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Vanessa B. Morrison

Andrea R. Milner

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by Vanessa B. Morrison and Andrea R. Milner

"Literacy is eating up the school day – it has become the curricular bully. Literacy doesn't have to put science off the curricular stage – it can become a curricular buddy," (P. David Pearson, 2011, p. 70).

Introduction

Vanessa Morrison

Andrea Milner

Classroom teachers are beginning to consider a broader range of instructional approaches as they prepare to accommodate the Common Core State Standards (Common Core State Standards [CCSS] Initiative, 2010) into their content area lessons. The CCSS is a progression of learning expectations by grade levels in English Language Arts and Mathematics, which seek to prepare students in K-12 for career and college readiness. One hallmark of the CCSS is integrating literacy in content area subjects, for example, the CCSS for K-5 reading in history, social studies, science, and technical areas are integrated into the K-5 Reading Standards (CCSS, 2010). Thus, the CCSS emphasize the idea that to become highly proficient in a specific subject area, students must experience an integrated model of literacy that includes reading, writing, listening, and speaking. Literacy integration across subject areas may have potential when it comes to understanding content at a deeper level (Anderson, West, Beck, MacDonell, & Frisbie, 1997; Eick, 2012; Guthrie, Wigfield, Humenick, Perencevich, Taboada, & Barbosa, 2006), and can serve as a valuable way of managing instructional time in various subject areas such as science (Pearson, 2011).

Jennings and Rentner (2006) indicate that science is not a critical component in many elementary schools. Others note that teaching and learning time for science is being decreased in elementary classrooms in favor of greater focus on reading instruction (Blank, 2012; Griffith & Scharman, 2008; Jennings & Rentner, 2006; Klentschy & Molina-De La Torre, 2004, Wisseher, Concannon, & Barrow, 2011). For example, one key finding from the 2009 National Assessment of Educational Progress confirmed that nationally, instructional time for science in elementary classrooms dropped to an average of 2.3 hours per week, compared to 11.7 hours per week spent on English Language arts and reading (Blank, 2012).

One significant factor causing concern over the reduction of time spent on science in elementary classrooms is the national focus on high stakes testing, especially since the passing of the No Child Left Behind mandate (No Child Left Behind [NCLB] 2002). This law requires greater emphasis on reading and mathematics instruction since these two subjects are assessed in the elementary grades (NCLB, 2002). Thus, attention from the NCLB annual yearly progress on students' reading abilities required teachers to focus their instruction on reading and language arts for a majority of the instructional day (Eick, 2012; Pearson et al., 2010). Classroom teachers in one study (Pegg, 2010) expressed concern for the increased amount of time they are required to teach reading; while others struggle to find sufficient time to conduct inquiry-base science investigations. However, some teachers in Pegg's study (2010) accommodated for the time deficit by teaching literacy and science in an integrated manner; and as Pearson (2011) noted, instead of being a bully, literacy can be a buddy.

Literacy does not have to occupy center stage for a majority of classroom instructional time; instead teachers can fold literacy practices into content area lessons as recommended by the CCSS. To be literate in the 21st century, students must know how to apply effective literacy techniques to read, write, talk, listen, view, represent, and think about ways to study the content being taught. Content literacy can be viewed as the use of a combination of language and thinking practices to engage and make sense of or obtain meaning; and in the context of subject areas, it "refers to the ability to use reading, writing, talking, listening, and viewing to learn subject matter in a given discipline" (Vacca, Vacca, & Mraz, 2011, p. 13). A recent search of the literature regarding trans-disciplinary literacy practices found limited results. Thus, this article shares the literacy-science teaching practices of one teacher as she engaged her students in studying variation and relatedness in living organisms. More specifically, we provide detailed moment-by-moment examples of one lesson showing how the literacy and science learning of fourth graders can be increased when the teacher embeds various literacy elements as part of a science lesson.

Review of the Literature on Literacy-Science Connection

Hapgood & Palinscar (2007) and Pearson et al. (2010) noted that literacy and science are closely related because they share similar thinking and communication skills. For example, when learning in either domain, students are able to compare and contrast their thoughts with others; they can also express their ideas through words and images in both verbal and written formats. Yore (2004) passionately argued that language is a significant part of science; and scientists use the language arts components in talking and writing about their ideas, and in describing, defending, and presenting their lines of inquiry. Talk is necessary not only to communicate ideas, but to stimulate internal thoughts. For example, Vygotsky (1962) proposed the idea that speech and language plays an essential role in cognitive development because it determines how students think and learn; and in turn share their understanding through words. Pearson (2011) stated that language is used to talk and write about science which is a social context where the language used is a powerful and specialize way of talking and writing about the world.

Rivard and Straw (2000) posited that oral language is vital for proposing, clarifying and sharing ideas with colleagues; while asking and generating questions, predicting, and providing explanations serve as important aspects during communication. Scientists are speakers, listeners, readers, and writers who use language as a vehicle to transmit scientific concepts, "language is both a means of doing science and of constructing scientific claims and an end in that it is used to communicate inquires, procedures, and science understandings …" (Yore, 2004, p. 71-72).

Constructing knowledge involves the use of reading, writing, and oral language; and utilizes numerous cognitive processes. Casteel and Isom (1994) examined the similarities between literacy and science and concluded that many of the cognitive processes inherent in literacy are also significant to science and when taught together can propel learning. Pearson (2011) advocated that reading comprehension strategies and science inquiry strategies are meaning making strategies in literacy and science. For example, the science process skill of formulating a conclusion is equivalent to the reading process skill of analyzing and evaluating information; so is hypothesizing to predicting, observing to noting details, and using evidence in support of claims to distinguishing fact from opinion (Klentschy & Molina-De La Torre, 2004).

Several investigations (Anderson, West, Beck, MacDonell, and Frisbie, 1997; Guthrie, McRae, & Klauda, 2007; Guthrie et al, 2006; Romance & Vitale; 2001) have focused on integrating literacy and science with the common argument that this cross-curricular linkage can improve reading comprehension and advance scientific knowledge. In one study (Anderson, West, Beck, MacDonell, and Frisbie, 1997) seeking to integrate reading and science, fifth graders self-selected a trade book on a science topic before joining peers with a similar interest. Before reading the book, students entertained thoughts and questions about the topic, then engaged in a three-phase activity designed to promote minds-on science in the following ways: (a) Wondering — In relation to their chosen topic, students posed wonderments of what they want to know and explore; then selected one of the wonderment and turned this into a research question for further investigation; (b) Exploring — Students accessed prior knowledge about the topic, conducted additional reading, posed explanations and elaborations, interviewed experts, and visited museums and planetariums, completed written logs, and engaged in discussions with group members; and (c) Explaining —Students condensed and summarized their discoveries, posed additional questions based on their inquiry, and made presentations. The researchers claimed that interrogating the text motivated students to go beyond the information read to making connections to their real life experience.

In a series of multi-year studies seeking to understand how science instruction can be fused with reading and language arts instruction, Romance & Vitale (2001) conducted professional development sessions, and implemented the In-Depth Expanded Applications of Science (IDEAS) model of integrated science and language arts instruction. In the research settings, IDEAS replaced the time for traditional reading and language arts instruction of basal readers in favor of science trade books. This occurred within a daily two-hour time block specifically allocated to teaching in-depth science concept instruction including hands-on investigations, science processes skills, construction of concept maps, reading of science material, comprehension strategy instruction, and writing. To create a purposeful context for learning science and reading, the teachers engaged students in a series of reading activities to boost their knowledge for upcoming science investigations. Findings over five years showed that IDEAS students outperformed students not receiving the intervention in both science and reading. Additionally, IDEAS students demonstrated significantly more positive attitudes and self-confidence toward both content domains.

Guthrie & Ozgungor (2002) claimed the integration of literacy components during science instruction increases students' motivation and enhance achievement in both areas. For example, the Concept-Oriented Reading Instruction (CORI) framework was created to motivate and engage students in sustained reading of science trade books. CORI further promoted students' cognitive competencies in reading through explicit teaching of cognitive strategies such as, identifying main ideas, questioning, activating prior knowledge, and summarizing. Additionally, CORI sought to expand students' knowledge of life science through hands-on experiences and peer collaboration. Findings from other CORI studies (Guthrie, McRae, & Klauda, 2007; Guthrie et al, 2006) revealed that students who received the intervention showed increased comprehension in science and reading, as well as conceptual learning and strategy use.

Magnusson & Palincsar (2004) found that text-based experiences can better prepare students for inquiry-based investigations, particularly when the activity involves reading information written in a notebook. For example, Magnusson and Palincsar (2004) designed a science notebook to support the teaching and learning of an inquiry-based science activity using this tool. Guided by specific questions, fourth graders read the entries of a fictitious scientist using reading, writing, and thinking as a reciprocal cycle to conduct an investigation, gather and analyze data, and communicate claims. Through this notebook, students learned how to read and interpret data; and came to understand how scientists use language and thinking as revealed through their interaction with the science notebook. Findings based on students' comments indicated their growing awareness of the different aspects involved in the inquiry process, including discipline specific language, and different forms of graphic representations to convey information.

The Project

This descriptive article was drawn from a larger research study entitled Strategies Modeling and Reading Together Through Integrating Science (SMARTTIS), a collaborative project between a small liberal arts college (LAC) in the Midwest and a nearby rural public school system. SMARTTIS has six major objectives:

1. To develop, support, and utilize effective teaching practices in science and reading for (Public School System (PSS) elementary teachers.
2. To provide effective and sustained professional development for PSS elementary teachers.
3. To implement quality inquiry-based integrated science and reading curriculum and instruction.
4. To enhance students' attitudes about science and reading.
5. To coordinate curriculum, classroom practice, and student assessment with the district adopted science and reading courses of study and district science and reading assessments.
6. To enhance the science and reading content knowledge of PSS elementary teachers.

This project was part of a summer school, science-reading-math program in a small rural school district in the Midwest. The teacher was a veteran fourth grade classroom teacher within the district and volunteered to participate in this project after receiving professional development on ways to integrate science and reading content. Seventeen academically struggling end-of-year fourth graders participated in quality inquiry-based integrated science and reading curriculum and instruction consistent with local, state, and national recommendations so they may receive opportunities to become proficient in science content and reading skills. The students were drawn from the district's four elementary schools, and recommended by their classroom teachers as candidates who could benefit from the district's summer school academic intervention. The U.S. Census Bureau (http://www.quickfacts.census.gov/qfd/states/26/2600440.html) estimated that in 2010, 30.1% of this town's population lived below the poverty level; and 18.8% of the population was Hispanic or Latino and an additional 4.4% was African American. Participants were a representative sample of the town's population.

Data were collected over nine consecutive days during the combined science-reading lessons and consisted of: pre and post interviews with the teacher, students' post interviews, videotaped recordings of the interviews and teaching practice, photographs, field notes, students' pre and post attitude surveys, students' artifacts, and students' pre and post assessments. Data collection and analysis were conducted simultaneously throughout the project. The video recordings of literacy/science instruction were transcribed verbatim and coded using the constant comparative method of data analysis to examine for emerging patterns and themes on specific instances of literacy episodes (Glaser & Strauss, 1967). The curriculum utilized was *Seeds of Science/Roots of Reading* (www.scienceandliteracy.org).

Snapshots of One Lesson

The following section provides snapshots of different segments of one lesson with particular focus on literacy episodes or multimodal instructional practice showing how Mrs. Wendel (all names are pseudonyms) implemented several essential literacy elements to help advance students' understanding of science and reading. The literacy episodes shared in this article are critical components of the *Seeds of Science/Roods of Reading* curriculum utilized by Mrs. Wendel. It is important to note that these fourth graders already had some knowledge and experience reading informational texts. Therefore, the strategies discussed were not completely new to them; however, students need numerous opportunities to practice using what they learn, especially those having difficulties with reading comprehension. The detailed moment-by-moment lesson that follows was implemented on day 2 of the project and consisted of Mrs. Wendel's instruction of comprehension strategies and dialogue with students. The SSRR curriculum utilizes the multimodal instructional practice of: Do-it, Talk-it, Read-it, Write-it. The Do-it, Talk-it, Read-it, Write-it approach, engages students in learning science concepts in-depth, while increasing their skills in reading, writing, and discussing in ways similar to scientists. That is, processes such as discussing, questioning, predicting, clarifying, and providing explanations serve as important aspects in understanding material and communicating this information with others.

Read-it

The topic of this lesson was variation and relatedness in living organisms and one activity involved an interactive read-aloud of the book *Blue Whales and Buttercups* (Goss, Curley, & Chase, 2009), which presents a colorful photographic display of rich informative text with captions about earth's diverse creatures. It addresses numerous variations of living things in our world and the different characteristics that make each group unique; these shared characteristics are evidence that all living things are related because they are made of cells. Reading aloud to students is a dynamic tool to motivate and build reading and listening skills, and an essential ingredient for instruction. Effective teacher interactive read-alouds in part consist of elements such as: the modeling of fluent oral reading, use of animated expressions, and interspersing thoughtful questions that directs students' attention to specific parts of the text (Fisher, Flood, Lapp, & Frey, 2004).

In *Becoming a Nation of Readers: The Report of the Commission on Reading*, Anderson, Hiebert, Scott, & Wilkinson (1985) stated "the single most important activity for building the knowledge required for eventual success in reading is reading aloud to children," (p, 23). Interactive read aloud of science trade books is an excellent way to build numerous literacy components, including oral language skills, word recognition abilities, vocabulary awareness, graphic images/text connections, and text feature and text structure knowledge (Graves, Juel, Graves, & Dewitz, 2011). During this project, the teacher emphasized interactive read aloud techniques interspersed throughout the session. These interactions supported students' learning of specific comprehension strategies, and served to increase their overall reading acquisition. The following section explains how the teacher periodically paused to discuss information in the text by explicitly drawing students' attention to comprehension techniques to help promote their understanding.

***Previewing*:** Previewing a text before reading can enable students to focus on particular aspects of the text, and perhaps this can make the reading process less difficult for many of them. Additionally, this technique creates anticipation and enthusiasm for information to be read (Graves et al., 2011). Previewing can include examining the book for text-specific knowledge, for example; Duke and Pearson (2002) noted that readers' effective use of text features can advance understanding of important ideas which increases recall of specific material. Text features are organizational aids that help to facilitate reading and consist of text elements such as, bold and italicize words, headings, illustrations, graphs, table of contents, glossary, and similar features. Clark, Jones, and Reutzel (2013) stated that previewing for text features is similar to a picture walk and strongly recommended that teachers model and encourage students to take a text feature walk before reading an information book. The following scenario explains how Mrs. Wendel activated students' prior knowledge about text features, a skill many had learned from reading numerous expository texts while in fourth grade; and one they had practiced on the first day.

Wendel: When you begin reading a science book like *Blue Whales and Buttercups*, what is the first thing you do?

Chad: Look at the pictures.

Wendel: Looking at the pictures is a good thing because it helps you better understand what you're reading by connecting pictures to the information … but what else can you do?

[No responses.]

Wendel: One important thing you can do when you're reading your science book is to preview the information so you can get an idea of what the book is about. You can do this by looking through the book at the headings, and perhaps read the table of contents because this shows what topics are located where in the book. You can also look at the bold words because they often contain main ideas or important words you need to know. In your book, notice the headings and bold words the authors used.

[Mrs. Wendel demonstrated and pointed out a few examples to students before continuing.]

Wendel: The authors organized this book to show how living things are different and similar. The first section of the book shares differences, and the second section shares similarities … and look at how the authors share this information in the table of contents so we can more easily find what we need.

In the above case, Mrs. Wendel offered a reason for examining text features before reading a science book and pointed out specific examples by taking students on a text feature walk. She acknowledged the importance of using pictures as an aid when making connections to the text and emphasized that previewing text features can help readers access necessary information more quickly.

Questioning: Teaching students to monitor their understanding by generating and answering questions is important in making meaning of texts; asking and answering questions that involve deeper levels of thinking is a form of knowledge construction (Chan, Burtis, Scardamalia, & Bereiter, 1992). Students can increase and monitor their understanding when they integrate text information with prior knowledge through text-based and knowledge-based questioning and wondering. The following example shows one way Mrs. Wendel encouraged students to probe the text.

Wendel: When you're reading a book like this one [holds up *Blue Whales and Buttercups*], it's a good idea to stop after every page or two and ask yourself a question about the information you read. Questioning can help you keep track of what you're reading. So after reading page four, I will stop and ask myself a question about something I find interesting or something I'm curious about. It says here, "Living things can have very different characteristics. A characteristic is anything you can notice about the way a living thing looks or acts. Some animals have fur, and others have feathers. Some plants have flowers, and others do not. Some animals protect themselves by running fast, and others protect themselves by biting" (p. 4). So I'm wondering … since animals can run fast and bite to protect themselves, how do plants protect themselves? How do you think plants protect themselves?

Matt: They can't.

Jennifer: Yes they can … some don't make flowers because if they do … some animals would come along and eat the flowers.

Wendel: And maybe the plant too. And Jennifer is absolutely right because some flowers make seeds for the next generation of plants.

Matt: Also … some plants like poison ivy make you itch, so you don't go near them or pick them.

In this particular instance, the question Mrs. Wendel asked encouraged students to think beyond what was stated in the text. In order for higher levels of learning to occur, students must go beyond the factual material presented to thinking about the meaning of that information and its relationship to what they already know. As seen here, the question posed by Mrs. Wendel elicited Jennifer and Matt to share their thoughts on how plants protect themselves. Jennifer's response informed Matt about an aspect he probably did not consider.

***Predicting*:** Generating expectations, hypothesizing upcoming information, and predicting what can happen in alternative scenarios are powerful influences on how students create meaning when reading or listening (Anderson, Wilkinson, & Mason, 1991). When students predict, they apply prior knowledge, draw on what they have read/viewed in the text thus far, develop hypotheses, and later test these to confirm or reject their predictions. Further, generating expectations and predictions allow students to anticipate upcoming information, integrate text knowledge with prior knowledge, and monitor for understanding (Palincsar & Brown, 1984). After one student had read aloud pages 12-13 of the text on how living things are similar, Mrs. Wendel posed the following:

Mrs. Wendel: The authors share that different species are related to other species. Look at the picture of the wolf, the fox, and the wild dog ... why do you think the authors are saying the wolf, the fox, and the wild dog are related?

Danny: 'Cause they kinda look the same.

Wendel: What makes you say that?

Danny: They have fur, they have tails, they have four legs. They remind me of a dog.

Wendel: Good ... so you're saying they share similar characteristics.

[Danny nods head.]

Malcom: Their legs can help them run fast like some dogs.

Wendel: The authors said animals with four limbs are related ... and these animals all have four legs. So maybe we're going to read more about animals with four limbs and how they use these limbs to help them move.

In this scenario, Danny shared three common characteristics among the animals by examining the photographs and activating what he already knew about these animals. This prompted Malcom to indicate that all four animals use their limbs to help them escape from predators, a topic discussed earlier when talking about protection. Further, Mrs. Wendel predicted that perhaps information in upcoming text will explain more about ways animals use their limbs for movement. Her statement is an example of cognitive modeling regarding prediction of upcoming text.

***Clarifying*:** Reading aloud to students can provide numerous academic benefits, including vocabulary growth. Some (Coyne, Simmons, Kame'enui & Stoolmiller, 2004) believe that students acquire rapid access of words and ideas through reading and listening to informational texts. Teacher read-alouds combined with explanations, discussions, and implicit questioning can significantly increase students' vocabulary abilities (Biemiller and Boote, 2006). Additionally, activating students' background knowledge can prompt retrieval of stored information. The following episode highlights one way Mrs. Wendel focused students' attention on the word *compare*.

Wendel: We're going to add one more word to our vocabulary wall [holds up the word *compare* – written on sentence strip] ... the word we're going to add is this ... does anyone know what this word is?

Tisha: Compare.

Wendel: Compare ... compare. Have you heard this word before?

Tisha: Yes.

Wendel: Elliot, where have you heard the word compare before?

Elliot: In school.

Wendel: How have you heard it used in school?

Elliot: We usually have to compare and contrast.

Wendel: Elliot said that in school, he usually has to compare and contrast. Can anyone tell me what that means? What does it mean to compare?

Tisha: To find the same in things.

Wendel: Exactly, to compare things are to state how things are alike and how things are different [posts sentence strip with definition of compare on wall.] I have 2 questions for you – give me a thumbs-up if you agree with this question – a thumbs-down if you disagree. Can you compare an apple and a banana?

[Lots of thumbs-up from students.]

Wendel: Could you tell how an apple is like a banana?

S1: Oh yeah, they're both fruits.

Wendel: And could you tell how an apple is not like a banana.

[Lots of students' talk on similarities and differences between an apple and a banana.]

Wendel: Can you compare your family members?

S1: Yeah.

[Lots of students' talk on similarities among family members.]

Wendel: Can you compare one dog?

Some students: Yes.

Many students: No.

Wendel: Stan, why couldn't you compare one dog?

Stan: Cause it's only one thing.

Wendel: It's only one thing. Stan told us you couldn't compare one dog because it's only one thing. Look at your animal cards and select 2 cards [passes out packets of colorful photographic cards showing various animals] … you pick one and your partner will pick one and then you're going to compare them.

Rhianna: Telling what are the same.

Wendel: Telling how they are the same and …

Rhianna: How they are different.

This example demonstrated how Mrs. Wendel taught the word *compare* from a conceptual knowledge approach. First, she showed the written word and queried students regarding their understanding of the word before providing a written definition of the word and later posting it on the classroom wall. Next, she asked students to compare and contrast familiar fruits and family members. Additionally, Mrs. Wendel used the word several times during the same conversation; she engaged students in a hands-on visual literacy activity, required them to work in collaborative pairs, and allowed each to self-select an animal card and discuss the similarities and differences between the two animals. According to Biemiller & Boote (2006), students can successfully acquire conceptual vocabulary through repeated exposure in meaningful and engaging contexts.

Do-It and Talk-It

Wigfield, Guthrie, Perencevich, Taboada, Klauda, McRae, & Barbosa (2008) argued that many students do not learn in meaningful ways with text-only experience or hands-on-only experience; therefore, one ideal entryway to meet different needs is to use a combined approach. This collective method combines text experience with hands-on experience. Text experience provides a meaningful context for literacy opportunities, while hands-on experience prompts students to evoke all of their senses for richer learning. Palincsar and Magnusson (2001) indicated that research on ways teachers implement this combined approach is limited, and some (Guthrie, Wigfield, Humenick, Perencevich, Taboada, & Barbosa, 2006) clearly stated that more attention must focus on the use of stimulating tasks that can arouse student's curiosity prior to or during instruction.

Observation is an essential component during the teaching of science, as many teachers believe that teaching students how to observe using their senses can serve as a springboard to deeper learning. In this unit, observations functioned as the *do-it* part of the investigation. This occurred when Mrs. Wendel provided a visual literacy experience using photographic images of animals for students to examine and discuss. Advocates believe that implementing stimulating tasks before and during reading and having students discuss their observations can motivate them to become active participants in learning events (Guthrie, McRae, & Klauda, 2007). The next segment shows teacher guided instruction as students worked in collaborative pairs to compare and contrast their selected animal cards, and communicate their observations using descriptive language.

Wendel: You and a partner are going to carefully observe some animal pictures. When scientists observe living things, they use their five senses. What are the five senses?

Rhianna: Sight, taste, touch, smell, and hearing.

Wendel: Scientists use their sense of sight to observe how living things move and how they look … not only on the outside, but on the inside as well. They use their sense of taste to sample different flavors in food … to taste if something is sweet or sour. They use their sense of touch to examine the texture of rocks. They use their sense of smell to judge whether something has a pleasant odor or not. They use their sense of hearing to listen to chirps and whistles of birds. You're going to use your sense of sight to observe similarities and differences of animals using picture cards. Each partner will pick one card and then tell how the animals are alike and different. Remember to use descriptive words.

[Pairs of students sorted through several decks of cards before choosing two. Students spent five minutes talking about the card they selected.]

Wendel: When you are comparing them … remember the sentence we used earlier … I observed this animal has the characteristic of … [teacher points to chart paper showing an example, I observed this animal has the characteristic of bright, green skin]. So I went from … I observed the falcon has the characteristic of feet, to I observed the falcon has the characteristic of yellow feet with long toes and sharp claws on the end. I want you to use descriptive words in your sentences.

[Lots of students' talk as they examined animal cards and worked with partners and teacher.]

Wendel: Do I have any pairs willing to share? You can tell us two ways they're alike and two ways they are not alike. Tell us two similarities and two differences.

[Lots of raised hands wanting to share.]

Wendel: Let's have Kay and Libby. Can you show everybody your cards and stand up.

Kay: The bird has feathers so it's soft.

Libby: The alligator has rough, scaly skin.

Wendel: Rough, scaly skin and soft feathers.

Libby: And they're different sizes, and colors.

Wendel: Danny and Rhianna … what did you observe?

Danny: We observed this one (*inaudible*) has rough skin and the turtle has a shell. The alligator has long, sharp teeth and the turtle don't … and they both got cells.

Wendel: Yes … so you took that from the book … all living things have cells. We cannot observe this by looking at the pictures, but we know all living things have cells.

Earl: We thought that the frog has smooth skin and the kangaroo has soft skin with fur, and the frog has *inaudible* and the kangaroo does not … the kangaroo has a pouch for its baby and the frog does not and they both have four limbs.

Wendel: Okay … good observations scientists.

As seen in this dialogue, students observed picture cards of animals, and noted distinct and unique aspects, then used descriptive words to share features common and different to both animals. Students also incorporated their background knowledge as part of their observations to make inferences. For example, Kay noted the bird's feathers are soft; while Earl stated the kangaroo has a pouch for its baby (a joey was not featured in the photograph).

Do-It, Talk-It, and Write-It in Combination

Sorting pictorial images, comparing them, and communicating these observations can be seen as knowledge construction processes. In the above example, sorting the photographs provided a stimulating task; while comparing required students to use their sense of sight and background knowledge to gather evidence from the pictures in order to make inferences. The following scenario shares one way Mrs. Wendel promoted observation and communication skills during her lesson.

Wendel: I'm going to show some videos … after you've watched each video clip, I want you to write a complete sentence on how that animal uses its limbs to move. We're going to observe first, talk about our observations, write it, then share [turns on video showing hummingbirds in flight.]

Wendel: Alright, do we know what we're looking for with the hummingbirds?

Malcom: Yes … at their limbs.

Wendel: We're looking at what type of limbs they have and how they use them to move …

[Students' talk and low laughter as they watched.]

Wendel: How are their limbs moving? Are they going fast or slow? Are they going in a circular motion? Are they going in an up and down motion? Raise your hand if you'd like to share an observation before we write about hummingbirds. Shane, what did you observe?

Shane: They fly in an up and down motion.

Wendel: Shane made the observation that when a hummingbird flies, its wings move up and down very fast. Stan, did you observe something else?

Stan: Yes, it uses its wings to go places … like move from flower to flower.

Wendel: They use their limbs to move from place to place. So what we can write about hummingbirds … hummingbirds move their limbs or wings …

Malcom: Fast.

Wendel: Fast … and what kind of motion?

Malcom: Circles.

Wendel: In a circular motion … and were they flapping like this [teacher uses lots of gestures throughout the lesson.]

Stan: Like this [uses hands make very rapid up and down motion] up and down and like this to move back …

Wendel: Okay … so up and down and back and forth motion. Stan … you said something interesting … you said they use their wings to take them from flower to flower and from place to place … but also … look right now … what are their wings helping them do?

Stan: Stay still.

Wendel: Stay in the same place. So I'm just wondering because I don't know a lot about hummingbirds … so I wonder how its different when they flap … do they move when they're flapping … sometimes they move when they're flapping and sometimes that flapping keeps them in the same place. So, what are you going to write?

Stan: Hummingbirds use their wings to control how they move and where they want to go.

Throughout the discourse, the teacher prompted students to respond and provide further explanations through questioning. Developing explanations, supporting claims with evidence, and questioning are key aspects of scientific dialogue. Students learned that although the four-limbed animals look different, they are all related; they share common characteristics; they are similar and dif-

Table 1

The multimodal instructional approach of: Read-it, Do-it, Talk-it, Write-it

Domain	Lesson Focus	Teaching Strategy	Goal
Read-it	Previewing	Identifying text features and text structures	To enable understanding of topic specific ideas and increase recall of material
	Questioning	Asking and answering text explicit and implicit wonderings	To promote deeper levels of thinking
	Predicting	Generating expectations of upcoming text	To develop hypotheses and later test these to confirm or reject
	Clarifying	Monitoring thinking of text ideas and vocabulary	To create awareness of words and ideas
Do-it	Observing	Utilizing any of the 5 senses (sight, taste, touch, smell, hearing) to explore and probe	To help evoke all of the senses for richer learning
	Collaborating	Working together to further learning	To promote cognitive development and team work
Talk-it	Explicit & Implicit Questions	Using interrogative to request further information	To query about ideas in the text or ideas not in text
	Co-constructions of ideas	Sharing and collaboratively building on ideas	To enhance responses of others
	Connections	Making connections to self, texts, and larger world	To link prior knowledge to self, other texts, and aspects in the world
	Coordinating positions with evidence	Using evidence to support claim	To make a statement and support it with evidence from text or prior knowledge
	Clarification	Questioning for clarification	To query in order to clarify questions or responses
Write-it	Observation notes	Writing to note details and remember information	To represent learning
	Interpreting and transforming information	Writing to answer questions	To share understanding
	Illustrating	Drawing to represent an idea or concept	To recall information

ferent in some ways; and they all use their limbs to move in different ways.

Discussion

Cross-curricular integration is a powerful practice for students to learn scientific content while developing their literacy abilities. This instructional format holds potential for meeting the needs of teachers, students, as well as district, state, and national standards for subjects often placed on the back burner. The lesson discussed here was part of a science unit on variation and relatedness in living organisms. Table 1 lists the various types of literacy teaching strategies Mrs. Wendel embedded for each multimodal domain: read-it, do-it, talk-it, and write-it.

Interactive read-alouds of science trade books, such as *Blue Whales and Buttercups* can enrich students' learning through accurate accounts of the natural world, introduce them to new and expanded content specific words and ideas, clarify confusing information, and increase their curiosity to want to learn more (Duke & Pearson, 2002). This text type can broaden scientific knowledge as it plays an important role in building students' understanding of the natural world.

A closer look at the data showed questioning was the most frequently utilized cognitive process during the lesson. Questioning as a comprehension strategy allows teachers and students to ask, clarify, predict, and obtain information about aspects they want to learn more about (Hapgood & Palincsar, 2007). It was interesting to see the large number of questions generated by the teacher and students. One possibility for this might be high interest of the texts (book, animal cards, and video clips) being discussed and explored. Mrs. Wendel and her students used questioning to increase and monitor understanding by integrating text explicit information with prior knowledge through text-based and knowledge-based questions and wonderings. Mrs. Wendel posed text explicit questions to enable students to recall basic surface level material. The inferential questions prompted students to stretch their thinking beyond the texts to make inferences and interpretations, and also to pose additional related questions.

Observation is the cornerstone of any inquiry process and can serve as a stimulating activity to entice scientific learning. The students in this project examined an assortment of animal cards and video clips, discussed their thoughts with a partner, gathered evidence based on their sense of sight and background knowledge, organized their ideas, and communicated this with others.

Verbal and written communication has enormous value to any social learning community. Talk allows teachers to scaffold and build students' comprehension in areas such as recall of factual ideas and details, questioning text and one another, making connections, providing explanations, and identifying similarities and differences (Rivard & Straw, 2000). Throughout the lesson, Mrs. Wendel engaged students in social discourse to promote the knowledge construction process, especially in the area of making connections. Transcriptions and field notes revealed that students made numerous connections about the topic. A possible reason for this can be attributed to the teacher's belief that students needed more experience on drawing connections by relating their own knowledge to that of the text, picture cards, and video clips. Written communication is significant and can serve as a permanent record of the learning process. Writing is used to communicate information, but more importantly, it is a power tool for thinking (Yore, 2004). Writing builds and supports social learning communities and allows collaborative sharing of ideas. On several occasions during the lesson, Mrs. Wendel asked students to provide written responses to questions, and this process can probe for deeper levels of understanding.

Conclusion

Data from this portion of the project suggested that cross-curricular instruction can take on a multimodal approach (do-it, talk-it, read-it, write-it, or in any combination) which has significant pedagogical implications for self-contained elementary classroom teachers. The literacy-science teaching practices Mrs. Wendel utilized to engage her students in studying variation and relatedness in living organisms, highlight the close relationship between literacy and science. As indicated, there are several benefits to teaching literacy and science in an integrated format. First, Mrs. Wendel was able to effectively manage the instructional minutes of both domains. Second, this approach met requirements for district, state, and national mandates. Additionally, the stimulating tasks embedded within the lesson heightened students' curiosity; while the learning context enhanced students' motivation and advanced their knowledge. Further, the selected teaching strategies engaged students in higher level cognitive processes used by scientists. These meaning making strategies included: previewing, questioning, predicting, clarifying, observing, discussing, and scientific journal writing. Thus, literacy does not have to be the foe; instead it can be a friend on the curricular stage.

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Vanessa B. Morrison, PhD, teaches literacy courses at Adrian College, Adrian, Michigan. For questions or comments, please contact her at vmorrison@adrian.edu.

Andrea R. Milner, PhD, teaches science methods classes and is the Director of the Institute for Education at Adrian College, Adrian, Michigan.