Integrating Literacy Instruction into Secondary School Science Inquiry:  
The Challenges of Disciplinary Literacy Teaching and Professional Development

Elizabeth Birr Moje  
LeeAnn M. Sutherland  
Tanya Cleveland  
Mary Heitzman

The University of Michigan

Please direct correspondence to:  
Elizabeth Birr Moje  
University of Michigan  
610 E. University, 4122 SEB  
Ann Arbor, MI 48109-1259  
734.647.9571  
moje@umich.edu

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Incorporating literacy learning strategies in an urban middle school chemistry curriculum:
Teachers’ successes and dilemmas

Although interest in developing integrated science and literacy instruction has been on the rise in the last ten years (e.g., Hand, Wallace, & Yang, 2004; Palincsar & Magnusson, 2001; Saul, 2004), little is known about how secondary school teachers and students employ print-based tools in the service of science learning and, in particular, of scientific inquiry learning. In particular, how do secondary school teachers negotiate the popular and accountability-driven demand to cover content while also teaching young people how to read and write that content? How do secondary teachers work with the constrained amounts of time they have to engage young people in sophisticated scientific literacy practices? How do secondary teachers augment their own knowledge of what is involved in literate practice and, specifically, in science literacy?

Through our work developing, enacting, and researching project-based curricula in Detroit middle schools (e.g., Krajcik, Blumenfeld, Marx, Bass, & Fredricks, 1998; Moje et al., 2004b), we have come to understand more fully some of the demands facing secondary school teachers who wish to foster students’ science learning through doing and reading about science. In this paper, we write about those conflicting demands, via an analysis of our work with teachers in several urban middle school science classrooms. Specifically, we present analyses of our work focused on the classroom enactment of literacy teaching practices designed to enhance students’ scientific literacy. These literacy practices were embedded in project-based science curricula that teachers, researchers, and curriculum developers had crafted together.

As we worked to craft project-science curricula, the team of teachers and developers in our recognized that real-world scientists use print texts extensively in their work. In fact, teachers with whom we work requested the opportunity to learn how to engage students in reading and writing in ways that support their in-class investigations, just as scientists use various kinds of texts to support their investigations. However, integrating literacy instruction into science inquiry requires (a) an understanding of how people learn and use oral and written language in the service of learning and doing
science, (b) high-quality print materials, (c) effective ways to use them, and (d) time to integrate reading and writing into day-to-day teaching. As a development and research team, we challenged ourselves to address the first three of these requirements directly. We designed a print-based tool, which we refer to as the *curriculum reader*, to support students’ science and literacy learning in project-based science units. We also worked with a subset of teachers in the overall development and research project to develop and to integrate scientific literacy teaching practices into their ongoing project-based science instruction. This report reflects our study of that process.

Our guiding research questions for this aspect of the study were: (a) How did teachers use the print-based tools? (b) How did teachers enact the literacy teaching practices and strategies that we modeled, discussed, and planned in professional development sessions? (c) How did students appear to use the print tool and take up the teaching as learning? Although we are interested in the effect literacy practices might have had on students’ content and literacy learning in their science class, in this paper we focus on the teachers’ enactments of text materials materials, literacy teaching practices, and reading strategies. Before turning to the context and findings of the study, we review the theories and extant research studies that guide our work.

**Theoretical and Empirical Perspectives on Subject-Matter Literacy**

The work of our entire research and development group is informed by sociocultural theories of teaching and learning. In brief, these theories suggest that teaching and learning are always situated in and mediated by particular contexts and relationships with other people. In addition, sociocultural theory argues that learning is a result of tool use, with tools ranging from objects such as pencils to language practices to electronic technologies to cultural models.

**Science Learning Theory**

Inquiry- or project-based science approaches fit neatly within a sociocultural theoretical framework. The goal of inquiry science (or any project-based curriculum) is that student learning is framed and motivated by real-world questions that are of interest to real people in real places. The features of inquiry science curricula generally include (a) driving questions anchored in real-world
problems; (b) investigations and artifact creation; (c) collaboration among students, teachers, and others in the community; and (d) use of technological tools (Krajcik, Blumenfeld, Marx, Bass, & Fredricks, 1998). Because some claim that inquiry science engages students in knowledge making as a method for learning science (Marx, Blumenfeld, Krajcik, & Soloway, 1997), and because project-based science is both discourse enabling and discourse dependent (Author A, X, Y, and Z 2001), it is an appropriate venue for developing content-area curricula in which literacy practices play an integral role (in other words, content-area literacy). The results of our PBS and literacy development work have been encouraging, with analyses of nearly 5,000 students’ test scores demonstrating statistically significant increases in science learning for each year of participation. Moreover, the strength of the effects has grown over the years, as evidenced by increasing effect size estimates across the years (Related Author et al., 2004; Related Author et al., 2004).

We are particularly interested in questions of language and literacy because although students have made knowledge gains while engaged in these curricula, the gains tend to be highest at basic knowledge level of science content learning, and are less strong when it comes to process questions, in which students must read data tables and graphs as they produce short-answer responses to questions about fictional investigations (Marx et al., 2001). In addition, a number of questions and challenges raised by teachers in professional development meetings, together with the [city name] Public Schools’ systemic commitment to the improvement of content-area literacy learning, has led us to focus a substantial aspect of our current systemic reform efforts on the development of scientific (or content-area specific) literacy teaching practices that support teachers as they develop scientific communication skills in their students.

**Literacy Theory**

Our team operates from the theory that literacy is a tool for both developing and representing knowledge (Vygotsky, 1978). We also assume that producing knowledge in a discipline requires fluency in making and interrogating knowledge claims, which in turn requires fluency in a wide range of ways of constructing and communicating knowledge privileged by different discourse communities (Luke, 2001).
Literacy, in that view, becomes an essential and highly particular aspect of disciplinary practice, rather than only a set of strategies or tools to improve reading and writing of content-area texts. Furthermore, we argue that a person who has a deep understanding of content and disciplinary discourse conventions can use a variety of representational forms (including the reading and writing of written text, as well as oral language and visual images) to communicate their learning, to challenge their prior understanding vis a vis encounters with new ideas, and to synthesize and express new ideas. Concomitantly, the use of multiple forms of communicating and accessing understanding can build deeper content knowledge and more sophisticated process skills.

Although we use the phrase “literacy teaching practices” herein, teachers commonly encounter reading, writing, and literacy “strategies” for teaching in workshops, professional development, practitioner journals, and books designed to support content literacy instruction. This use of the word strategies to apply to what teachers do, as well as to what reader do, has led to some confusion as teaching strategies are put into practice. In part, the confusion has arisen because the teaching strategy is modeled on the principles of good reading practices; the argument around the development of content literacy teaching strategies went something like this: If teachers model via instructional strategies the strategies used by readers to make sense of text, then student will take up the strategies and make them part of their reading practice.

Attempting to mediate this confusion, Alvermann and Moore (1991) distinguished between literacy teaching strategies and literacy learning strategies. Literacy learning strategies are those actions readers take when they recognize that their skills have broken down. Readers who recognize, for example, that they did not make sense of text they just read may choose to reread, to outline or map the text, to check the meaning of vocabulary that may have affected their understanding, or to implement any one of a number of other comprehension strategies. On the other hand, teachers employ teaching strategies to guide and support students as they become increasingly independent, skilled readers.

In response to the messiness of the construct of strategies, Greenleaf et al. (2005) refer to routines rather than strategies (cf. Deshler and Schumaker, 2005). Routines, they argue, become part of everyday
classroom life—the things teachers and students regularly do in class. As donning protective goggles and
gloves become part of the routine of preparing for lab activities, using section titles to foreground prior
knowledge and to stimulate questions about a topic is part of the routine of preparing to read science text.
Building on the work of these scholars, we offer a slight twist on the concept of routines. We echo the
habituated notion of routines, but we use the word *practices* to signal that these actions and habits of mind
are situated in social contexts and thus may change with the demands of that context. They are not
routines, per se, such as donning protective goggles for lab; they are habits of mind and action called up
by and situated within particular tasks. Using section titles to prompt prior knowledge, for example, may
only be useful if the requisite prior knowledge is available or if the section title accurately signal the
upcoming text. Thus, we seek to instantiate larger teaching practices of setting purposes and framing
problems, previewing texts, building requisite knowledge, questioning, and summarizing and
synthesizing across texts (Author A and Author X, 2008). Within these practices, we draw from many of
the well-known literacy teaching “strategies,” or what we think of as tools, to carry out these practices.

*Disciplinary Literacy Research and Theory*

Classroom teachers in secondary schools often find it difficult to infuse literacy teaching into
content-area curricula (O’Brien, Moje, & Stewart, 2001). Explanations for the difficulty include
institutional constraints on time, secondary teachers’ limited knowledge of literacy processes and literacy
teaching practices, and teachers’ resistance to envisioning literacy as part of learning in their content area
(O’Brien, Stewart, & Moje, 1995). Germane to this project, science teachers’ beliefs about the nature of
science also shape their sense of whether and how literacy will help their students to adequately learn in
the discipline (Dillon, O’Brien, Moje, & Stewart, 1994; Yore, 1991). If teachers believe written texts to
be authoritative representations of scientific truths, for example, they may seek ways to help students find
the right answers to teacher-posed questions, rather than to guide students in reading for deep
understanding (Author A, 1997).
Challenging such views of text as authority, project-based science may seem to suggest that the role of language in inquiry-based classrooms is secondary at best. “In much of science education, language is pushed into the background or ignored, while thinking or doing are brought into the foreground as if these tasks had little to do with language” (Gee, 2004, p. 13). Yore (2004) indicates that in 30 years of working with language and science, his most difficult task has been to convince science educators about the importance of language in science and the importance of language-oriented tasks in inquiry science instruction.

Even when teachers do value the role of language in inquiry science and hold positive attitudes toward teaching their students to read in science, other dilemmas surface. Vigil and Dick (1987) found that positive attitudes towards teaching reading did not necessarily produce higher quality literacy instruction. Similarly, Hall (2005) asserted that, “Though some teachers in their study felt that a wide range of reading strategies was important, their instruction with students centered primarily on developing their study skills and vocabulary knowledge. Students received little help on learning such things as how to set purposes for reading and how to summarize text” (p. 407).

What’s more, effective literacy teaching practices can be adapted to the specific needs of the students, as well as to the material being used and the context in which it is used, but adaptations may also alter a strategy to render it less effective. For example, Sutherland and George’s (2005) analysis of teachers conducting interactive read-alouds in class demonstrates that what was meant to be a meaning-making activity became a literal level exercise as the questions teachers posed asked students to recall factual information or to repeat the language of the text.

Similarly, adolescents do not often have opportunities to hear good, fluent oral reading; literacy educators therefore, recommend oral reading of short, interesting segments of text in secondary classrooms as a way to stimulate discussion, generate interest, and provide a model of fluent reading. Yet, in Sutherland and George’s (2005) analysis of teachers reading aloud to students in class, teachers used the opportunity primarily to call attention to reading skills and to the extraction of information from texts. Teachers stopped reading, for example, to ask students, “Should we be underlining that?” when
they came to a main idea or an important piece of science content. The fluency and increased interest in
the text that the researchers hoped to prompt seemed to be stifled by teachers’ beliefs that their students
needed to get the right information out of the text.

Even as they highlighted main ideas, however, teachers were not explicit about how they
determined which sentence(s) expressed the main idea. The ability to determine text structure, such as
how text is organized and where main ideas are stated, is a key factor in students’ comprehension (Cook
& Mayer, 1988; Dickson, Simmons, & Kameenui, 2003). Yet, instead of guiding students to recognize
signals for determining importance, teachers said, “This is important; underline it.” This practice
illustrates teachers “orchestrat[ing] students’ reading… in the name of predetermined outcomes of the
required curriculum” (Hinchman & Moje, 1998, p. 120) to which students are not privy.

To make matters more complex, although the general value of these various literacy teaching
practices for helping young people learn to access information from texts is well documented (Alvermann
& Moore, 1990), literacy instruction is often viewed as separate from the learning of the content. This is
not merely a function of secondary school teachers’ enactments of literacy strategy instruction, but is also
the dominant mode of practice in teacher education programs. Rather than embedding the teaching of
disciplinary literate practices into a discipline’s education courses, generic literacy teaching strategies
typically have been offered in single courses, and teachers are expected to apply to the texts of their
disciplines (O’Brien, Stewart, & Moje, 1995).

In contrast to the generic approach, we argue that content learning is as much about learning to
use the language of the disciplines effectively and fluently as it is about learning disciplinary concepts.
Learning science, from a sociocultural learning perspective, is as much about learning to talk, read, and
write science as is it about learning scientific concepts or facts (cf. Lee & Fradd, 1999; Lemke, 1990;
Moje et al., 2004a). The opposite is also true: To be literate in a content area involves learning the
content associated with the area.

As Moje et al. (2004) argue, readers must be able to interpret a text’s meaning and import,
beyond basic comprehension. Further, writers of content text must be able to predict what their audiences
will know and believe, and writers must use language and concepts in a way that persuades the audience to interpret their texts in particular ways. To engage in any of those literacy skills requires knowing certain information, recognizing what are the valued concepts of the area, and being able to define the highly used and valued terms and phrases. In other words, it requires domain-specific knowledge. Equally important, literate skill—and even strategy use—in a content area requires an understanding of how knowledge is constructed and organized in the content area, an understanding of what counts as warrant or evidence for a claim, and an understanding of the conventions of communicating that knowledge (Moje et al., 2004a). In sum, being able to access content knowledge depends at some level on one’s understanding of the existing knowledge base and discursive conventions of the content area. Similarly, developing strong interpretive or rhetorical skill in a content area requires that one understand the relevant content concepts. Teaching students these skills is what constitutes disciplinary literacy instruction.

Drawing from these theoretical and empirical perspectives, we attempted in our professional development work to introduce teaching practices that we hoped would integrate well into the existing curriculum, support the use of the print-based tool we had developed, help the teachers support struggling readers in developing decoding and comprehension skills, make assumptions about science more visible, and foster disciplinary—or in this case, scientific—literacy instruction. We also worked from the participating teachers’ professed interests and needs; in other words, as the teachers described particular instructional dilemmas, we tried to offer teaching strategies and broader teaching practices to address those dilemmas

**Background on the Project**

Our team of teachers and researchers worked together to integrate literacy and science teaching in the context an inquiry science curriculum on chemical reaction. The project-based unit was organized around the driving question, “How can I make new stuff from old stuff?” (hereafter referred to as the *Stuff* unit). Many of the teachers in the project participated in developing the *Stuff* curriculum; and the
researchers designed the print-based curriculum reader that teachers used with their students in the process of investigation. The project-based inquiry unit focuses on substances and their properties, chemical reactions, and conservation of matter. The curriculum reader was comprised of expository (informational) text, narrative text (i.e., problem-based cases), and real-world text (such as one might find in a newspaper or popular magazine), sequenced to help students build understanding through multiple encounters with these difficult concepts. The curriculum reader’s composition also reflected a belief we share with Yager (2004) that “science content must be related to the real world—the world the students know and operate in” (p. 103). The texts we developed incorporate numerous real-world applications of science principles to help students make sense of science concepts that are difficult, abstract, and not always of obvious importance in their lives.

Although the expository texts were constructed according to principles of considerate text (Anderson & Armbruster, 1984), we knew that even carefully designed texts can challenge those adolescents who either struggle with basic reading and writing processes or with the technical and interpretive demands of science text. Studies have found that most students require support in comprehension, composition, and meaning making or application of science texts (Goldman, 1997; Ivey, 1999; Lee & Fradd, 1999; Nicholson, 1985). Most of the teachers on the team considered their students to be struggling readers and writers and were interested in ways to help students learn increasingly complex science that requires reading and writing as an aspect of inquiry and knowledge production. Thus, in addition to attending closely to students’ prior knowledge and to real-world application in the texts we designed, we presented teachers with literacy teaching practices that addressed fluency, vocabulary knowledge, challenges of text genre and structure, question generation, summarization, and metacognition or self-monitoring of comprehension, all dimensions of reading considered important for rich comprehension of ideas in text among older readers (Biancarosa & Snow, 2004; Kamil & Bernhardt, 2004; Snow et al., 2004).

In addition, reading research has demonstrated that reading instruction needs to be modeled (Pearson & Dole, 1987; Spencer, Yore & Williams, 1999), practiced with teacher guidance, and
embedded in actual assigned texts (as cited in Yore, 2004). As a research team, we chose research-based literacy teaching practices that would support student learning using the curriculum reader embedded in inquiry activities. In choosing and adapting established practices, we remained cognizant of teachers’ concerns regarding the amount of time literacy teaching requires and thus tried to develop integrated inquiry and reading practices that teachers could use without adding significantly to their already overwhelming set of classroom tasks.

In our work with these teachers across multiple years, and our concentrated effort on literacy teaching practices during the school year, we recognized teachers’ challenges in making literacy practices work in their classrooms. This article presents the most salient aspects of those challenges, those that resulted in literacy teaching practices appearing to be stand-alone tasks, separated from curricular activities, text reading, and metacognitive or strategic reading instruction. A constellation of factors resulted in literacy teaching practices looking more like traditional worksheet completion than like reading and writing integrated into the science curriculum to support student as they learned science content.

These findings are particularly important in light of past work in content-area literacy, which has theorized that structural, cultural, and institutional factors challenge teachers from fully integrating literacy instruction into their content areas (O’Brien et al., 1995; O’Brien, Moje, & Stewart, 2001). Some explanations have argued that teachers resist the integration of literacy teaching practices as antithetical to their work as content specialists (O’Brien & Stewart, 1990; Vacca & Vacca, 2004). In our case, however, the teachers were fully committed to the work of integration, yet challenges remained, raising important questions and suggesting implications about how best to enact professional development that supports both enthusiastic and skeptical teachers in the integration of content literacy teaching practices and about how to design or enhance secondary school structures to better support literacy integration efforts.

Research Design and Methods

Just as our substantive questions are guided by sociocultural theories of both learning and teaching, our research design is similarly framed by sociocultural theories. Sociocultural theory demands
attention to both growth over time (i.e., learning) and the processes, practices, and relationships that led to
growth. Specifically, although we attempted to measure growth over time by focusing on teaching and
learning growth via experimental methods that compared teachers and students using different teaching
tools, we also examined the processes, practices, and relationships of both the classroom teaching and
learning and the professional development through the collection of intensive observations, interviews,
and artifacts. This paper focuses on the professional development and curriculum enactment by teachers.

Participants

Twelve teachers volunteered to participate in a project designed as a small-scale quasi-
experimental study, in which half of the teachers used the text tool we developed and half did not, but all
teachers engaged in professional development around the integration of literacy teaching strategies into
the Stuff curriculum. Our experiment hit some snags along the way (both teachers and students being
transferred in and out of experimental and control classrooms and sometimes even out of schools), and
one of the participating teachers was moved to a high school classroom just days before the unit began in
late fall, but our study of the professional development with the remaining 11 held firm. The 11 teachers
participated in professional development sessions in which we designed integrated science literacy
instruction, and we documented the conversations of those 11 teachers during the session. We also
observed practice in 6 of the 11 classrooms, constituting a sub-sample of 6 teacher participants.

Professional Development

Professional development sessions, held prior to and during the chemistry unit, included activities
designed to introduced teachers to research and theories of literacy learning, which were discussed at
length. Author A and Author B designed and led the professional development sessions, and adapted
each session to teachers’ expressed needs. In past research with some of these teachers and their peers,
we had been asked for strategies that would help their students read in science. In particular, the teachers
voiced concerns about students’ reading ability based on evidence of test scores and in-class performance,
especially reading aloud, which was a popular practice in the classrooms. Consequently, we designed the
sessions to emphasize engaging students in reading, particularly focusing on pre-reading activities that
would encourage student interest; setting purposes for reading; revealing the meaning of new terms or of everyday words used in unique ways in scientific discourse; making predictions about the ideas or concepts to be read; and writing in science. As a group, the teachers had been using a rubric for writing scientific explanations, and we thus focused these sessions on writing activities that fostered reading comprehension.

Initial sessions focused on the reasons for integrating literacy instruction into science inquiry, together with presentations on and discussions of how people read and how, in particular, they read science texts. We then turned to practices and strategies for such integration. Each of the remaining sessions focused on some of the basic aspects of and strategies for integrating reading comprehension instruction into science inquiry. The strategies included the use of preview guides, perspective-taking activities, categorization activities such as “List-Group-Label” and word sorts, Text Impressions (McGinley & Denner, 1988; Textual Tools Study Group, 2006), vocabulary concept cards, semantic feature analysis, and morphemic analysis (see Appendix A for a detailed description of specific practices referred to in the Findings section). At each session, we would model a teaching tool, discuss its theoretical rationale (i.e., why one might do it, with an emphasis on the practices that should surround it), and then discuss as a group how teachers might weave it into the inquiry lessons. Teachers then returned to their classrooms to enact these integrated science-literacy inquiry lessons with their students.

In subsequent meetings, the teachers shared their successes in using the strategies as well as their dilemmas in the enactment or in future enactments they imagined as the strategies were incorporated into their classroom routines. For example, one challenge in this planning activity involved managing the time required for engaging in such activities. Teachers who had not yet tried the integrated science-literacy lessons benefited from hearing their colleagues talk about where they had felt pressured by time and how they had addressed those timing issues in the midst of the lessons. Another oft-cited dilemma was the feeling that students had not engaged in the literacy activity “correctly.” We often used these discussions to talk about the value of the activity, despite the lack of a perfect product. Several of these
dilemmas surfaced in our analysis as key to explaining our overall findings, and we discuss them in more detail in the sections that follow.

**Data Sources and Methods of Collection**

Data collection occurred over the course of 8 months (the duration of the professional development) and classroom data collection occurred over the course of one unit of study, approximately 8-10 weeks, depending on the teacher.

For the professional development aspect of the study, we audio and/or videotaped professional development sessions, took notes on the sessions, and conducted informal interviews with all teachers. The formal professional development sessions, however, are only one aspect of documenting teacher learning. We also studied their practice in classrooms. To do so, we conducted focused classroom observations of 6 of the 11 classrooms to document aspects of the particular literacy teaching strategies and practices that the teachers employed, as well as on the details of how and why they made moment-by-moment instructional decisions about how to use the strategies and the text materials. We also employed naturalistic observation methods to ensure that we did not miss important aspects of classroom interaction that may have shaped the use or effects of the readers, but that were not included on our observation protocol. The in-class observations were conducted at least once a week for the entire unit, and field notes were supplemented by audio- and videotape recordings of classroom practices whenever possible. Artifacts of instruction/student learning were collected when possible by researchers and by teacher partners (e.g., we collected copies of vocabulary concept cards, concept-of-definition maps, etc.).

We also conducted informal interviews with 3 target students in each of the 6 focal classrooms throughout the unit, and we gave informal reading inventories to 18 target students. The informal reading inventories relied on the Qualitative Reading Inventory (Leslie & Caldwell, 2000), together with materials pulled from the curriculum readers, thus allowing us to assess students’ facility with the reading materials and with written language communication skills relevant to the science concepts under study. Students were chosen purposely by asking teachers to identify students they thought would fall into the categories of “high-,” “medium-,” and “low-performing” readers. In addition, we administered a
computerized diagnostic reading assessment (in pilot stages of development) to all students in the 11 classrooms. The reading diagnostic was given pre and post-unit, but student attrition, combined with classroom changes and challenges in obtaining informed parental consent, prevent us from analyzing with any power the students’ reading scores post-unit. However, we have been able to score students’ pre-unit reading responses to three different types of passages, two of which are science-related, and one of which is a general text. All the pieces are expository in type, although, only the curriculum reader text represented “true” or “hard” expository texts (Santa & Alvermann, 1991).

Although we do not report findings from the student reading assessments in this paper, the assessments serve as a context in which we can think about why and how teachers make instructional decisions related to literacy, science, and the integration of the two. In particular, teachers’ reports of students as “low-performing” and contradictions between these reports and our student reading data led us to hypothesize how teachers’ beliefs about their students’ skills might have constrained their attempts at integration of literacy teaching strategies. We discuss these hypotheses later in the paper.

Additional contextual data sources included pre- and post-curriculum science test score data, observation data, and content and process interview data collected across all classrooms in the larger research initiative. These data are not reported here, but also provide a backdrop for our analyses. In short, our years of research with these teachers and in these schools, together with the rich data context of literally thousands of students’ pre- and post-test scores collected over multiple years, provide us with much more information than we could possibly collect in our short-term focused study of professional development during one unit of instruction. We draw on all of these data sources as we theorize the results of this particular data collection event.

These data were collected by five researchers, all women. Three are science education researchers, two are literacy researchers with a background in science curriculum development. The two literacy researchers have extensive classroom teaching, professional development, and research experience. One of the literacy researchers also has experience as a high school biology teacher. We represent a range of ethnic and racial backgrounds.
Data Analysis Methods

We relied on methods from constant comparative analysis (Strauss, 1987), although our analysis did not begin during data collection, as CCA would prescribe. That is, although we discussed observations as they were occurring throughout the unit, data collection procedures were so time-consuming that the bulk of open coding was delayed until after the unit was completed and data collection activities ceased. At that point, we engaged in an extensive and intensive open coding process, beginning with two team members each taking responsibility for reading a set of field notes that at least one member of the duo had not taken. Using this partner process, we each coded the field notes by teacher for evidence that the particular literacy teaching tools and practices we presented in professional development had been enacted. We noted teaching tools and practices, excerpted field notes, and described the tools in a chart that allowed us to see the quantity, quality, and range of teaching strategies employed at any observation point by each teacher. We looked specifically at the nature of the activity, the context in which it was enacted; how it was enacted; what, if any, follow-up occurred; and how students took it up.

This process led us to discern that the literacy teaching tools were enacted in a wide variety of ways across the classrooms. Moreover, in addition to the teaching strategies we had presented, we documented a number of other types of literacy activities. We then revisited our field notes in the same manner as described above, although on this occasion, we coded for any type of literacy teaching activity that had occurred. An activity could include anything from assigning reading from text to engaging in a strategic reading lesson. Following that open coding process, we noted that certain codes were repeated throughout our individual analyses. In particular, we documented (a) various uses of and talk about the curriculum reading material, (b) particular kinds of teaching tools enacted, (c) a focus on the constraints—especially time constraints—on their scientific literacy teaching, documented in both in informal interviews and classroom talk, and (d) a focus on teaching vocabulary related to the unit.

These initial codes led us into an axial coding stage in which we again worked through the field notes, but this time reading and coding for the codes listed above to determine whether they did, indeed, represent categories in the data. More important, we searched for possible areas to collapse or for
disconfirming evidence. As called for in axial coding, we analyzed each code in relation to the others (e.g., examining whether issues of time were present in the predominance of vocabulary-based tools). We also tried to leave ourselves open to noting “other” codes. At the conclusion of this process, we had prepared five different category charts, labeled (a) reading materials, (b) teaching tools, (c) time, (d) word/vocabulary, and (e) other, which contained moments or moves of interest, but with too little redundancy or saturation to justify categories unto themselves (an excerpt of one is included as Appendix B).

We then moved into selective coding, wherein we each took responsibility for one category chart, and we swept the data again, looking for any additional evidence and for disconfirming evidence. Because we saw little use of the classroom reading materials except when specifically called for in the curriculum, our data analysis revolved around the categories of strategies, time, and words/vocabulary. We did, however, document the general lack of focused attention to reading materials. Team members wrote interpretive commentary for each data exemplar in a particular category. Following the selective coding process, we constructed a key linkage chart that suggested two related major assertions.

Two of the team members—Author C and Author D—then took responsibility for the last stage of the coding process, again sweeping the database with the key linkage chart in mind, fleshing out the chart and beginning to produce text to explicate our assertions. We met periodically to review the key linkages as we wrote. What follows is a report of our assertions and the data exemplars and patterns that warrant these assertions. In each case, data presented from one teacher or classroom are representative of the entire group; that is, we do not present patterns that held only for some teachers in the group, although, of course, teachers differed in their discourse and practice. These exemplars, however, represent broad patterns of discourse and practice across all the teachers.

**Findings**

As a result of our analyses, we put forth three closely related assertions. First, we assert that teachers in this study tended to enact literacy teaching tools as stand-alone activities rather than as integrated tools or practices for supporting students’ scientific inquiry or learning. That is, the teaching
tools functioned more as tasks to be completed than as practices that facilitated students’ interactions with texts and promoted the development of scientifically literate and strategic readers. Closely aligned with this is our second assertion that vocabulary teaching tools, in particular, tended to be most privileged among the literacy teaching practices the teachers employed with regularity.

Our data suggest a third assertion: This stand-alone enactment was shaped by a constellation of three factors: (a) the teachers’ beliefs about their students’ literacy abilities, (b) the teachers’ struggles to meet conflicting curricular and time demands, and (c) the nature and extent of our professional development. For example, vocabulary tools were likely to have been the most popular because they met what teachers saw as their students’ reading and writing challenges and needs, which teachers appeared to view as separate from, but impinging on, the learning of science. In addition, vocabulary tools appeared to be the most discrete, or the ones that stood apart most evidently from the curriculum and, as such, they could be inserted into the existing curriculum more readily. In particular, vocabulary tools could be conducted in relatively short time frames and produced immediately assessable artifacts. Finally, because the teachers were eager for these tools, we offered a host of them and emphasized their use during professional development sessions, thus reinforcing their usefulness as stand-alone tools.

In the next section, we discuss these assertions, followed by explication of those factors that seemed to shape the enactment we observed, drawing on data from fieldnotes and teacher interviews to support each claim.

**Literacy Teaching Tools as Stand-Alone Rather than Integrated Activities**

Although the teachers reported success with using the literacy tools, analyses indicated that they focused on literacy teaching as tasks to be completed. Teachers ostensibly employed literacy tools as a way to integrate learning with inquiry activities and learning with print, yet that integration was often tightly constrained or proceduralized, making the integration appear cursory. In some cases, we saw no evidence of integration. The teachers’ overarching emphasis seemed to rest on the act of *doing* (doing reading, doing writing, doing literacy) in science rather than on using literacy activities and practices to develop investigations or on helping students develop independent scientific reading and writing skills in
the context of the science curriculum. Thus literacy teaching stood alone as exercises to be completed, set
apart from the science investigations and sometimes even from the reading of texts around which they
were designed.

**Literacy tools: Activities to complete.** The stand-alone, task-like nature of literacy tools was
evident most obviously in teachers’ discourse, particularly as they communicated about classroom tasks
with their students. For example, as part of their daily routine, many teachers commonly wrote the day’s
agenda on the board. As one teacher prepared to enact one of the literacy practices, she¹ told students that
the day’s agenda included, “a reading trick.” Another told students they would be “doing a literacy
strategy.” A third teacher wrote the following on the board as she described the practice in which they
were about to engage:

- Science information
- Imagination
- Literacy skills
- Writing skill

Note how literacy skills are set apart, and writing skills set even further apart, from the “science
information” the students were going to be learning. Discourse that positions literacy as a “reading trick”
or “doing a literacy strategy” conveyed the teachers’ framing of the literacy activities as isolated
activities, rather than as tools integrated into inquiry to support meaning making. The next exemplar,
discussed below in some detail, further warrants the stand-alone assertion and exemplifies a consistent
pattern across the 6 classrooms.

In the following exemplar from fieldnotes, one teacher enacted the List-Group-Label (LGL)
(Taba, 1967) teaching tool (see Appendix A for origin and description). The LGL teaching tool aims to
make students aware of words and their uses by asking them to group words together in possible
categories of relationships prior to reading a text (e.g., *cat*, *dog*, and *canary* might be predicted to fall into

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¹ Only two male teachers participated in this research; therefore, only female pronouns are used throughout this
paper to ensure participants’ anonymity.
the category of pets. It also provides a purpose for reading as students read to determine what target words mean in the actual text and to evaluate their predictions relative to the use of the words in the target text. Whether or not students’ categories are accurate according to the word meanings in the assigned text is unimportant in this strategy because the emphasis is on encouraging the students to think about how words represent larger concepts, and about how those concepts are related to each other and, in this case, to a scientific phenomenon.

In this instance, the teacher gave students a list of words she had selected from the text (which students had not yet read) and told them that they had 5 minutes in which to categorize the words in any manner that made sense to them based on their prior knowledge or everyday experiences. After students categorized the words, the teacher called upon groups to share one of their categories and the words they had assigned to it. This fieldnote excerpt represents the nature of the group sharing session:

The teacher asks Table 3 to pick one of the groups they made and what words they put in the group. The students had made a group: “Eyes” – and put see and bright into the group.

The teacher then asks Table 2 to tell one of its groups and the words they put into the group. Table 2 made a group, “Science” — and put teacher, chemical reaction and substance into the group.

The teacher then calls on Table 4 – asking for one of their groups, and the words they placed in the group. Table 4 made a group called, “4th of July” and put fireworks, sparkler, burning, bright and rocket.

After having the groups present their categorizations, the teacher moved on to having the students read the text. Thus, the teacher’s first step in the process as represented in the data exemplar illustrates that although she engaged in the steps of the strategy, she did not integrate the strategy with the science under study. She did not engage the students in a discussion of categorization schemes, which is key part of the strategy. The word bright, for example, appears in both the “eyes” category and the “4th of July”
category in these examples. Asking the students to discuss why they had categorized the words differently would have not only helped all the students think about what the words might mean in this and other contexts, but would also prime the students to attend closely to the use of the word in the target text they were going to read.

In addition, categorizing the words replicates a key act of inquiry in science, classification. Classification systems abound in science, and categorization is important throughout this unit (e.g., differentiating among solids, liquids, and gases according to the spacing and the movement of molecules in each state of matter). If students were to talk about the rationale for their choices, they would see that words can justifiably be classified differently—and still “correctly”—depending on the purposes and context for the classification. Such an activity can scaffold categorization and classification practices important to science learning. In addition, as a reading comprehension strategy, LGL can help students activate prior knowledge and become more aware of word meaning and their own comprehension as they read. The reporting of categories by group, with no discussion of why they chose the categories they did, as illustrated in this field note excerpt, however, did not stimulate prior knowledge related to the science text, set a purpose for reading, or promote the learning of categorization skills in overt ways.

This group sharing of categories was followed by another strategy, Text Impressions, which was meant to further engage students in the text and in learning the meaning of a chemical reaction and its related vocabulary. The Text Impressions strategy, based on McGinley and Denner’s (1988), Story Impressions, requires students to link the selected words together by producing their own text from the words. The purpose is to encourage students to think about everyday meanings of these words (prior knowledge) and to work with words and meanings before reading. This excerpt from field notes illustrates how the teacher proceeded after three groups of students had shared their categorization scheme:

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2 It’s worth noting that the reporting of different ideas may have stimulated student learning that was not evident in observation. Nevertheless, the enactment of the strategy did not realize its possibilities as originally conceptualized.
The teacher mentions that today they will read through the student reader section from which she took the words; she reminds them about putting words into groups and making their stories, and tells students that they can read this story and see which they like better. The teacher explains that the story they’ll read isn’t a “story-story” but a “learning story, so that we can learn about how fireworks work”… the teacher then mentions that after they read through the story and answer questions, they’ll watch video about fireworks and then read a short story about fireworks.

In this enactment, the narrative and expository texts that the students read after the Text Impressions activity explained the chemical reaction involved in firework displays. The strategy, as enacted, however, seemed to stand alone as one of a series of four tasks related to fireworks. Procedurally, the enactment was congruent with the strategy’s sequence of steps. First, the teacher gave students a list of words she had chosen (using criteria) from the text they would be reading. Second, she had students categorize the words. Third, she had students share the categories they created in order to group the words (although without analysis or discussion). Fourth, students composed their own texts using the target words. Fifth, students read the text(s). The teacher spent three days on these activities—evidence of her commitment to promoting literacy in her science classroom. She was committed to and successful in inserting reading and writing into science class, in doing literacy. However, this pattern of using strategies in ways that appear disconnected from their purpose as reading and thinking tools was evident here and in numerous other instances across classrooms.

In another instance, a different teacher created an independent seatwork exercise in which students practiced retrieving information from text:

Today, Ms. Carlos told the observer that the class was having problems with finding answers to questions in text. She said that they needed to practice reading and answering questions by retrieving the information from the text. She chose passages from Lesson 7.1: *What is a Chemical Reaction?* Ms. Carlos copied the text onto a separate sheet of
paper and numbered the paragraphs from 1 through 10. She supplied students with 25 questions and told them that the answers can be found directly from the text. However, there are three questions that required them to take answers from multiple paragraphs. She told them not to write the questions down, just the answers. The entire class was a silent, independent workday. Students were not allowed to talk or discuss their answers. Ms. Carlos explained to the students that she wanted them to be able to be self-sufficient in this type of work.

This representative data exemplar provides evidence of teachers’ desire to support their students’ reading comprehension. In this case, the teacher believed that she could support reading comprehension in the context of inquiry science, and she applied the idea in ways that made sense to her. However, this enactment of literacy teaching reflected little scaffolding of reading comprehension with attention to the factors we had discussed in the professional development: textual factors (e.g., difficulty, interestingness), individual student factors (e.g., ability, interest, prior knowledge), and the reading context (e.g., purpose for reading, scientific discourse). The teacher did not model how students might use the questions to help them make sense of the text, how to retrieve information from text when answering literal questions, or how one synthesizes information from multiple paragraphs. Nor did the teacher discuss why this way of “practicing” might be important. In short, this teacher’s understanding of how to enact literacy teaching strategies to support comprehension of science texts appeared to be vastly different from the theories we had articulated and practices and strategies we had modeled in professional development. At first puzzled by this observation, our hypothesis—based on analyses of her discourse and other teachers’ practices and feedback on the strategies—was that she saw the activity as a task that students needed to improve their skills prior to engaging in scientific inquiry via texts. This notion of improving skills—thus leading to literacy instruction as separate, stand-alone activity—was evident across the classrooms we studied.
Strategies: Activities to Complete Correctly. Another warrant for our analysis that teachers saw the literacy teaching practices as separate from the science learning was the pattern of practicing literacy strategies we noted. Practice took a variety of forms. At times, the teachers used simple concepts to practice before employing the strategy with a more difficult concept. For example, one teacher had students practice the LGL activity by using words such as cat, dog, or mouse. Some teachers used the texts we used in professional development (with adult teachers) to practice strategies with their students before enacting the strategy with science texts. For example, one text we used in professional development was a passage about a richly appointed home originally used by Pichert and Anderson (1977) with undergraduate students to study whether the perspective from which one reads shapes both comprehension and retention. In the Pichert and Anderson study, the researchers had different groups read from the perspective of a burglar “casing the joint,” or a prospective home buyer.

During our professional development, we engaged the teachers in the same activity to illustrate the importance of perspective on reading comprehension. At the conclusion of our demonstration, one teacher suggested that perspective taking could be employed as a reading strategy to support students’ meaning making about the science texts. The entire group agreed because the activity has been persuasive to the teachers as they saw evidence of how the different perspectives influenced what they focused on and recalled from the text. They all agreed to the potential for supporting their students’ learning. Consequently, we developed an activity using one of the curriculum reader articles, a website text on cubic zirconium (CZ). All teachers agreed to try the strategy as part of their next set of lessons, which is when the CZ text was scheduled to be used. However, one teacher, as these field notes indicate, decided to practice this as a strategy first, using the burglar/home buyer text:

T then did the example perspective taking activity (burglar/homebuyer) that we had done in PD: She handed out slips of paper which told each student whether s/he was a burglar or a homebuyer. The teacher then read the description of the house, and had a discussion of things they noticed in the reading, and to figure out which students are burglars, and which are home-buyers.
Practice before using the strategy with content-related text is a well-supported teaching practice when the activity itself poses conceptual demands that may be challenging for students. The idea of practice with familiar concepts is based on the desire to reduce the cognitive complexity of the task. However, in this instance, the cognitive complexity of the task—taking a perspective—was not particularly demanding because we had chosen a target text for the curriculum that would build on students’ prior knowledge. In fact, the challenge of taking a perspective may have been increased by the choice of the home buyer/burglar text because seventh-grade students were unlikely to have been in the position of either home buyer or burglar in their everyday lives. Indeed, the teacher in the above excerpt reported that her students were confused by the practice text, but understood what it meant to read from a particular perspective when they were assigned the target curriculum text, as illustrated in field notes:

The teacher also mentioned that the students in the first hour seemed to be confused with the first task (with the burglar/buyer – of how to take on the perspective) but they seemed to get the idea while doing the diamond text set from the curriculum reader.

This field note entry suggests two trends among the teachers. First, it seemed here that the teacher was evaluating the students’ abilities to engage in the strategy successfully (confusion versus “getting the idea”), suggesting that she saw the strategy as an activity to be completed correctly or incorrectly, rather than as a strategy intended to develop strategic reading abilities. Second, the students’ struggle to take a perspective on the home buyer/burglar text underscores both the importance of prior knowledge and experience (one assumes—or hopes—that the students have little prior knowledge and experience for either perspective) and the fact that the teacher may not have fully understood the point of the strategy as demonstrated by her desire to have them practice and to practice with an adult-appropriate text and set of roles.

In effect, there was little need to practice the strategy because the point of the strategy is not complete is successfully, but rather to use the strategy as a way of working with language and concepts prior to reading. The use of a practice activity suggests, then, that the teachers were concerned with their students’ skills and that they saw the activity as a task to be completed with a certain level of correctness,
rather than as a strategy for engaging students in the text, wherein correctness would be immaterial. The activity functioned as a practice run, revealing that the teacher wanted students to learn the strategy before they could learn with the strategy.

Practice, procedure, and correctness dominated and overshadowed several literacy practices’ potential to help students become strategic readers, as illustrated in this field note from professional development (supplemented by audiotape):

Tonight Sharon brought samples of her students’ work to the professional development session but was reticent to share them with the group, explaining that she was embarrassed by her students’ poor performance with the task. Encouraged to say more, she indicated that students had used the science words from the Concept-of-Definition Maps activity in scientifically “incorrect ways.” She said, “They didn’t get it. Look what they wrote for ‘property’ on the maps!”

This incident led to a discussion in the professional development about the purpose of literacy teaching strategies. The group discussed the point that correctness in this literacy strategy, as in many others, is not the goal. And yet, on another occasion, a second teacher lamented her students’ Text Impressions, saying, “I don’t want to show anybody these, they aren’t good!”

We discussed the fact that the pre-reading activity functions to engage students in reading the required material, and to highlight—in a low-risk situation where everyone is guessing and all are encouraged to use their imaginations—what they do and do not know about the concepts they are studying. But what they do not know is only important insofar as it creates an “aha” moment when students encounter a word in the text and learn its “correct” meaning in the particular context of that science passage. Attention is focused on vocabulary, then, in a way that encourages concept building, semantic relationships, and contextual definitions, rather than definition memorization and correctness. The strategy, ultimately, is intended to highlight the polysemous nature of words, and to help students think through how words shift meanings as they move from everyday to scientific domains. It was clear from this exchange—and subsequent exchanges—that we needed to do something different in professional development to make
the purpose of integrated literacy instruction clearer. However, analysis also indicates that our professional development efforts to clarify the why of science literacy instruction need to be understood in light of teachers’ views of their students’ literacy skills and motivations, which we examine in the next section.

**The Role of Teachers’ Beliefs about Student Skills on Literacy Instruction**

Data analysis of enactment and professional development sessions suggests that teachers’ enactments of the literacy strategies as stand alone instead of integrated science literacy instruction were mediated at least in part by their beliefs about students’ literacy skills and motivation to engage in effortful practice. Our data from informal interviews, professional development sessions, and teacher reports of student skill indicate that these teachers all understood their students to be in need of reading remediation. From the start, each of the teachers joined the project because she believed her students’ literacy skills to be below basic levels. One novice teacher reported that “none of her students could read,” and that she had “given Fs to 65% of one class.” Others reported that students would not read unless they read aloud, in round robin style, as a group. Influenced by test scores as well as what they knew from experience, teachers made decisions about approaches to reading instruction in science based on their understanding of students’ reading ability. In addition, the teachers routinely asserted (both in this study and in our years of work with the larger group) that students’ motivation to engage in class was low and that they did not complete assigned homework. In all but the highest-performing classes, the teachers understood their students to be struggling readers and struggling students, more generally. Moreover, all were encouraged by administrators to use reading and writing in their classrooms because

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3 In the 2004-05 school year, the majority of these schools had large numbers of students who performed at “basic” or “apprentice” levels on the state’s standardized test, and who might honestly be called “struggling readers.” In fact, one teacher reported that every one of her students was required to attend a “corrective reading” class during one period of the school day. What remains an unknown for many of the teachers, however, is the nature of their students’ reading difficulties. Our reading diagnostic data suggest that what teachers assume to be basic reading challenges may actually be challenges in dealing with the discursive, structural, and semantic demands of scientific texts.

4 A number of teachers stopped assigning homework, in fact, because they believed it to be a waste of their time and energy given the poor return rate.
of the district’s desires to improve literacy test scores. As a consequence, the teachers articulated a need to focus on basic skills, correctness, assessment, and on evaluation rather than on the conceptual understanding that might result from consistent and integrated scientific literacy practices. The vocabulary strategies, in particular, were readily been taken up by teachers because enacting strategies helped teachers feel that they were doing something about a pervasive problem; they were playing a role in improving students’ reading skills by using research-based word-level strategies in their classrooms.

We observed teachers acting on these assumptions about student skill by focusing on literacy procedure and skills (even as they provided discovery or inquiry experiences in science content), suggesting that these teachers believed certain literacy skills to be essential before struggling readers could read and comprehend science texts. Given their beliefs about the students’ reading skills and their motivation, the teachers saw the purpose of the literacy teaching strategies as providing students with access to the information locked in texts, rather than as practices designed to support comprehension, teach science reading strategies, and to foster growth in conceptual understanding of science. Thus, doing the strategy was the goal because in doing the strategy, students gained access to ideas and information embedded in texts.

For example, in the field notes excerpt below, a teacher employed a Preview Guide strategy (see Appendix A). The purpose of a preview guide is to activate prior knowledge and to create a purpose for reading—for readers to find out whether they were correct or not in predicting the answers to pre-reading questions. Typically, readers predict responses to a set of predetermined questions before they read; discuss and provide rationale for those responses as a way of activating prior knowledge and setting a purpose; read the passage to search for the information in the passage; and then examine their predictions in light of the material in the passage. As discussed in the professional development sessions, the emphasis in the strategy is on the discussion of ideas both before and after reading as a way of setting a purpose and evaluating and synthesizing what one has read and learned. The teacher/research team developed this particular preview guide strategy together for a text; the activity was to preface/follow an inquiry activity. In this instance, the teacher had already previewed the text with the students and had
moved on to the after-reading portion of a Preview Guide reading strategy for her students, setting it up as follows:

The teacher asks students to take out the questions they answered before reading. She tells the class to go through the sections they just read in the reader to answer the questions on the ditto. She also tells Ss to find and underline the answers, and says that she’ll be giving some points for every answer they underline.

Although the teacher should be commended for completing the after-reading portion of the guide in class—something many teachers struggle to find time for—her assignment to underline answers for points focused the students on answering questions rather than on making sense of what they read and connecting the ideas to the larger inquiry goals. Her enactment may be influenced by the teacher’s beliefs about her students’ skills, and about their need to develop skills (e.g., underlining important text); it may also be influenced by her belief that in order to motivate students to read in science, they need to be given a reward (e.g., points). Finally, it may have also been prompted by a desire to keep the students under control while reading silently because all teachers frequently noted in the professional development session that their students could rarely focus on a reading unless they read aloud in a “round robin” fashion or used some other form of management to keep the students focused on the reading task.

Another teacher of students identified as struggling readers chose to adapt the Perspective Taking strategy in ways that reflected her belief that her students needed particular kinds of reading guidance. The perspective taking strategy sets a purpose for reading that encourages students to become more focused and engaged as independent readers and, of course, to think about how meaning is shaped by one’s perspective. However, the field notes indicate that the teacher adapted this strategy in a number of ways that veered away from that purpose in favor of others:

T passed out slips of paper with the five different roles the teachers agreed upon for the CZ/diamond text. She told students that they are adopting the role they were given, and to keep track of things that “stand out because of the role you’re playing.” The teacher and students took turns reading the article about diamond/cubic zirconium (CZ) earrings’
aloud. When finished with the ad, T asked Ss to underline the sentences they felt were important for their perspective. The teacher/students then read the article silently, and again the teacher asked students to underline three sentences that may be important for their perspective. After class, the teacher mentioned to me that she did not have a chance to go through students’ responses and discuss their understanding.

The class did not discuss what students underlined and why, or what they wrote in their sentences. In other words, the kind of meaning making via the examination of different perspectives intended in the strategy was not accomplished. The teaching strategy became a “task” rather than a literacy learning strategy or science learning tool in the way it was intended, possibly based on the teacher’s notion that for her students to carry out the perspective-taking activity, they needed do it in the context of shared oral reading with an underlining task to maintain their focus while reading along.

Another artifact of the teachers’ views of students as struggling readers was the attention they focused on teaching the technical vocabulary of science. All teachers in the project expressed concern over the technical vocabulary of science and attributed at least some aspect of students’ reading challenges to difficulty with the words of science.

**Vocabulary Learning Strategies Privileged Among Stand-Alone Literacy Strategies**

One of the most popular forms of literacy instruction in these classrooms was vocabulary instruction. Our analysis produced evidence in teacher talk, their writing, and in observations of enactment, that teachers placed high value on scientific discourse. That is, they wanted their students to use the language of science.

In their everyday practice, apart from using those practices introduced in this project, teachers were already engaging in routines that require students to work on vocabulary via bell work, in-class tasks, and homework. Two vocabulary strategies were part of teachers’ everyday practice prior to our PD. “A-Z words” is the name given to individual dictionaries in which students recorded words identified by the teacher as important for them to know in science. In their folded-notebook-paper dictionaries, students recorded science vocabulary words and their definitions. At times the definitions
came from dictionaries in the classroom; at other times they were copied from the student reader, but most often, teachers wrote definitions on the board for students to copy. A-Z words were typically assigned every week.

Another common vocabulary-related practice across these classrooms was for the teacher to provide students with a list of a dozen or fewer words that students then used to construct a paragraph. A variation asked students to, “Write 5 terms that we have used in class for the Stuff unit. Use each word in a sentence or provide a definition for each word.” Underscoring the focus on vocabulary, in informal interviews, one teacher described her literacy practices in this way by stating that, “Each week, I list vocabulary words that students are to use in a paragraph and turn in at the end of the week. So, my students have been practicing scientific stories all year long as homework” (Textual Tools Group, 2006, p. X).

In professional development, we introduced two vocabulary strategies, both of which were used more often than any other strategies we introduced. Our aim was to offer literacy teaching strategies designed to help students build conceptual understanding rather than simply to memorize definitions, copy others’ language, and use vocabulary words in sentences. Teachers readily took up the vocabulary teaching strategies we introduced and incorporated them into their practice. They also asked for more such strategies, demonstrating their high levels of enthusiasm for these tools.

As teachers enacted these teaching strategies, however, we observed the same practice evident in their use of the other strategies: Word-learning strategies seemed to stand alone as tasks to be done, rather than as ways to think about and learn scientific terms (or everyday terms used in scientific ways). Even when teachers attempted to scaffold conceptual understanding through the vocabulary strategies, they often talked in ways focused on learning discrete words and their definitions.

Our data suggest, in particular, that the teachers viewed vocabulary strategies as useful for building skills and motivating students. In addition to their usefulness in meeting teachers’ need to assess student understanding on an ongoing basis, the word-focused strategies were popular, in part, because vocabulary strategies were challenging enough to hold student interest without being overwhelming.
Teachers indicated that their students liked both the Vocabulary Concept Cards and the Concept-of-Definition map vocabulary activities—a frequent refrain throughout our professional development sessions and in the teachers’ written reflections on their literacy instruction.

For example, when we discussed Vocabulary Concept cards (VC) and Concept of Definition (CD) maps (see Appendix) in professional development, all sources—fieldnotes, teachers’ written responses, and audio and video of professional development sessions—illustrate that all 11 teachers were happy to have these teaching strategies in their instructional toolkits. When these strategies were modeled in professional development, we discussed the importance of using vocabulary concept cards for words used frequently in the unit and for which understanding the concept and knowing its definition made sense. Candidates for this strategy were “substances,” “solubility, “melting point,” and “density.” By contrast, Concept-of-Definition maps were better suited for abstract or complex concepts central to the curriculum that were likely to be more difficult for students to make sense of, such as “properties” and “chemical reactions.”

Several excerpts of teacher talk illustrate the value teachers placed on these strategies. In an all-curriculum, teacher-led science workshop, teachers who had participated in this scientific literacy research shared their knowledge with colleagues who had not participated. As one described CD maps, she emphasized the assessment value of the maps, stating, “If you have them do the word property, you can use their examples of uses as an assessment [of whether they really understand the concept].” One of the tasks for the workshop, in fact, was to design a rubric for evaluating a strategy, and most teachers chose to create a rubric for either a CD map or a vocabulary concept card. One teacher shared with colleagues in the workshop her use of vocabulary cards for quiz and test preparation:

“My students have a great deal of difficulty reading and comprehending text. If they have a familiarity with some of the vocabulary, it encourages them to read further and attempt passages they would ordinarily ignore. One of the methods I used to introduce

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5 It should be noted that we did not obtain artifacts from two of 11 teachers and thus we have only their interviews as evidence that they actually used these strategies.
and further develop vocabulary knowledge is vocabulary concept cards. When we were studying properties of substances, students constructed cards for *color, melting point, hardness, solubility,* and *density.* Students were intense in their quest to have a "perfect" card to reflect their knowledge. They asked each other for opinions of what they had written. We punched holes in each card, and students used a ring to keep them together, adding new cards throughout the unit. Students used the cards to quiz each other as they prepared for a game or an assessment. Making vocabulary cards appears to help students *understand* words more than they do after simply looking up definitions” (Textual Tools Group, 2006, p. X).

The same teacher also described her use of Concept-of-Definition (CD) maps:

Although we had spent a great deal of time doing activities and reading about properties, what students wrote in the “examples” section [of the CD maps] reflected some of the prior knowledge that I thought had been revised. Some students listed items such as land, houses, cars, jewelry. After a quick reminder of what the class had been studying, students replaced those answers with appropriate science terminology. They revised their maps as the lessons continued, and ultimately submitted them for assessment” (Textual Tools Group, 2006, p. X).

Another teacher commented, “I liked the [CD] map as an assessment tool, and especially with little prompting, can give great insight into understanding of the topic” (Textual Tools Group, 2006, p. X).

And yet another teacher discussed using CD maps for assessment:

“You can definitely see an evolution of understanding of concepts by using this literacy strategy [CD maps]. As a culminating assessment of this term "property" I guided students as they completed their maps. The results provided me with a clear description of students’ thinking. I was able to use this pertinent information to address any present misconceptions and assure that the proper conceptual and relational knowledge was
applied. I will continue to use this strategy in my quest to build a solid bridge between science and literacy” (Textual Tools Group, 2006, p. X).

These modifications and even complete additions to the literacy strategies and practices of the classroom offer important insight into the teachers’ assumptions about their students’ skills and needs and about the purposes they saw for literacy instruction at the secondary level. In general, it appears that literacy instruction was viewed as necessary for remediation of reading difficulties or low reading motivation, rather than as the teaching of the unique inquiry and comprehension skills necessary as students moved into more advanced literate practices in the disciplines.

In sum, as all good teachers do, these teachers adapted literacy practices to their students, their purposes, their context, and the materials. But these examples illustrate that those adaptations may have changed the nature of the practices and produced the sense of literacy strategies as stand-alone activities. We offer this analysis not to portray the teachers as ineffective, but to demonstrate how the realities of teachers’ classroom experiences may reshape the purposes and goals of even “scientifically based” teaching strategies and practices. Additional data suggest that the teachers’ commitment to student success and to completing the curriculum in a timely fashion seemed to override the idea of engaging in messy conceptual and literate development. Instead, they wanted their students to get it right the first time and not to experience too much struggle, interpretations we warrant further in the next sections.

**Conflicting Demands on Teachers’ Practice: Issues of Time and Accountability**

As has long been shown, institutional factors affect the time available for literacy skill development in content-area classrooms (O’Brien et al., 1995). First, time available for literacy skill development was affected by in-the-moment interruptions of instructional time. In the classrooms we routinely observed across the district, instructional time is frequently interrupted by public address announcements or knocks on the door. In addition, broader institutional factors for these teachers included (a) an administrative directive to progress through the school year according to a district-mandated “pacing chart,” and (b) pressure to improve standardized test scores and to devote time to practice testing.
Two examples from this study serve to illustrate the challenges of local and institutional constraints on teachers’ time for instruction.

In one classroom, students shared the ways in which they had categorized words for the LGL strategy and provided rationale for their choices—the type of conversation that might have led to a rich understanding of the reading material by making sense of how the text is linked to prior knowledge and experiences. However, fieldnotes document a number of interruptions that affected the teacher’s schedule, goals, and planning as well as students’ sense-making. Students might have been expected to have a difficult time making connections among ideas, comparing alternative ways of categorizing terms, and synthesizing information when their class was interrupted by a lengthy public address announcement about stolen property accompanied by two instances of teacher being called out of the room, all in one class session. Teachers were well aware of the impact of these interruptions on instruction: As the teacher in one classroom re-entered the room after being summoned into the hallway by an adult, the third interruption to occur during an LGL discussion, she apologized to the class: “I’m sorry for all the interruptions.”

In another classroom, near the beginning of a class period as the teacher began to get a lesson underway, the class was interrupted while approximately 10 students were called out of the room to eat breakfast. A few minutes later, the class was again interrupted by an administrator who came in to remind the class that, “Breakfast is very important, that they should be ready when they take tests, and that the results of these tests would be in published in newspapers.”

Managing instructional time and student behavior was an ongoing juggling act for the teachers. We also saw management issues in the following example in which the teacher set forth an ambitious agenda for the day, but did not pace the lesson to match that agenda:

The T explains that she will give each student a task to do and different roles, and depending on the role they will “read it differently.” Students say they don’t understand.

T tells them to focus on p. 65. She says it will make sense after they begin reading. Most students are off-task. T walks around telling students she will time them.
As the T walks around, she explains the task to individual students.

Several students say they don’t understand. The T tells them to focus on p. 66 and that they have 5 minutes . . . .

This movement through the lesson seems to illustrate the teacher’s sense that she would move forward with the lesson—and do the literacy strategy—whether or not students understood what they were supposed to do. In other instances, teachers used a substantial amount of time to complete relatively simple tasks, leading us to wonder, again, whether a literacy strategy was being used purposefully as a stand-alone task. The following exemplar illustrates a pattern we saw consistently used in two of the classrooms:

About 9:00 – the teacher asks if people were done – most were not. The teacher hands out another paper for people to “fix” or rewrite their paragraphs so they are “neat.” The teacher lets students continue to work on their paragraphs.

9:15 Teacher tells students to finish up…that she’s giving everyone 3 minutes.

In this class period, 25 minutes were actually given over to writing neat paragraphs. For the Text Impressions strategy to support students’ reading, the paragraph they write matters only insofar as it stimulates their thinking. The paragraphs are not likely to be suitable for grading purposes (given the task), and are not meant to undergo revision. This task then, seemed to function as a 25-minute time filler without a purpose other than classroom management. The same teacher illustrated this when she talked and wrote about creating Preview Guides (which she did regularly) for her students:

After preparing an overhead transparency for solubility, I noticed that for my students to have ownership of the strategy, they needed even more active engagement setting up the task. So as part of the start-up strategy, I had students copy into their science notebooks each of the seven questions I had prepared on an overhead transparency. They were quiet, occupied, and writing from the start of the activity (Textual Tools Study Group, 2006, p. X).
Rather than using class time to enact the preview guide strategy with students and helping them to develop strategic reading skills, the teacher chose to have students spend time copying the seven questions on the preview guide, with establishing “ownership” as a guiding principle.

In an example cited earlier, in which the teacher had students complete several activities in a single class period, the teacher allotted ten minutes for students to reexamine the questions they had answered on a preview guide and to reread the text so as to find and underline answers to the questions. Ten minutes was not adequate for students to re-read the extended series of questions, and to read to locate and underline the answers to those questions in the text. Another teacher reported that she “did both the home buyer/burglar activity and assigned the roles” in one class period. She indicated that the two activities “worked out well,” but also acknowledged, “We did not have much time for the discussion at the end” (Textual Tools Group, 2006, p. X). Field notes indicate that the teacher did not review students’ responses to the reading nor did they discuss their understanding of the real-world text. Having “worked out well,” minus the meaning-making pieces, suggests a view of working well that was more about getting the strategy done that about using the strategy to develop understanding.

**Accountability demands.** Teachers also reported a ubiquitous administrative emphasis on students’ test performance. One teacher, in an informal post-class interview, indicated that she planned to end the Stuff unit without finishing the entire curriculum, stating that she needed to give the posttest and wrap up the unit in time for another round of district testing in addition to the state’s standardized test. Then, according to the district pacing chart, she needed to get started on the next unit. In another classroom, the teacher used a small segment of one of the literacy strategies, but did not see the strategy through its sense-making components, because she, too, claimed that she needed to stop the unit, give the posttest the following day, and prepare students for the district-wide testing. She indicated that she, as well, needed to begin the next curricular unit on schedule in order to keep pace as required and monitored by administrators.

Time and accountability factors are omnipresent in the lives of teachers. Accountability demands are factors that shape teaching, but over which teachers have little control. Within the classroom, at the
level of day-to-day lesson planning, they have far more control, although still set within the larger context of test pressures and pacing charts. Within that context, we saw teachers make use of time in ways that were not always effective for helping students learn to be strategic readers of science texts or inquirers about scientific phenomena. In professional development sessions the teachers discussed the importance of attending to literacy learning before, during, and after reading and could articulate the importance of that practice; in practice, however, they often did not provide adequate time for sense making during each phase of the reading process, at least in part because their pacing of activities was shaped by conflicting goals for doing science, doing literacy, and managing the class time with all its interruptions. We often observed teachers using strategies in ways that seemed to be as much about managing schedules as about helping students learn. The following data exemplars show those moments in which we clearly saw time as a factor in how strategies were enacted.

One teacher’s written account of her enactment stresses time issues:

Time constraints made it impossible to have the students read the actual text in which the words were used on the same day that they wrote their stories. However I kept the words posted and held onto their stories so that we could do so in the next class period. I think it might be beneficial at the start of the day we are going to read the actual text to have the students read (not dramatize) their stories again. . . . (Textual Tools Group, 2006, p. XX).

Teachers found different ways to adapt the strategy to account for the fact that it requires more than one class period. Nevertheless, these instances highlight the difficulty teachers may have had trying to integrate the strategies in a timely manner, given the length of a class period and the other demands on their teaching time. The example below suggests that teachers’ management of time may also have limited students’ abilities to use the strategy optimally:

The teacher switches on to talking about what they’re doing today – a density reading – she mentions if they have time today they’ll be doing vocabulary cards, and asks students to name the words they’ve already used for vocabulary cards. Students say solubility,
substance, mixture, and properties. The teacher continues to go over what they’ll be doing today…that they’ll try to split up readings with ERT [Earned Reward Time], there’s an investigation they’ll be doing after the reading, and adds that they have 2 A-Z words [sentence writing] today. The teacher goes directly to A to Z words activity.

In summary, the dominant practice across all teachers was to engage in literacy instruction as a series of stand-alone strategies with a focus on correct task completion, rather than as instruction integrated with scientific inquiry and engaged in for the purpose of teaching students how to make meaning of or communicate in writing about both scientific phenomena and concepts rendered in texts. In particular, vocabulary strategies appeared to be taken up by the teachers as useful ways to support students’ interactions with texts.

At least three intersecting reasons for this stand-alone practice surfaced across data sources and classrooms. First, teachers’ understanding of their students’ abilities as readers in science shaped the ways in which they chose to enact the strategies. Second, conflicting demands such as, issues of time—time management imposed by the district, use of time implicit in science education standards, and teacher allotment of time in their advance planning and in their in-the-moment time rationing across a class period, coupled with institutional influences on science learning such as standardized test pressures and district-mandated pacing charts, shaped the enactment of literacy strategies. Third, the nature and extent of professional development may have rendered the purpose of the strategies less clear to teachers than the procedure for doing the strategies. Interwoven with these reasons are possible conflicts between teachers’ beliefs about the nature of science instruction and how it should be carried out and the nature of literacy instruction, its purposes, and its enactment. Although each of these is discussed separately, their complex interplay is evident throughout. We discuss these issues more fully in the next section of the paper

Conclusions and Implications

This study offers a glimpse of what implementing literacy teaching strategies in their everyday instruction looked like for eleven dedicated middle school science teachers. These teachers reported, as
in other studies, that they understand the importance of literacy learning in science and believed that they were responsible for helping students read and write science texts (Dupuis, Askove, & Lee 1979; Stieglitz, 1983; Wedman & Robinson, 1988; Hall, 2005). They also reported that they do, in fact, implement literacy teaching strategies in their everyday instruction. They were not, then, resistant (O'Brien et al., 1995) to literacy instruction. And yet, the teachers’ literacy teaching practices did not match our vision of integrated project-based science and literacy instruction. The data complicate explanations of why literacy teaching strategies are implemented as they are.

Although we introduced all teaching practices and strategies in professional development by having teachers enact them first—modeling what we hoped they would do with students—and then debriefing the experience, discussing the research and theory undergirding the practices, and planning the enactment to be embedded in their actual practice, ultimately, we may not have made the core purposes of each as a teaching practice clear or sensible to teachers. Each of these teachers used literacy (reading and writing) in their science instruction, but their use generally involved carrying out a given strategy as an activity to complete, rather than as a practice that was situated within particular content goals, text demands, and reader needs. That is, they focused on their most immediate teaching need: to scaffold what they saw as students’ poor reading and writing skills while engaging the youth in inquiry science learning activities that had to be completed in a timely fashion and to particular standards.

In a context in which teachers must negotiate many demands and students’ literacy motivation challenges, our professional development did not focus enough attention on the practices of integrated literacy teaching, instead emphasizing discrete strategies for engaging in those practices. In our zeal to seize the moment when teachers asked for discrete strategies, we may have zeroed in on the doing of the strategies too eagerly, signaling to the teachers that literacy strategies are “things you do” rather than practices in which to engage students in the process of learning science using text. The teachers had already used the curriculum readers, reported that the readers really help their students understand the science, and reported that their students, in many cases, seemed to like the reader. They were eager for strategies to make even greater use of the reading materials. However, we may have misread their
eagerness as a sign that they wanted to fully integrate reading and writing into the inquiry activities of the curriculum, when, in fact, they wanted tools to remediate their students’ reading struggles and to motivate their students to pay attention to the reading materials.

This desire, coupled with district administrators’ admonitions to focus on “content area reading” for the year and that all teachers must get reading into their curriculum, may have signaled to teachers that they needed to arm themselves with techniques and materials to “do reading.” Had we done a better job of clarifying the role of literacy teaching practices in helping students—over time— not only to become strategic readers but also to engage in scientific inquiry, the teachers might have enacted the individual strategies in ways more congruent with their original design and with our goals of developing scientific literacy and inquiry skills in students. Our choices of reading practices and accompanying strategies were thoughtfully taken up by teachers as techniques but they were taken up in ways that reflected the teaching of reading as an act separate from the teaching of science concepts, processes, and practices.

Even had teachers understood the idea of literacy teaching practices and the purposes of the teaching strategies within those practices more fully, however, we still cannot be certain what influence other factors would have had on their practice. Because they understood their students to be struggling readers who did not read at home, did not do homework, and would be likely to have trouble with the reading materials designed as part of the science unit, teachers at most of the school may have continued to believe that students would “get” the material only if time is spent reading in class. Because teachers understood their students to be in need of remediation, the teaching practices and strategies discussed in professional development may have helped teachers feel that they were doing something about a pervasive problem as they used researched-based literacy teaching strategies to improve what they saw as students’ low-level reading skills in their classrooms.

The belief in a need for remediation of low-level skills, rather than comprehension instruction around scientific constructs, may have led teachers to take the teaching strategies up as something to be done and done away with, rather than as part and parcel of the science learning process. How do their beliefs about where the “problem” of adolescent literacy lies (i.e., is this about remediation or about
learning new ways of interacting with disciplinary texts?) shape their take-up of the strategies? Instead of seeing the teaching of scientific literacy as something that would continue across a student’s learning trajectory, the teachers seemed to see literacy as something to be taught only when students had failed to learn basic reading and writing skills. This possibility begs a question about the relationship between teachers’ beliefs about the nature of science and the nature of their students’ literacy skills. How do their beliefs about the nature of science (and the use of language in science) influence how they will make sense of and enact literacy teaching frameworks?

We wonder, also, about the extent to which teachers may have experienced a conflict between what they think of as “constructivist” principles of project-based science in contrast with what they may think are “direct” or “explicit” principles of literacy teaching strategies. They may have experienced a conflict between how they think about teaching science (which they see as something be to be learned and requires a constructivist process) versus how they think about student reading and the need to remediate literacy skills they believed should have been already been learned. Might teachers perceive literacy teaching frameworks as a form of explicit instruction because of the step-by-step, structuralist (O’Brien et al., 1995) framework in which many of the literacy teaching strategies are embedded? Thus, although literacy teaching strategies derive from a cognitive science perspective that argues for constructing knowledge through a process of linking the new to the known, was there perhaps a disjuncture between the goals of constructing knowledge in project-based science and what the teachers perceived to be the need for explicit instruction in literacy teaching?

If we could refocus secondary school, disciplinary literacy instruction from an emphasis on strategies for comprehension toward an emphasis on practices for disciplinary inquiry, perhaps we could then encourage the development of frameworks and practices that support both disciplinary concept learning and disciplinary literacy learning. The beauty of a frameworks, or practices, approach is that it could make the most of the similarities between literacy teaching theories and content learning theories, especially in science. Literacy teaching frameworks, for example, that employ the cognitive science approach of activating and guiding knowledge construction and sense making before, during, and after
reading or writing fit well with scientific approaches to learning and knowledge production. Typically, scientific approaches to inquiry encourage investigators to make predictions, engage in literature searches, and hypothesize before they engage in empirical work; to reflect back on their hypotheses and relevant literature as they enact investigations; and to examine and communicate results after they conclude an investigation. If teachers can be engaged in examining the similarities of these frameworks (see Cervetti et al., 2006), then they may be better able to see the ways that literacy and science teaching can overlap in the same moments of instruction. In addition, a focus on teaching frameworks and practices to develop strategic reading helps to eliminate the confusion over whether the goal is for a teacher to carry out a strategy or for students to learn to engage in learning and literacy strategies.

Finally, issues in how class time was used, including factors in and out of teachers’ control, were a pervasive problem here as in other research. The strategies were often not allotted the time required for adequate pre-reading, during-reading, and post-reading sense making modeled by the teacher and practiced using the required texts. Time use was influenced by teacher planning, by teachers’ ways of managing the instructional environment and student behavior, and by external demands such as pressure to increase standardized test scores and to proceed through the curriculum according to a district-mandated pacing chart. In other words, the sociocultural context in which teaching and learning are situated cannot be ignored when thinking about how professional development plans get enacted in actual classroom practice.

The interplay of these factors made teasing apart components difficult, but only in looking at the components can we think about which of them we can shape as literacy educators. Ultimately, however, we understand that it is these factors—together—that influence scientific literacy teaching practice in significant ways. In combination, these factors appeared to influence teachers to take up vocabulary strategies with particular enthusiasm. The purpose of vocabulary strategies seemed straightforward (to help students’ learn the science vocabulary required in the unit). Those vocabulary strategies we introduced aligned with what teachers were already doing in the classroom. The procedure for enacting them was straightforward (complete the steps indicated by the handout). Vocabulary strategies produced
artifacts that could be used as assessments—graded in order to give teachers, students, and administrators quick feedback on classroom learning. Vocabulary strategies are ready-made tasks that can easily be adapted to time constraints and that require a limited amount of class time (compared with other reading strategies we introduced). And, vocabulary strategies met a remediation need, especially as vocabulary understanding is central to meaning making. In other words, a focus on vocabulary in science—a discipline replete with complex technical language and discourse—is not unreasonable; however, the overwhelming emphasis on it by these teachers was revealing of assumptions about why and how literacy should be taught in secondary school subject matter areas.

Finally, teachers must make trade-offs among competing goals. These teachers have to move through a pacing chart at a rate determined by administrators. They are required to incorporate reading and writing into their content area classrooms, and they believe in doing so, yet incorporating literacy strategies takes time. Time spent on literacy teaching strategies lengthens the curriculum enactment and conflicts with the pacing chart. Instructional time is limited by numerous days devoted to practice testing for the state-mandated standardized test as well as other tests mandated by the district. And limited instructional time is further lessened by frequent interruptions of varying sources and degree.

Despite the challenges to enactment that we documented, the teachers in this study experienced many successes (see Textual Tools Group, 2006) and continue to be enthusiastic about enacting scientific literacy teaching practices. We applaud their efforts and successes, and struggle alongside them as they face many dilemmas. We ask ourselves what difference we, as literacy educators, might make given their contextual realities. The need to help teachers integrate reading, writing, and hands-on activities into a coherent whole that can support students’ conceptual understanding is central to our professional development efforts. That is, in fact, what we aimed to do. But we also experienced successes and dilemmas of our own. For example, we taught that teaching strategies must be adapted to learners, learning goals, and the learning context, but an important consideration includes how to help teachers make appropriate adaptations that do not compromise a teaching practice’s effectiveness for teaching students how to be strategic readers. We need to determine how literacy educators can conduct the kind
of professional development that will help teachers see both the forest and the trees, but that remains
cognizant of the factors that shape enactment over which we—and often they—have little or no control.
References


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Appendix A

Description of Literacy Strategies Introduced in Professional Development

Preview Guides

A preview guide is a series of statements, written by the teacher, to which students respond before, during, and after reading an assigned text. The preview guide is a modification of anticipation-reaction guides (Readence, Bean, & Baldwin, 1989). A preview guide may contain either a) a series of statements with which students are asked to agree or disagree or b) a series of questions to which students will respond in writing (See Figure A1). Statements are designed so that they can be answered with information stated directly in the text (e.g., definition, cause and effect), and with information from various parts of the text integrated as inferences. Statements require students to predict, summarize, synthesize, or challenge previously held misconceptions. Students’ prior knowledge is activated as they respond to the items before reading. The statements help to establish a purpose for reading that shapes interest and encourages students to be actively engaged during reading. After reading, students revisit their initial responses and indicate whether and how their ideas have changed.

Figure A1. Preview Guide Example for a Passage on Solubility (adapted from one of our teachers)

<table>
<thead>
<tr>
<th></th>
<th>Guess (before reading)</th>
<th>Answer (after reading)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Is solubility a property?</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>What other words can you think of that might be related to solubility?</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>What might make a substance dissolve?</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>What kinds of substances might be soluble?</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>When might one substance dissolve in another?</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Why is solubility important?</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>List two key aspects of solubility.</td>
<td></td>
</tr>
</tbody>
</table>
**Vocabulary Concept Cards**

Vocabulary concept cards (Nist & Simpson, 1997) are easy to construct and can be used in many different ways, but the underlying premise is that the target term is taught conceptually, rather than as a memorized definition. Thompson (2003) has demonstrated that, in addition to vocabulary breadth and depth, vocabulary flexibility—the ability to use the same word with different meanings in different contexts—distinguishes strong readers from average and poor readers. Vocabulary cards help to build vocabulary flexibility by requiring learners to examine word meanings from different angles. To carry out the strategy, the target word is written on one side of an index card or notebook page. On the other side, the card is divided into at least 4 quadrants (additional divisions can be made depending on learning goals) (See Figure A2). Students record (a) what the word *is*, (b) what the word *is not*, (c) an example of the word (or a drawing or sentence using the word), and (d) the definition in the context of reading material (or as defined in the dictionary). Critical to the use of the cards is the idea that with each new term, some quadrant is scaffolded in whole-class, small-group, or partnered instruction, at least until the word is learned independently.

**Figure A2. Vocabulary Concept Card Template**

```
<table>
<thead>
<tr>
<th>Side 1:</th>
<th>Side 2:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>What it is</strong></td>
<td><strong>Example/ Drawing/ Sentence</strong></td>
</tr>
<tr>
<td><strong>What it is not</strong></td>
<td><strong>Reader/ Textbook/ Dictionary Definition</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Target Word</strong></td>
</tr>
</tbody>
</table>
```

**Concept of Definition Maps**

Concept of Definition Maps (CD Maps) were developed and tested by Robert Schwartz (1988) to achieve a purpose similar to that of Vocabulary Concept Cards. The CD Map can be a tool for building
prior knowledge before a reading; encouraging and guiding a discussion before, during, and after a reading; or for assessing students’ understanding following a reading. As with the Vocabulary Concept Cards, the ultimate goal is to encourage students to use the categories of the CD Maps as they encounter and learn new words in the future. That is, if learners begin to think of concepts as having (a) characteristics, (b) uses, (c) examples, and (d) verbal definitions, and start to learn words using those categories, then they have a heuristic for learning and remembering words independently (see Figure A3).

**Figure A3. Concept of Definition Map Student Example**
List-Group-Label/Story Impressions

In this section, we present two strategies that we have linked together for the multiple purposes of building vocabulary knowledge, conceptual and word relation knowledge, and even knowledge of how texts and language works in scientific texts and in other genres. These strategies also help to set a purpose for reading and motivate students to read and compare texts. The first strategy, List-Group-Label (LGL) (Taba, 1967), asks students to group a list of words chosen by the teacher (or by groups of students, as they progress with the strategy) into categories that they think make sense, based on what they know about the words before reading. Students are then asked to identify cover terms for the categories. This categorization activity encourages students to think about how words are related to one another, thus developing conceptual, rather than mere definitional, understandings of terms and phrases.

Our team combines the LGL strategy with an expository text application of McGinley and Denner’s (1987) Story Impressions, a pre-reading strategy in which students are asked to construct their own text passages from a list of words. (We call it Text Impressions.) After grouping and labeling the terms used for LGL, and sharing their ideas about the terms, students work in groups to construct their own texts using the terms in order and exactly as they appear in the list. Another modification of the original strategy that we have developed is to assign different text types for the writing activity, such as a news report, an encyclopedia entry, or a popular science magazine. In other words, students are encouraged to write in different genres or types of text as a way to draw their attention to how text differences may shape the ways that words get used. The purpose of the activity is to set the stage for reading the target science text, so the key is to encourage students to think and talk about word meanings and relationships among words so that they will have a focus for their eventual reading. And it is especially important that the class or small groups discuss the differences between the texts they produced and the target text they read after the reading activity is concluded.

Perspective-Taking Strategy

In a Pichert & Anderson (1977) study, participants were asked to read a brief story of two boys spending the day at home. The story provided great detail about the boys’ house and property. All were
asked to read and then recall as many details as they could, but some study participants were asked to read from the perspective of a home buyer, others from the perspective of a burglar. Findings indicated that readers’ recall varied significantly depending on the perspective from which they read. Home buyers focused on structural aspects of the home (e.g., number of bedrooms) and those things that would stay with the house (e.g., hardwood floors), whereas burglars remembered the layout of the home (e.g., behind a hedge) and focused on items that could be carried out of the house (e.g., stereo equipment).

We enacted the home buyer/burglar study with participants to help them think about how comprehension and retention are shaped by students’ background experiences, prior knowledge, purpose for reading, and perspective as readers. We agreed that perspective taking would be a good strategy for science texts, as awareness of perspective and bias (one’s own and that of others) is crucial for rigorous scientific inquiry. For one of the texts students would read for this study, we created a list of possible perspectives from which they could read and after which a lively meaning-making discussion could likely be conducted. Our hope was that using this activity with the assigned text would encourage students to think about why someone outside of science class might care about substances and their properties. These reading inquiry activities were directly linked to firsthand inquiry activities that asked students to test various substances to determine their properties (and thus, whether they were the same or different substances).
## APPENDIX B: CATEGORY CHART

**FOCUS:** Word Focus

<table>
<thead>
<tr>
<th>DATE</th>
<th>DATA EXEMPLAR/DISCONFIRMING EVIDENCE</th>
<th>INTERPRETIVE COMMENTARY</th>
</tr>
</thead>
</table>
| 120804    | On the board:  
1) Stuff can be __________ or a substance  
2) a substance is made of one __________.  
3) Substances have __________ that help identify them  
4) Hardness and __________ are properties  
5) __________ have more than 1 material throughout                                                                 | Fill-in-the-blank questions focus on vocabulary                                           |
| CKBM mh   | Later on How much later?, the teacher goes over the questions on the board (answers: 1)mixture; 2)material; 3)properties; 4)color; 5)mixture).                                           | Focus on single words and their “definitions” via the exercise                         |
| 011405    | The teacher first went over some A-Z words in the class.                                                                                                                       |                                                                                       |
| conversation L1.3 text set ANDM mh |                                                                                                                                                                            |                                                                                       |
| 01/12/05L#6.1 CKBM na | 10am The students share their answers. 24266 answers the question, “How can I make old stuff from new stuff?” He says that you have to review-examine the properties. Have to make properties better. May be able to endure. Might be hard or denser. They make it better and capable of more. 24218: Stuff is… you can use everyday. 24277: Stuff is a major property, like hardness, color, melting point, density. Stuff is what some people…. (Inaudible) | Some of the student responses seem more like definitions of “stuff” rather than answers to the question as posed. Could indicate a focus on defining individual words rather than on larger, conceptual understandings. |
| (CTools label says 12.15.04, L1.1-1.2, but contents of file are labeled as above; note that the file listed in CTools as 01.12.05 contains exactly the same set of fieldnotes. Where are the fieldnotes for 12.15.04???) |                                                                                                                                                                            |                                                                                       |
| 01/12/05L#6.1 CKBM na | She [T] reminds them of the definition of stuff using properties in her explanation.                                                                                      | Focus on vocabulary, definitions                                                      |
| na | T tells them to use their lab manuals, reader and journal to get uses of properties and to give examples and describe them.                                                        | Focus on vocabulary with potential for more conceptualized meaning making              |