includes one class composed solely of ELLs.

Overall, results regarding literacy strategy instruction practices and beliefs mirror those we reported regarding text practices: There is a misalignment between teacher beliefs and implementation of effective practices.

Grouping practices

Altering the delivery of instruction in purposeful ways, such as through the use of a variety of grouping structures, is a recommended practice for all classrooms (Archer & Hughes, 2011). For example, teachers can capitalize on the typically heterogeneous nature of the general education setting and utilize partners or small-group instruction instead of the typical lecture-driven format (Scruggs & Mastropieri, 2007; Wexler et al., 2015). These grouping structures can enhance feedback and practice opportunities, which are especially important for struggling learners (Vaughn et al., 2012).

Although the majority of the teachers indicated that they were implementing a variety of grouping structures, the most common grouping structures we observed included whole-class instruction and independent work, in which teachers typically provide students with the least amount of opportunity to respond and immediate, corrective feedback (Cavanaugh, 2013; Sutherland & Wehby, 2001). It may be that we happened to conduct our observations on days when teachers who responded positively to using different grouping structures were at a point in their lessons when they felt that teacher-directed instruction was necessary. However, when interviewed, teachers elaborated on their lack of use of grouping structures that include partners or small groups, citing reasons such as a fear of misbehavior. Regardless, because we observed an overwhelmingly large portion of time in which whole-class and independent instruction were occurring, we suggest that teachers may benefit from PD in ways to increase their use of a variety of purposeful grouping structures.

Limitations

This study does have several limitations that need to be considered when interpreting the results. Although we made every effort to recruit teachers who represented a variety of science content areas and whose classes contained a large number of struggling readers, this study was conducted using volunteers. Therefore, observations were not evenly distributed across science content areas (e.g., biology, chemistry) or academic levels (e.g., honors), and the number of struggling readers in teachers' classes varied. This may impact the generalizability of the findings. However, our sample included struggling readers (34% of the sample), ELLs (11% of the sample), students in Advanced Placement classes (9% of the sample), and students in honors classes (44% of the sample). In addition, our results align with findings of previously conducted studies in other content areas conducted in other areas of the country (e.g., E. Swanson et al., 2015). There are also several possible threats to the reliability and validity of the data common in observation research. They include observer effects, observer drift, and narrow focus of the coding tool. To mitigate observer effects, the research team conducted multiple observations and gave teachers advanced notice about observation dates so that they could prepare their students for a visitor. It is also worth noting that the teachers and students observed in these classes were familiar with the research team from having participated in a prior unrelated study we conducted with them. Because we only had resources to support one observer per observation, we were concerned about observer drift. To lessen observer drift we held repeated booster trainings and weekly meetings to review codes, even after establishing interrater reliability. Finally, although literacy instruction was rarely observed, our code sheet did not capture the broader context of instruction (e.g., quality of instruction) or discipline-specific literacy practices the teachers may have been implementing. We also acknowledge that there may have been additional practices not captured in particular categories on the code sheet. For example, there are likely additional methods of providing background knowledge instruction that we did not capture.

Future research

Lee and Spratley (2010) recently published a review addressing specific challenges for students comprehending text in each of the content areas. They asserted that although researchers can consider some strategies to be generic (e.g., main idea/summarization), other strategy instruction can be considered unique to each discipline (e.g., science-specific vocabulary). It would be beneficial to structure future observation studies to capture the distinction between generic and discipline-specific instruction. Furthermore, future studies should capture quality of instruction and student engagement. It may also be beneficial to explore other ways to capture a realistic picture of instruction, such as observing several consecutive days of instruction of one teacher and/or scheduling observations more purposefully so that they coincide with types of lessons (e.g., labs).

The teacher interviews provided valuable insight into the impact of the PD teachers were provided and participated in with regard to evidence-based literacy instruction and specifically how that PD was influenced by pressures related to the current standards (e.g., CCSS). It might be useful to explore the impact (or lack thereof) of the PD teachers receive in more depth.

Furthermore, although our original intention was to include enough teacher and student participants to be able to explore the relationship between teachers' instruction and students' achievement, this was not possible because of the relatively small sample size. It would be valuable for researchers to include enough teacher and student participants in future observation studies to allow for these types of analyses.

Finally, considering teachers' concerns about pressure to cover content and a lack of time to do so in content classes that often contain struggling readers, it may be important to explore alternative ways to efficiently integrate literacy instruction into content instruction. For example, perhaps it would be beneficial to determine ways to capitalize on the use of a special education coteacher in the classroom.

Implications for practice

We were interested in documenting the frequency with which secondary science teachers were implementing evidence-based literacy instruction. Overall, we find it compelling that our observation findings align with findings from similar previously conducted studies in other content areas and grade levels (e.g., Ness, 2009; E. Swanson et al., 2015) given the recent increase in expectations and emphasis on integrating literacy instruction into content-area instruction (e.g., CCSS) as well as the sheer numbers of struggling readers who take content-area general education classes. In general, by replicating studies that yielded similar findings, we can build a body of evidence (Cook, 2014). In this case, we extended previous observation work at the secondary level by investigating the types and prevalence of literacy instruction in the area of science. The alignment of our findings with findings from previous studies conducted in social studies and ELA (a) builds a stronger case that evidence-based literacy instruction is occurring infrequently across *all* core content areas in the secondary grades and (b) lends support to the idea that PD support needs to be provided to *all* teachers so that the delivery of literacy strategy instruction is implemented schoolwide. This is critical given that leaders currently advocate that secondary-level students need 2 to 4 hr of literacy instruction on a daily basis (Biancarosa & Snow, 2006).

It is also compelling that the results from this study present evidence of a research-to-practice gap (Cook & Cook, 2013). Although teachers indicated that they were aware of recent literacy expectations and evidence-based practices, and some even testified that they were utilizing strategies to enhance instruction (e.g., purposefully grouping students), others provided several reasons (e.g., lack of time) for why they did not integrate text or literacy strategy instruction into their lessons. Teachers would likely benefit from PD designed to address these issues. It is encouraging that teachers indicated that they were familiar with the expectations set forth by the CCSS, and we therefore hypothesize that they would likely be amenable to PD. This includes PD on a few evidence-based literacy strategies appropriate for science instruction (e.g., main idea generation) and on using features of effective instruction (e.g., modeling) to implement that instruction. Norris and Phillips (2003) pointed out that the act of reading for understanding actually reflects some of the same processes fundamental to science; perhaps a hook for PD with science teachers starts with the transference of this sentiment.

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