FEATURE ARTICLE

Teachers' Enactment of Content Literacy Strategies in Secondary Science and Mathematics Classes

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This study highlights the importance of attending to the various ways that teachers enact content literacy strategies and the influences of goals, previous practices, and local contexts on their enactment.

The incorporation of literacy strategies into content area instruction has been proposed as an effective way of improving student content area learning (Draper, 2002; Yore & Treagust, 2006). Teachers have been encouraged to incorporate such strategies into content area teaching, and many states require a content area literacy course for teacher certification; however, literacy strategies are seldom used in secondary content courses (Fisher & Ivey, 2005). Previous studies of teachers' content literacy practices have primarily examined whether or not teachers use specific content literacy strategies and factors that affect the extent of classroom implementation (Bean, 1997; Cantrell & Callaway, 2008). However, little is understood about how teachers actually shape and use particular literacy strategies.

To understand the nature of teachers' enactment of content literacy strategies, we observed classroom lessons of secondary teachers involved in professional development focused on integrating science/mathematics and literacy practices. We found that although all teachers were using the specific content literacy strategies introduced in the workshops, the nature of their enactment of these strategies varied in ways that influenced learning outcomes. It is important to better understand these variations to become aware of the implications of the instructional choices made when enacting literacy strategies in particular ways. Our purpose in this article is to share our framework for characterizing these differences in enactment, provide examples of these variations, and discuss implications of enacting literacy strategies in these different ways.

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Content Area Literacy

Content area literacy has a long history in education, although purposes, perspectives, and approaches have changed over time. Historic shifts in content area literacy have occurred along two dimensions. One dimension relates to shifting understandings regarding student learning, and the other dimension involves the relationship between content and literacy. Although we describe these shifts generally, they have not occurred uniformly across all areas of the field. Content literacy practices based on diverse perspectives can still be found in current research and practice.

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As theoretical understandings of student learning have evolved from emphasizing behaviorist and cognitive processing theories to socioconstructivist theories of learning, perspectives on content literacy have similarly shifted focus, from developing skills for extracting information from text and writing structured essays to emphasizing engagement with reading and writing text as individual and social constructions (O'Brien, Stewart, & Moje, 1995). Current perspectives of content literacy support the "view that students construct and coconstruct knowledge through activities such as discussion, reading, and writing from multiple perspectives" (Fisher & Ivey, 2005, p. 5). From this socioconstructivist perspective, content literacy practices are less centered on transmission of knowledge and development of technical reading and writing skills and more focused on students' active engagement in knowledge construction, supporting students' use and development of disciplinary discourses and content understandings (Blachowicz, Fisher, Ogle, & Watts-Taffe, 2006; Fisher & Ivey, 2005; Holliday, Yore, & Alvermann, 1994; Vaughan, 1986).

Views of content literacy have also shifted along a second dimension, from understanding literacy as a collection of general skills that can be applied to any discipline, to viewing literacy as an integral part of content learning within the discipline. The view of content literacy as general skills is evident in reading and writing across the curriculum movements and in the development of content literacy courses that teach generic literacy strategies to secondary teachers across disciplines (Fisher & Ivey, 2005; O'Brien et al., 1995). More recent perspectives emphasize that all learning is language based, and therefore attention to literacy is integral to teaching and learning disciplinary content and engaging in discipline-based discourse (Draper, 2010; Fisher & Ivey, 2005; Moje, 2008).

Contemporary perspectives on content literacy indicate the need to consider the nature of discipline-specific discourses (Draper, 2010; Moje, 2008). To learn subjects such as mathematics or science, students "need to be exposed to the use of a domain's conceptual tools in authentic activity" (Brown, Collins, & Duguid, 1989, p. 34). Science and mathematics disciplines have each developed their own ways of knowing and generating new knowledge. In science, claims are made and supported by empirical evidence, using scientific arguments. In mathematics, new knowledge is generated via proof and justification, using laws of mathematics and logic (Draper, 2010). As Draper described, "Because each discipline has distinct ways of engaging in inquiry, marshaling evidence, and expressing findings and ideas, each discipline has a unique way of reading, writing, speaking, and acting—in other words, a particular literacy" (p. 27). Therefore, literacy serves the learning process by supporting engagement in discipline-based practices and using those practices to develop understanding of content concepts of the discipline (Draper, 2010; Moje, 2008).

Attention to literacy is integral to teaching and learning disciplinary content.

Many colleges of education require secondary preservice teachers in all disciplines to take content literacy courses (Romine, McKenna, & Robinson, 1996). However, content literacy approaches are still rarely incorporated into secondary school classrooms (Fisher & Ivey, 2005). O'Brien et al. (1995) proposed that when literacy strategies are used traditionally, to extract information from text, they are seen as time consuming, inefficient, and inappropriate; yet when used to help students socially construct knowledge, these strategies are viewed as radical. Moje (2008) also suggested that part of teachers' resistance to content literacy use may arise from the historical emphasis on literacy rather than on content.

To understand why some teachers do not use content literacy approaches, previous studies have focused primarily on the degree to which teachers use these strategies and factors that influence their use (Bean, 1997; Cantrell & Callaway, 2008). Although it is important to understand the factors that may affect the extent of strategy use, it is also essential to examine the ways in which teachers are implementing (Hall & Hord, 2006). Though content literacy approaches have been promoted in preservice and inservice courses for decades, few studies have specifically examined the nature of teachers' incorporation of literacy in secondary content classrooms. Studies of secondary teachers' literacy-related practices conducted by Alvermann, O'Brien, and Dillon (1990) and Dillon, O'Brien, Moje, and Stewart (1994) suggest that literacy-related practices may be influenced by the teacher's purpose for the lesson and philosophies of teaching and the

discipline. Our study extends this work by examining and characterizing the nature of teachers' enactment of specific content literacy strategies.

The Study

This qualitative inquiry examined the nature of 26 science and mathematics teachers' enactment of content literacy strategies over two years. The teachers were participants in professional development focused on developing integrated science/mathematics and literacy practices. Participating teachers were recruited from high-need districts, taught grades 6 through 12, and participated in the project for one or two years. Seven teachers taught science, 12 taught mathematics, and seven taught both subjects.

Each year project teachers participated in a weeklong summer workshop, follow-on workshops, classroom visits by project staff, and an online discussion forum. Consistent with current perspectives regarding content literacy and reform approaches to mathematics and science education, the project took a socioconstructivist approach to learning (National Research Council, 1996; National Council of Teachers of Mathematics [NCTM], 2000) and a discipline-based approach to literacy strategy use (Draper, 2010; Moje, 2008) in which teachers were encouraged to use literacy strategies as tools to support student construction of content understandings and engagement in disciplinary discourses.

Summer workshops focused on the role of language in learning mathematics and science and theories of student learning in these disciplines; they introduced teachers to literacy-based instructional strategies for use with authentic texts of the disciplines, with the purpose of supporting student construction of content meaning. Teachers were actively engaged in instructional activities that modeled specific strategies (e.g., Frayer Model, Verbal Visual Word Association [VVWA], Anticipation Guides, conceptual writing prompts, science notebooks, concept maps) related to vocabulary development, writing, and reading, in the context of mathematics and science. Oral discussion was presented as an important component of instruction that does not stand alone, but rather is embedded in these other strategies.

The specific strategies introduced during the workshops were selected based on their appropriateness for use in science and mathematics, ability to support student understanding of disciplinary concepts, and engagement of students in disciplinary discourses and practices. For example, Anticipation Guides were selected because they support students in interacting with text to understand key concepts, examine the evidentiary basis for disciplinary ideas, and engage in disciplinary discourses involving argumentation and justification.

Teachers were provided time and support to develop classroom lessons for the next school year and encouraged to adapt the strategies to their classroom contexts. During three follow-on workshops, teachers discussed their experiences teaching lessons using these strategies and continued planning instructional activities with support from project staff and teachers. Project staff provided guidance in identifying key concepts, developing related instructional objectives, and selecting or adapting literacy strategies for accomplishing those objectives. Project staff also visited each teacher's classroom to observe instruction and provide constructive feedback. A project website containing resources and a discussion forum was used throughout the year.

Data were collected from a variety of sources. Yearly data from each teacher included two to three classroom observations, four lesson plans, reflections, student work, and online forum discussions. Project staff observed 98 classroom lessons over two academic years. Observations were conducted by a mathematics or science educator and another project staff member. Observers recorded detailed field notes about teacher actions and classroom discourse. An observation protocol (Lawrenz, Huffman, & Appeldoorn, 2002) was used to record types of classroom activities, use and integration of literacy strategies, nature of cognitive activity, and degree of student engagement in learning activities.

Initial classroom observations suggested that although all teachers incorporated new content literacy strategies into their instruction, the ways in which they enacted these strategies varied. When many of these differences persisted over the first project year, we initiated a deeper examination of the nature of teachers' content literacy strategy use and identified two contrasting patterns of enactment in science and mathematics instruction. These were characterized as a Rehearsal or Reorganization pattern of enactment. We also observed a third pattern of strategy enactment that we coded as Transitional, which included elements of both Rehearsal and Reorganization. Two researchers independently examined observation data, lesson plans, and student work and coded each strategy enactment as

Rehearsal, Reorganization, or Transitional, based on the teachers' goals for the lesson, the lesson design, and the teachers' instructional actions during the teaching of the lesson. Teacher reflections and online discussions were used to triangulate findings.

Rehearsal, Reorganization, and Transitional Strategy Enactments

In this section we provide a general description of these three patterns of strategy enactment; then in the next section we provide classroom examples illustrating these patterns. Awareness of these patterns can help teachers become conscious of the implications of decisions regarding content literacy strategy use in their classrooms. This framework can also inform teacher educator awareness of ways that particular strategies may be enacted and could be used in workshops and classroom observations to highlight relationships between instructional goals and specific aspects of content literacy strategy enactment.

In the Rehearsal pattern, teachers primarily use literacy strategies to revisit and rehearse content. In these cases, the goal of learning activities is acquisition of an accepted body of knowledge. Reading strategies are generally used to engage students in finding and recording information (primarily factual and procedural) in books and notes. Writing strategies are used to reinforce ideas, rehearse procedures, and support memorization of material. Vocabulary strategies emphasize memorization of definitions.

In the Reorganization pattern, teachers enact literacy strategies with a goal of supporting students in developing deeper conceptual understanding. Strategies are enacted in ways that provide opportunities for students to do their own thinking or develop more personal meanings and connections with the material. Students are encouraged to make claims supported by evidence, write definitions based on personal understanding, and engage in activities designed to develop meaning and understanding of terms, key concepts, and relationships. Strategies enacted as Reorganization are typically integrated with other learning activities throughout a lesson. This pattern is termed Reorganization because it supports students in reorganizing their conceptual knowledge to include new understandings that grow from the learning activities.

The third pattern of enactment, labeled Transitional, incorporates elements of both Rehearsal and Reorganization. It is evident in cases where teachers' goals include deepening student conceptual understanding, in line with the Reorganization pattern; however, this potential is not necessarily realized because the strategy is not enacted in a way that supports conceptual understanding. This may occur, for example, when assignment prompts require analysis or synthesis, but students are not given sufficient time to engage in the assignment or opportunities to discuss and reflect on their understandings. As a result, strategy enactment is more likely to result in student rehearsal of content material than reorganization. In the Rehearsal and Reorganization patterns, teachers' goals are aligned with their enactment of literacy strategies. In contrast, in the Transitional pattern of enactment, a mismatch occurs between teachers' goals and aspects of the strategy enactment. The Transitional pattern may represent teachers learning to enact strategies with a more conceptual focus but who haven't yet adopted instructional practices matching this focus.

Examples of Rehearsal, Reorganization, and Transitional Strategy Enactments

In this section we provide examples of specific reading, writing, and vocabulary strategies enacted according to a Rehearsal, Reorganization, or Transitional pattern. These examples were chosen because they are representative of the data, clearly illustrate each pattern, and highlight the different ways that strategies were enacted. The strategies discussed here are a sample of the strategies introduced to teachers and subsequently used in their classrooms.

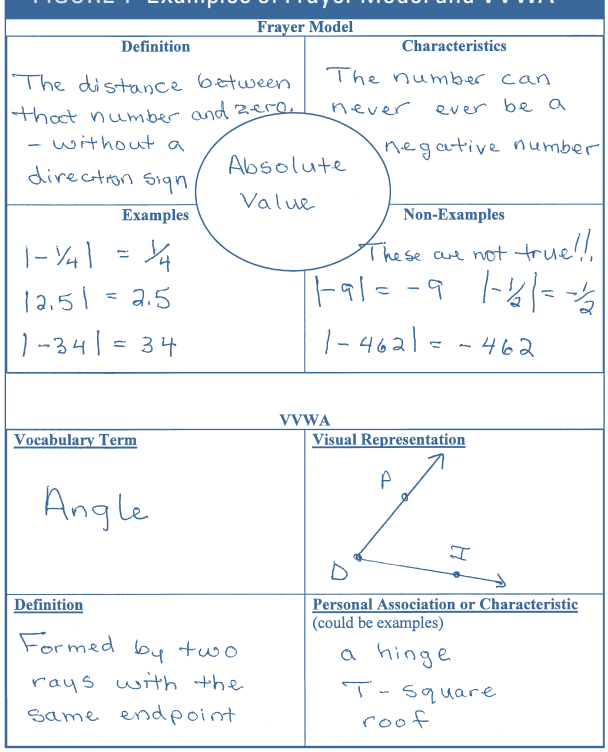
Vocabulary

Teachers' use of the Frayer Model and Verbal Visual Word Association (VVWA) vocabulary strategies is described here to illustrate how content literacy strategies may be enacted with the three patterns of use. Frayer Models and VVWA are word categorization activities that help students develop understanding of concepts (Billmeyer & Barton, 1998). With the Frayer Model, students describe concept characteristics, provide examples and nonexamples, and write a definition for the concept in their own words. VVWA is a similar strategy in which students write their own concept definition, provide a visual representation of the term, and describe a personal association or characteristic (Figure 1). Discussion after using these

tools provides an opportunity to consider additional ideas, connect to previous experiences, and revise entries and understanding. The Frayer Model and VVWA are often used interchangeably based on teachers' perception of student needs and the nature of the terms to be learned. We observed teachers using each strategy in both the Rehearsal and the Reorganization patterns.

A mathematics teacher using the Frayer Model in a Rehearsal pattern described how he made sure to "give an answer for each of the four sections of the Frayer Model during my lecture." He then had students copy these into their Frayer Model diagram during the lecture or transcribe from their notes after the lecture, in which he would "try to hint right where we covered examples and non examples and defn [definition] in their notes." At other times the teacher would explicitly require students to complete the Frayer Model using the definition from their notes. In a contrasting example classified as Reorganization, another mathematics teacher described how she used the VVWA strategy to develop students' understanding of concepts. "We usually do some sort of activity where they 'discover' the concept.... Then we fill out the VVWA, but I ask them to tell me what a good definition would be."

FIGURE 1 Examples of Frayer Model and VVWA



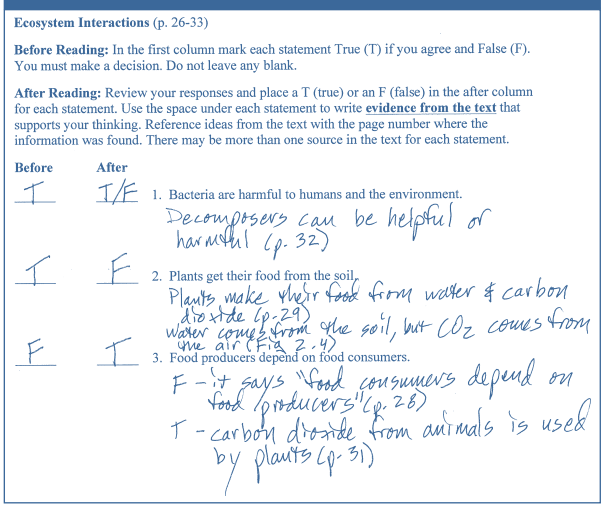
In an example coded Transitional enactment, a mathematics teacher devoted an entire class period to work with a modified Frayer Model. In an introductory lesson for a chapter, students were given 16 vocabulary words, encouraged to write definitions, and drew pictures of examples and nonexamples they identified for each. They were instructed to use both their books and their knowledge to write definitions in their own words. While the teacher's intent was to elicit prior knowledge and deepen student understanding of each term, the large number of words and use of the textbook meant that students were drawn toward using the textbook definition. No class time was devoted to discussion of student ideas or to connecting words with meanings developed during prior learning experiences. Instead, the teacher reviewed terms and definitions so that students could see where they were right or wrong. Words were considered in isolation from other meaningful learning experiences. As a result, thinking about each word was more closely connected to a textbook definition than to any learning activity that might have been used to develop conceptual understanding of the term. Thus a lesson with potential for Reorganization of student understanding resulted instead in students revisiting and rehearsing definitions.

Reading

Anticipation Guides are designed to lead students to thoughtfully read and interpret text (Forget, 2004). They consist of a series of plausible statements that rephrase the text and require student analysis and interpretation of the reading. Students begin by determining and discussing whether they believe each statement is true or false. This task elicits prior knowledge and motivates learners to read and interpret the related text, looking for evidence to support their predictions. After reading, students are asked to reassess their identification of each statement, change their responses if needed, and justify responses with evidence from the text (Figure 2). Subsequent discussion of student findings provides opportunities to extend interpretations of the text as they justify their responses using information from the text as evidence. In project workshops, teachers had used such guides and discussed critical features.

Enactments of Anticipation Guides identified as Rehearsal focused primarily on finding facts from the reading. In one case, a science teacher designed an Anticipation Guide that covered five pages of text

FIGURE 2 Example of Anticipation Guide



Ecosystem Interactions (p. 26-33)

Before Reading: In the first column mark each statement True (T) if you agree and False (F). You must make a decision. Do not leave any blank.

After Reading: Review your responses and place a T (true) or an F (false) in the after column for each statement. Use the space under each statement to write **evidence from the text** that supports your thinking. Reference ideas from the text with the page number where the information was found. There may be more than one source in the text for each statement.

Before	After	
T	T/F	1. Bacteria are harmful to humans and the environment. Decomposers can be helpful or harmful (p. 32)
T	F	2. Plants get their food from the soil. Plants make their food from water & carbon dioxide (p. 29) water comes from the soil, but CO_2 comes from the air (Fig. 2.4)
F	T	3. Food producers depend on food consumers. F – it says "food consumers depend on food producers" (p. 28) T – carbon dioxide from animals is used by plants (p. 31)

and required students to respond to 30 statements. Many of the statements focused on finding factual information from the text, such as "Platelets have a life span of 10–15 days," or were stated in ways that could be answered purely with prior knowledge, such as "Most people will bleed to death from a small cut." When giving directions for this activity, the teacher asked the students to note the page number as evidence of whether the statement was true or false and to correct false statements. The number of statements resulted in students focusing primarily on those they could easily answer and skipping the others. During the 17 minutes the teacher had allotted for this activity, students completed only about half of the 30 statements. Discussion was limited to one statement and focused primarily on noting the page where the correct information was found.

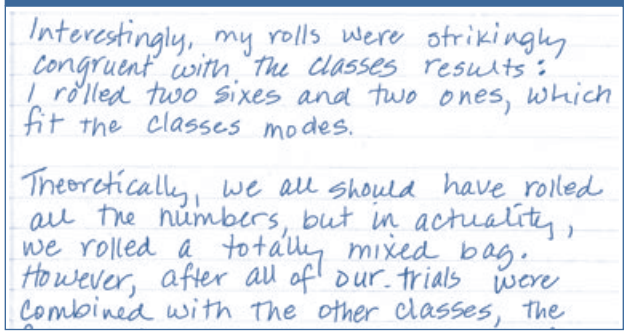
In examples categorized as Reorganization, teachers created Anticipation Guides that elicited students' prior knowledge, engaged students in making inferences from the readings, and required them to justify responses with evidence from the text. For example, in a science lesson on earthquakes, the teacher started by having students respond to statements, such as "Earthquakes are a form of energy" and "We are more likely to feel an earthquake living here in Idaho than someone in Minnesota," that were designed to evoke students' prior knowledge and required them to make interpretations of the readings. Before reading, students were polled to find out how many thought each statement was true or false, and students were asked to explain the thinking behind their responses. After reading, students were polled again and asked to explain their reasoning and justify their answers.

In another science example categorized as Transitional, a teacher designed an Anticipation Guide for a fictionalized reading about the periodic table. The teacher explained that his goals for this lesson were to reinforce concepts previously learned and for students to visualize the periodic table differently. The teacher created the Anticipation Guide by modifying a worksheet he had used previously with this reading. However, changing the questions into statements for the Anticipation Guide resulted in some statements for which students could not state an opinion before reading, such as "The author refers to the 'east coast,' the group of elements located here are the alkali metals." The teacher had not considered how changing the questions into statements would result in students being unable to respond to some of the statements before reading. Instructions for this guide asked students only to note the page and paragraph where they found supporting information. Although use of an Anticipation Guide with this reading had the potential for students to rethink their understandings of the periodic table, the design of the Anticipation Guide limited students' opportunity to examine their prior understandings and emphasized finding factual information from the reading rather than making meaning of the ideas.

Writing

Writing-to-learn activities can take a variety of forms in mathematics or science classes. A teacher might ask students to respond to a short writing prompt, briefly summarize their understanding of what was learned in a class activity, or write explanations and/or justifications of their problem-solving process or phenomena investigated in a science lab (Figure 3). Forget (2004) characterized writing as "thinking onto paper" (p. 46), and as such it is a powerful reasoning tool. Writing serves to help students organize, analyze, interpret, and communicate ideas, leading to a deeper understanding of content concepts and relationships (Burns, 2004; Holliday et al., 1994). Because writing requires reflection on work and clarification of thoughts, it can assist students in consolidating their thinking (NCTM, 2000). Additionally, students' writing provides content area teachers with a view into students' thinking process and conceptual understanding, which can be used for assessment and instructional modification.

FIGURE 3 Example of Quick-write, a Writing-to-Learn Strategy


Interestingly, my rolls were strikingly congruent with the classes results: I rolled two sixes and two ones, which fit the classes modes.

Theoretically, we all should have rolled all the numbers, but in actuality, we rolled a totally mixed bag. However, after all of our trials were combined with the other classes, the

When incorporating writing into lessons, teachers used a variety of writing-to-learn strategies, such as journal prompts, guided note-taking, or quick-writes that serve as brief summaries of concepts or learning activities. Each of these strategies had the potential to be used in the Rehearsal or the Reorganization pattern. In examples classified as Rehearsal, the focus of writing was either on students recalling information that they had learned or recording information as it was being presented. In a mathematics lesson, the teacher asked students to write the rules for the order of operations into their journals as an opening activity. Doing so required students to recall the rules, find them in notes or text, or check with others. This activity served as an opportunity for students to revisit the rules and resulted in a record that students could quickly and easily consult in future work. Discussion of the activity consisted of students reading their entries and the teacher asking the class if entries were right or wrong.

In an example classified as Reorganization, students began the lesson by finding the real square, cube, or fourth roots of various integers. After class discussion of this work, they were to write (a) why certain numbers have particular real square roots, (b) why 8 has only one real cube root, (c) a generalization about how many real roots a number will have for even and for odd root numbers, and (d) an explanation of why their generalization makes sense. After writing, student pairs discussed their generalizations, followed by a whole class discussion of student ideas. Finally, drawing on their generalizations and class discussion, students completed exercises in finding various real roots of real numbers. Students used writing to develop explanations and generalizations for mathematical processes they needed to use and understand.

In a mathematics lesson in which the enactment of writing-to-learn strategies was characterized as Transitional, students were asked to write concept paragraphs in which they identified key concepts in four sections of a common traditional textbook and described these in their own words. This strategy enactment was characterized as Transitional because the teachers' intent was for students to make meaning of these ideas by describing what the concept meant to them; this goal was not realized, however, because of aspects of the lesson enactment. First, the number of concepts to be described was too great for students to write thoughtfully about each. Second, before students were allowed to begin, the teacher spent more than half the class period walking them through examples and explaining concepts. When students were unsure how to proceed, they were directed to look up ideas in the book. Resulting student explanations primarily described computational procedures, rather than discussing the underlying concepts and relationships, and often used phrases found in the textbook instead of students' own words.

The Table summarizes the coding scheme we developed based on the Rehearsal and Reorganization patterns. The Transitional pattern is not included. Transitional patterns include elements of both Rehearsal and Reorganization resulting from mismatches between teachers' goals and aspects of their enactment of strategies. Because this mismatch can occur in many ways, it is not possible to provide a singular list of characteristics.

Use of Rehearsal and Reorganization Enactments in a Single Lesson

The previous examples have characterized teachers' enactment of specific strategies as Rehearsal, Reorganization, or Transitional. It is also important to look at the classroom lesson as a whole. In a single lesson, teachers may enact various strategies in different ways and for different purposes.

For example, in one science lesson, the teacher started class with the writing prompt, "What organelles do plant cells have that animal cells do not?" This question required students to recall previously learned information. When students struggled to remember these details, the teacher allowed them to look in their books, a Rehearsal pattern. However, the lesson then led into a concept-mapping activity in which students applied this knowledge of plant and animal cell organelles

TABLE Rehearsal and Reorganization Approaches to Content Literacy Strategy Use

	Rehearsal approach emphasizes	Reorganization approach emphasizes
Writing	Technical communication, such as writing formal reports Taking notes/recording information Supporting memorization or reinforcement of knowledge Assessing student knowledge	Processing/constructing new knowledge Reflecting on prior learning and clarifying thinking Explaining and justifying one's steps/process to further understanding Supporting students in making their thinking explicit
Reading	Decoding, vocabulary, and text structure Acquiring information/facts/vocabulary Nontextbook resources used to create interest or show applications	Drawing on background knowledge and text structure to support comprehension Active interaction with text to support conceptual understanding Nontextbook resources used to develop broader understanding of concepts
Vocabulary	Memorizing formal definitions Definitions taught first, followed by concept development	Engaging students in constructing meaning of vocabulary Integration of vocabulary and conceptual development

to identify and explain relationships among the organelles. This required students to revisit and revise their understanding of these concepts to create the concept maps and describe the relationships, a Reorganization pattern. The teacher's goals for the activity were to have students reorganize their understanding of plant and animal cell organelles by discussing the relationships between these structures through the creation of the concept map. In this case, a literacy strategy using a Rehearsal pattern was used to prepare students for a subsequent activity that used a Reorganization pattern.

This example demonstrates how teachers' enactment of literacy strategies is influenced by their goals for student learning. Using a Rehearsal pattern to lead students to activate their prior knowledge, in this case, prepared students to subsequently engage in an activity with great potential for conceptual reorganization. This suggests that to understand literacy strategy use in content classes, it is not enough simply to note which strategies are being used. It is important to characterize teachers' goals and the nature of their enactment of these strategies.

Discussion

Our observations highlight the importance of attending to the ways in which teachers incorporate content literacy strategies into their instruction, in addition to identifying whether or not the strategies are used. All project teachers in our study incorporated content literacy strategies into their instruction and adapted them for their classroom contexts. Additionally, we found that teachers tended to enact content literacy strategies in ways that aligned with their instructional goals and their current practices. As O'Brien et al. (1995) suggested, this tendency sometimes resulted in a mismatch between content literacy strategies based on socioconstructivist theories and teachers' goals and practices. However, we found that this conflict did not necessarily result in a failure to use content literacy strategies, but rather resulted in some teachers modifying the strategies in ways that minimized the conflict among their goals, classroom practices, and use of the strategies.

Characterization of the three patterns of strategy enactment highlights the ways in which these conflicts and modifications occurred. When strategies were enacted in alignment with the Rehearsal pattern, teachers' goals for instruction and classroom practices conflicted with the intended purposes of the strategies as presented in the project workshops—that is, they focused on transmission or rehearsal of knowledge rather than development of understanding, resulting in the strategies being modified from their intended use. When strategies were enacted in a Reorganization pattern, teachers' goals and classroom practices were aligned with the intended use of the strategies, and modifications were made to fit classroom contexts without altering the intended purpose.

In examples of strategy enactment characterized as Transitional, teachers described goals partially aligned with conceptual knowledge construction,

but aspects of lesson enactment resulted in failure to accomplish these goals. In these cases, teachers structured classroom time in keeping with traditional practices, such as expecting completion of a large number of questions or tasks within a short time and restricting discussion of activities to teacher-guided discussions of "correct" answers, thus limiting exploration and reflection on concepts.

Draper (2010) has argued that secondary content area literacy instruction should focus on sense making and understanding and engage students in authentic disciplinary activities. This approach relies on teachers' awareness and implementation of reform-based instruction. Although we agree with the goals set out by Draper, the reality suggested by our study is that not all teachers have adopted instructional goals and practices in alignment with reform-based instruction, and we cannot ignore the ways in which their goals and current practices influence content literacy instruction. Our observations of the transitional pattern suggest that if similar instructional activities and goals are not already in place in a teacher's practice, considerable learning and rethinking of the learning process may be necessary before a teacher can effectively teach in new ways, with a broader set of learning goals. For some teachers, the incorporation of content literacy strategies into their practice requires shifts in previous instructional patterns, such as in the amount of time allotted for particular instructional activities, the connections among lesson activities, and the role of discussion. Teacher educators and professional developers can support such shifts in practice.

In this article, we have presented specific examples of the ways in which teachers enact and adapt content literacy strategies. By presenting these examples, we hope to increase the awareness among teachers, teacher educators, and inservice providers of the importance of attending to these variations. Some might argue that these adaptations are not unexpected. However, until we begin to acknowledge and characterize these adaptations, the presentation of the strategies as simple tools that can be applied to any context, without associated discussion of the relationship between their purposes and possible uses, may lead to the tools not being used in ways that enhance student understanding.

Take Action

STEPS FOR IMMEDIATE IMPLEMENTATION

When teaching with content literacy strategies to develop students' understanding of science and mathematics concepts, consider both lesson design and lesson enactment.

Planning Instruction:

- ✓ Determine the key concepts you want students to learn from the lesson.
- ✓ Make sure the design of the lesson addresses these key concepts and provides time for student reflection and discussion of these ideas.
  - o Don't try to do too much. Doing the deep thinking takes time.
  - o Choose a few concepts for a single lesson.
- ✓ Think through the responses you want to elicit from students. Will the design of the lesson lead to the desired thinking and understanding? For example:
  - o Are the Anticipation Guide statements written in ways that elicit students' prior conceptions and encourage critical analysis of the text? Is space provided in the Anticipation Guide for students to explain their thinking?
  - o Can examples and nonexamples be identified for the terms used in the Frayer Model?
  - o Does the writing prompt require students to synthesize new learning and old, make a claim and develop supporting arguments, justify their thinking, or reflect on and make meaning of the learning in the lesson?

Lesson Enactment:

- ✓ Model the strategy for students and provide examples of types of responses that you seek.
- ✓ Encourage students to draw on prior experiences and reframe ideas using their own words when using text resources.
- ✓ Allow sufficient time for reflection and discussion.
- ✓ Act as a moderator during discussions and encourage students to explain their thinking and justify their ideas.
- ✓ Encourage full discussion of ideas from students' perspectives and avoid focusing on right answers alone.

Professional development and preservice courses can provide opportunities for teachers to use the strategies with content material, to conduct focused observations of lessons using literacy strategies, and to debrief what was observed. Such experiences help teachers create a vision for effective use of these strategies within the disciplines, provide them with evidence that students can engage successfully in these new ways of learning, and allow them to see how such strategies provide students with opportunities to deepen their understanding and extend their learning. When introducing content literacy strategies, it is important to spend time discussing current understandings of student learning and to explicitly tie discussion of the purposes and design of content literacy strategies to these theories.

Content literacy strategies offer a useful set of instructional tools for teachers of mathematics and science that can be used to achieve current goals in mathematics and science education by providing opportunities for student thinking, reasoning, and meaning making (Banilower, Cohen, Pasley, & Weiss, 2008; NCTM, 2000). However, achieving these goals is dependent upon the nature of instructional enactment. The particular ways that teachers enacted literacy strategies were influenced by multiple factors, including teachers' learning goals for their students, prior teaching practices, and pressures resulting from limited classroom time. If we wish to understand teachers' use of literacy strategies, we must consider a range of factors that go beyond teachers' knowledge of the strategies themselves. Only then can we provide effective support and opportunities for teachers to become knowledgeable and fluent in the use of these strategies, making them available to promote increasingly deep and connected learning of mathematics and science through authentic engagement in disciplinary discourses.

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CONNECTED CONTENT-BASED RESOURCES

Books

- Kenney, J.M., Hancewicz, E., Heuer, L., Metsisto, D., & Tuttle, C.L. (2005). *Literacy strategies for improving mathematics instruction.* Alexandria, VA: Association for Supervision and Curriculum Development.
- Pugalee, D.K. (2007). *Developing mathematical and scientific literacy: Effective content reading practices.* Norwood, MA: Christopher-Gordon.
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