THE ROLES OF PHOTOGRAPHY FOR DEVELOPING LITERACY ACROSS THE DISCIPLINES

Marva Cappello ▪ Karen E. Lafferty

"I took a lot of pictures and wrote a lot. I loved taking pictures.... It was sort of hard but still easy. I would want to do this again. I loved to use the camera and I don't really like writing. But I liked writing [these] stories."
—Brenda (all names are pseudonyms)

Children know that a pictogram of a man or woman indicates a restroom before they can read the words *men* or *women*. They easily manipulate icons on touch screens, interpreting their meaning often before they can explain it in words. We live in a visual world yet don't always recognize the role images can play in engaging and supporting our students. Brenda's comment is a fourth grader's enthusiastic reaction to a standards-based geology curriculum that used photography alongside traditional teaching strategies. In her classroom, photography supported science and literacy learning for acquiring knowledge and demonstrating understanding of new concepts—that is, for both receptive and productive purposes.

We wanted to explore photography's role in science and disciplinary literacy teaching because we believed it had the potential, especially in inquiry-based learning, to "enhance what is possible by amplifying what teachers are able to do...[and] by extending what students are able to produce as a result of their investigations" (Schiller & Tillett, 2004, p. 401). Because students are comfortable making photographs using both disposable and inexpensive digital cameras and camera phones, photography was a natural way to integrate visuals for teaching and learning. We intentionally chose to look at how photographs could help students construct multimodal

Marva Cappello is an associate professor at San Diego State University, California, USA; e-mail cappello@mail.sdsu.edu.

Karen E. Lafferty is a doctoral candidate at San Diego State University; e-mail karenlafferty@gmail.com.

projects—texts that incorporate a variety of communication systems—because familiarity with photography allows for a range of potential in designing an enhanced curriculum (Albers, 2006). We also chose photography because Marva (first author) brought to this research a background that includes a Bachelor of Fine Arts degree in photography and work in the field as a camera assistant, photo-librarian, and photographic fine art collection consultant, which enabled her to model an appreciation of image making for the classroom teacher and student participants.

We hoped photography would offer an additional pathway for literacy development through multimodalities, an important consideration for the many English learners in Southern California, where we work. As teachers implement the Common Core State Standards (CCSS), we believe purposeful use of visuals may help students approach complex texts and prepare them for evidence-centered assessment tasks (Stahl & Schweid, 2013). This idea is supported by David Coleman, one of the key authors of the CCSS, who reminds us that, like reading, "the arts reward sustained inquiry and provide a perfect opportunity for students to practice the discipline of close observation" (Coleman, 2012, p. 1). Photographic images may be particularly useful for supporting English and academic vocabulary development in content areas like science, where students may come prepared with less prior knowledge.

Pause and Ponder

1. How does the use of photography support the problem-solving and inquiry-based approach advocated by the Common Core State Standards?
2. How might writing support transfer of disciplinary literacy in the Visual Thinking Strategy from oral to written language?
3. What types of visuals and nonlinguistic representations might you include as scaffolds for English learners across the disciplines?

Visuals and Thinking

As Serafini (2012) argues, expanding definitions of literacy to include multimodal texts acknowledges the role of navigating, interpreting, interrogating, and designing texts. Visuals in the classroom can be used for receptive purposes, as scaffolds that help students comprehend complex information and support students' understanding. Researchers suggest visuals help students retain information (Gangwer, 2005) and support vocabulary learning (Jones, 2010). Visuals can also be used in a productive mode, providing an alternate language for students new to school or English or who need additional support in communicating their ideas. Constructing responses through photography may allow students new or alternate ways to communicate their understandings, improving learning outcomes by creating varied opportunities for assessment. Indeed, multimodal experiences create environments where "our language abilities do not define the limits of our cognition" (Eisner, 2002, p. 12).

Photography in Support of Disciplinary Literacy

We chose science to explore the potential of photography because the subject lends itself to visuals such as graphs, charts, equations, and animations (Lemke, 1998). Previous researchers have used photography to examine children's perceptions of science (Katz, 2011), as an instructional tool (Hoisington, 2002), and to support science vocabulary development for

"Schools can capitalize on the visual nature of contemporary society for learning and teaching."

English learners (Jones, 2010). In exploring how Internet photo books might support children seeing themselves as science learners, Katz (2011) described how photography facilitated conversations about science. Hoisington (2002) photographed her preschool students participating in science investigations, with the photographs resurfacing as an instructional tool for reviewing science concepts. Using his own photographs to introduce animal adaptation, Jones (2010) further described how photographs became tools for both formative and summative assessment for English learners through activities like card sorts. Our research builds on these prior constructions by suggesting how teacher- and student-created photographs might be integrated alongside a range of available images in the elementary school classroom to enhance development of students' academic vocabulary and metacognition, or thinking about their thinking. Our purpose was to explore students' perceptions about photography as an instructional tool and explore how photography played multiple roles in students' learning processes, especially in helping students acquire disciplinary literacy and express their understanding within the science curriculum.

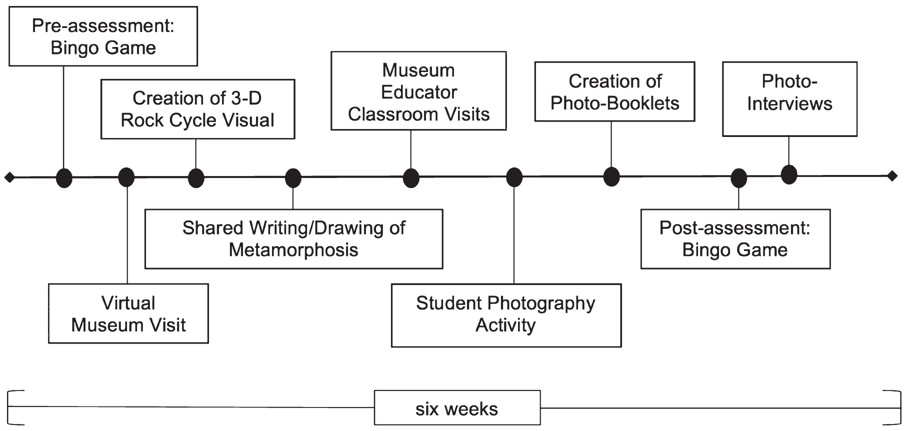
The Classroom Context

We focused on one class of 23 fourth-grade students and their teacher at a Southern California public elementary school. The classroom teacher, a graduate of our university–district partnership credentialing program, worked with visuals throughout her preparation program and during her first years teaching. She was hired at the school where she did her student teaching and was encouraged to try a range of methods to support her students. Even before we began our collaboration, the teacher filled her classroom wall with images created by students, images she purchased, and images she created herself. She didn't need convincing to integrate visuals into her curriculum, and she welcomed us into her classroom.

Integrating Visuals in the Science Curriculum

The standards-based fourth-grade science curriculum was an intentional and important element. Because the Next Generation Science Standards (NGSS) were still in draft form, we used the Science Content Standards for California Public Schools (California State Board of Education, 2000), paying attention to how the literacy standards from the CCSS, which are embedded in the NGSS, could be addressed in the earth science/geology unit (NGSS Lead States, 2013). The geology unit allowed the teacher and researchers to plan for teaching opportunities where photographs, graphics, and other visuals could provide academic language support beyond the use of textbook images. At the research site school, the traditional science curriculum depended on the textbook as the primary resource. However, students did engage in drawing diagrams of the rock cycle, and they referenced graphic organizers in charts hung around the classroom. We enlarged the traditional curriculum to integrate visuals—often photographs—beyond the simple use of textbook images and classroom charts. The fourth graders had continuous exposure to visual-based instruction throughout the six-week unit. Students engaged with photography for receptive and productive language purposes, creating varied pathways for learning the geology concepts and expressing their understandings. A timeline indicating the visual-based activities within the unit is provided in Figure 1. Throughout the unit, students negotiated a large number of visual texts and had continuous exposure to visual-based instruction, beginning with a pictorial bingo game as a preassessment. After a virtual museum visit, students collaborated on visual illustrations of the rock cycle and created diagrams depicting the process of metamorphosis. Instruction also emphasized multidisciplinary knowledge, including the acquisition of new science concepts alongside academic vocabulary and other disciplinary literacy skills such as making observations and identifying evidence from patterns (NGSS Lead States, 2013). In the next section, we highlight two components of the unit where visuals amplified student learning (Schiller & Tillett, 2004). We chose these activities because one illustrates the use of photography in the classroom for receptive or interpretive purposes and the other demonstrates image making for productive or communicative purposes.

Figure 1 Timeline of Unit Activities and Assessments



Receptive Purposes: Visual Thinking Strategy

We chose the Visual Thinking Strategy (VTS) as one powerful tool for integrating photography with student learning. VTS is a method for analyzing visual texts that we believed would support learning complex concepts across the curriculum. As a tool for interpretation, VTS serves receptive purposes in the classroom. VTS-based lessons follow a specific sequence designed to provide time "to think, to contribute observations and ideas, to listen, and to build understandings together" (Housen & Yenawine, 2005, n.p.). Developed for use in museums, this questioning strategy helps students talk about, interact with, and ultimately understand images. The prompts are sequenced to support this process: *What is going on in this picture? What do you see that makes you say that? What else is there to see?*

Learners create knowledge as they build from and upon their personal and social backgrounds. During a VTS lesson, "many aspects of cognition are called upon, such as personal association, questioning, speculating, analyzing, fact-finding, and

"Photography supported science and literacy learning for acquiring knowledge and demonstrating understanding of new concepts…for both receptive and productive purposes."

categorizing" (Yenawine, 1997, p. 845). The questioning sequence aligns with the CCSS, which focus on critical thinking and problem solving, and the NGSS, with their emphasis on inquiry-based learning. By design, VTS requires students to interpret (*What is going on?*) and draw conclusions based on evidence (*What do you see that makes you say that?*), mimicking the processes readers engage in when negotiating traditional texts.

We knew VTS could be easily integrated by the classroom teacher and would frame how students interacted with the still-novel experience of reading images. This strategy promotes visual thinking in ways that could be called upon in a range of contexts throughout the geology curriculum. Indeed, VTS lessons launched the earth science unit and later introduced new concepts. On the first day of the geology unit, students in the research classroom were joined by all of the school's fourth-grade classes for a virtual field trip. From the school's auditorium, we participated in a virtual VTS lesson with a museum educator from the local Natural History Museum. The museum educator led three VTS lessons where all students participated and responded to questions about fossils from the museum's collection. Twice during the unit, educators from local museums visited the research classroom to conduct follow-up VTS lessons with museum artifacts.

A museum educator from the Museum of Photographic Arts introduced slides of fine art photographs that illustrated many geological principles, including erosion, weathering, and sedimentary rocks, and continued use of the VTS lessons. In *Guiding Principles for the Arts, Grades K–12*, Coleman (2012) advocates for the use of the arts to meet the new and complex cognitive demands students will face in our (literacy) classrooms: "The arts reward sustained inquiry and provide the perfect opportunity for students to practice the discipline of close observation… . In both the arts and reading, such attention to the specifics can be hard, particularly when the work is complex" (p. 1). We explored VTS as a support for receptive purposes supporting this type of close analysis and then turned to photography as a means for students to express their understandings through the production of the mineral photo booklets.

Productive Purposes: Student-Made Images and the Mineral Photo Booklets

When given access to cameras, students discovered another language to convey their ideas (Walker, 1993). Specifically, using the cameras provided another way for students to express important understandings about geology and scientific thinking, one less tied to conventional school language. We thought this might be especially helpful for students struggling with limited language development. We asked students to take photographs near the end of the unit so we could also use the images to monitor their progress toward the curricular objectives.

Before we shared cameras with students, they read information from the assigned science textbook and engaged with traditional curriculum and instruction, including the shared writing of a semantic web (as shown in Figure 2), "What Do We Make With Minerals?" Following these activities, the students used disposable cameras to capture images that expressed their new geology knowledge, photographing both inside their classroom and outside it, on and around the school site (see Figure 3). Specifically, students looked for and documented images that answered the same question: What do we make with minerals? An example of one student's response can be seen in Figure 4. Students later used their images to create mineral photo booklets that included both text and visuals illustrating minerals and their use in our everyday world. These multimodal compositions included captioned photographs of their own creation, along

Figure 2 Student-Generated Ideas About Minerals on a Semantic Map

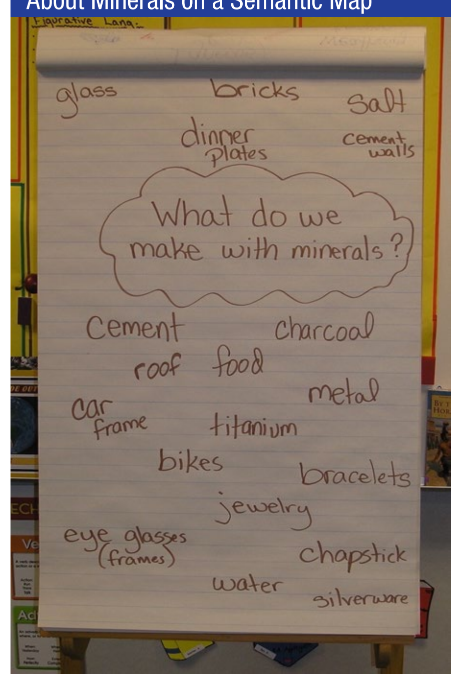


Figure 3 Students Taking Photographs

Figure 4 Melanie's Photograph of Minerals

with written justification for the inclusion of the image. Like Britsch (2010), we believed the photo booklets would also help students see their own work as important. In addition, these books helped the students, teacher, and researchers reflect on students' progress toward the learning objectives.

Enhancing Teaching and Learning

VTS and student-made images created several opportunities for photography to enhance teaching and learning. As visuals were integrated into teaching methods, students used the academic vocabulary necessary to communicate their new science thinking around geology. Using images also aided in metacognition, or reflection about their thinking, as students reflected on the novel ways of learning offered throughout the unit. Finally, students were comfortable taking risks to express themselves through their images even when they were less confident about the curricular content.

Academic Vocabulary

The VTS lessons provided scaffolds for supporting students' oral use of academic language in science. The VTS questioning sequence (italicized in the following transcript) was effective for helping students provide evidence for their ideas and use the relevant vocabulary necessary to demonstrate understanding of geology concepts.

Teacher	*What is going on in this picture?*
Damon	I see sedimentary rock in the cliff.
Teacher	*What do you see that makes you say that?*
Damon	I can see the layers of rock all pushed down on each other.
Teacher	So, you think it's sedimentary rock because of the way the layers of rock are all pushing together? *What more is there to see in this picture?*

Careful review of images (both photographic and illustrated) through the VTS process provided opportunities for students to use essential vocabulary such as *rock cycle* and *transformation* in their visual-based classroom discussions. They also described specific minerals and elements such as iron pyrite, steel, iron, chrome, and aluminum. In their oral responses, students increased their use of vocabulary such as *crust*, *mantle*, *luster*, and *erosion*, which Beck, McKeown, and Kucan (2002) define as Tier Two words, or high-frequency and multiple-meaning words that occur across a variety of curricular domains. The fourth graders also used Tier Three words (Beck et al., 2002), or low-frequency discipline-specific vocabulary such as *magma* and *igneous*, in the oral questioning sequence.

Metacognition

Metacognition, or as Flavell (1979) defines it, the monitoring of one's own "memory, comprehension, and other cognitive enterprises" (p. 906), was demonstrated by focus students during photo-interviews and allowed us to better understand their perceptions of photography as a tool in their science curriculum. Informal interviews were conducted using a photo-interview kit (Cappello, 2005; Cappello & Hollingsworth, 2008) and were treated as conversations (Kvale & Brinkmann, 2009). The photo-interview kits contained student- and researcher-made photographs as well as scientific artifacts such as fossils that guided our discussion and provided us a way to organize our data. (See Appendix A for more details on data collection and analysis.)

Questions about the photo activity during the interview conversations inspired student reflection on their learning. The prompt "Tell me why you took these pictures" encouraged students to explain the reasoning behind their choices. This metacognitive thinking is key for students to self-regulate learning (Flavell, 1977). Some students explained how photographs supported learning new ideas and how they could use photographs to represent their understandings of geology. Interview responses showed that students recognized that the visuals (photographs, illustrated charts, and artifacts) helped them retain information and make connections. Amber talked about visuals as classroom resources: “I think they [the photographs] help me because when a chart is already done, I just look at it and I start at *brick* and go, what is a brick made of.” In addition, students were able to articulate how the images, even those in the pre- and postassessment bingo game shown in Figure 5, served as scaffolds for understanding. “When you showed us the photos in the bingo game, that was important because you could *see* [emphasis added] what the pictures are and you would guess if you got it right because you understand it,” Thomas said. In this way, the images supported the receptive mode of literacy learning. Amber, an English learner, put it simply: “Looking at [the photos] helps me better.”

Students also recognized how the act of creating images affected their learning. Theresa explained, “It was educational because you would have to think about the thing you’re going to take a picture of.” Michael added that taking photographs “was helpful because when I started I wasn’t really good at rocks and minerals, but now I started learning more about rocks and minerals.” Writing samples expressed students’ surprise at how much they knew when asked to demonstrate their earth science knowledge through the camera lens:

Amber	I thought it was going to be hard but it wasn’t that hard. I liked to take one picture of a lot of things made out of minerals.
Thomas	It was very easy to find things made out of minerals.

Experiences with cameras enhanced student learning and reflection as the visuals and visual process helped students to see what they knew.

Risk Taking

In our classroom context, we defined *risk taking* as students’ willingness to engage with a novel instructional tool (the cameras) or take chances when not entirely certain they had correct answers, an important element for inquiry-based learning in both the NGSS and CCSS. Many students commented how they were comfortable using their camera to photograph minerals and demonstrate their learning. Most students had used similar cameras before and needed little instruction or technical support. The students also appeared to enjoy using the cameras and were excited to learn outside the confines of their classroom. As an innovative classroom tool, the cameras and photographic processes had fewer school-like expectations established.

“We believed [Visual Thinking Strategies] would support learning complex concepts across the curriculum.”

Some students took risks in photographing objects even if unsure they met the requirements of the assignment—to find and photograph objects made from minerals. The following journal entries illustrate students’ risk taking.

Sylvia	I took a picture of paint and I was not very sure it…[had] minerals in it.
Jackie	What I took a picture of was Miss G’s big camera. It was metal and man-made. She said nobody took a picture of her camera. I really didn’t know that was a mineral and that was what I learned.
Melanie	I took a picture of the roof because it was a metal but I wasn’t really sure [see Figure 4].

The camera provided a safe place for risk taking. The seemingly contradictory aspects of novelty (new for school) and familiarity (used outside of school) created a setting to support engagement. As Alice wrote, “I choose to take pictures of thing[s] that were unique.” Eddie admitted to taking three “accident” pictures as well as 27 other photos. In addition, photographic school norms have not been as widely established as writing norms, so students were not limited by expectations beyond the focus of the assignment (Shanahan, 2013). Photography may also provide less proficient language users a

Figure 5 Thomas’s Bingo Assessment

Form C 14/16 good!

igneous rock 4	weathering 5	mineral 10	mantle 9
erosion 16	rock cycle 8	sedimentary rock 2	luster 7
streak 11	core 14	magma 13	crust 1
renewable resource 15	metamorphic rock 12	cleavage 3	Moh’s scale 6

way to safely express their ideas without the fear of failing or measuring up to their peers. Indeed, most of the students quoted in this section are English learners. For these students, producing images provided a way for them to demonstrate and for educators to understand their science knowledge in a way less restricted by language skills.

What We Learned About the Roles of Photography

The words and images generated from these visual-based lessons helped make photography a legitimate tool for teaching and learning in this fourth-grade classroom. Photographs supported science and literacy learning, provided an alternate way for students to express knowledge, and helped the teacher determine whether students understood academic content. For example, in the preassessment bingo game (see Figure 5), 9 of the 23 students in the class could identify minerals, whereas in the postassessment, all students could identify them. Images became tools that helped students acquire and use content knowledge and academic vocabulary. The visual-based classroom offered curricular support through multiple modalities, allowing alternate pathways to access the earth science concepts and express understanding. This finding aligns with others' observations about how visual literacy expands the range of expression for students (Eisner, 2002; Serafini, 2012).

Our students are familiar with photography and typically have had wide access through inexpensive digital and disposable cameras as well as cell phone cameras. Here, the use of photography allowed students greater participation in the inquiry process, broadening avenues for learning (Schiller & Tillett, 2004). In addition, the nature of photography makes complex concepts more explicit. Students thought it was "easier" to learn with images, which we believe reflects Sinatra's (1986) assertion that visual literacy lays the foundation for reading and writing. Amber explained,

> I think when Mr. F [the Museum of Photographic Arts educator] came and taking the pictures was easier. Even though the book has a lot of descriptions and things that talk about, describe, rocks and minerals, I think it was easier because they [the pictures] described it better and even if it took more time to learn about it, it was easier.

Students' photographs also became a way to demonstrate new science knowledge. In what appeared to be the most engaging activity of the unit, photographing human-made objects containing minerals, students' images expressed geology knowledge in a way not limited by language skills or traditional school expectations for literacy. Students solved problems and took risks, validating visual literacy in a way less common in formal schooling (Shanahan, 2013). Integration of photography into the earth science curriculum fostered students' development of academic vocabulary, awareness of new learning, and risk-taking behaviors. We believe this is because, as Marzano, Pickering, and Pollock (2001) explain, visual images "have a positive effect on student achievement and provide diversity in the way that students process new information" (p. 86).

Recommendations for Instruction and Future Research

Our findings suggest several ways teachers might capitalize on contemporary society's ever-increasing visual emphasis by incorporating photography and other images into their instructional practice. Specifically, we advocate for integrating carefully chosen visuals when teaching complex concepts to help students engage in close observation and sustained inquiry (Coleman, 2012). We recommend using VTS for the development of students' oral vocabulary. However, we also encourage teachers to complement this activity with strategies such as shared or interactive writing that might help students transfer academic vocabulary from oral language into their independent writing. In our observations, while most students used the word *mineral* in their written texts, few other significant geology terms transferred from their oral use in photo-interviews and classroom discussions to students' written products. In addition, more emphasis should be placed on moving beyond the focus on academic vocabulary to include the forms of discourse needed to communicate in the discipline (Zwiers, 2007).

While our work, like that of Britsch (2010) and Jones (2010), suggests the English learners in the classroom benefited from visual scaffolds and activities, further studies are needed to explore the relationship between a visual-based curriculum and language development. Studies such as those conducted by Byrnes and Wasik (2009) provide a good framework to build upon. Teachers and researchers should consider how visual texts might serve to better represent content learning for English learners (Jones, 2010; Marzano et al., 2001).

"Using the cameras provided another way for students to express important understandings about geology and scientific thinking, one less tied to conventional school language."

Finally, photography offers an engaging method for gathering and reporting data from inquiry-based activities in science (NGSS Lead States, 2013). For example, in a life science unit, students could plan and conduct an investigation to examine plants' need for sunlight and water to grow. Students might sprout seeds under different conditions, controlling for one variable at a time (sunlight or water), then photograph each plant next to a ruler to record its growth. Other inquiry-based activities that lend themselves to photographic methods include the recording and sharing of local weather conditions to describe patterns over time and making observations and/or measurements to provide evidence of the effects of erosion by water, ice, wind, or vegetation.

We encourage teachers across grade levels and content areas to find meaningful ways to integrate the use of visuals for receptive and productive purposes throughout their curriculum. By recognizing the shift from purely printed texts to multimodal texts combining images and sounds with words, schools can capitalize on the visual nature of contemporary society for learning and teaching. We hope our findings on using photography to enhance academic language, metacognition, and risk-taking behaviors will inspire other teaching innovations that may promote greater equity and access to the curriculum for all students.

TAKE ACTION!

We believe there are advantages to using your own student and teacher-created images in your classroom. However, with the wide range of subjects across the curriculum, that is not always feasible. The resources listed here provide images with no known copyright restrictions.

- **Getty Museum:** There are many ways to search the Getty's digitized collection (www.getty.edu/art/collection/): by object type, medium, topic, theme, or keyword. You can also explore the 3,325 artworks curated for the Google Art Project.
- **Library of Congress:** The Library of Congress has an online catalog of prints and photographs (www.loc.gov/pictures/). It has a keyword search and collections organized by topics that might be useful to teachers planning units.
- **Creative Commons:** "Creative Commons develops, supports, and stewards legal and technical infrastructure that maximizes digital creativity, sharing, and innovation." This site (creativecommons.org) is a gateway to approved images hosted on other webpages such as Google and Flickr.
- **Metropolitan Museum of Art:** The Met has released more than 400,000 high-resolution images of its collection to the public (www.metmuseum.org/collection/the-collection-online). The collection can be searched by artist, medium, or even era.
- **Balboa Park Online Commons:** This resource was created "in support of the educational and charitable missions of the participating Museums and Cultural Institutions." The Balboa Park Online Commons (www.balboaparkcommons.org) allows access to the collections of seven cultural institutions within this San Diego oasis. There are a variety of filters to help teachers search for and create sets of images that can be bookmarked and shared.

REFERENCES

Albers, P. (2006). Imagining the possibilities in multimodal curriculum design. *English Education*, *38*(2), 75–101.

Beck, I.L., McKeown, M.G., & Kucan, L. (2002). *Bringing words to life: Robust vocabulary instruction*. New York, NY: Guilford.

Britsch, S. (2010). Photo-booklets for English language learning: Incorporating visual communication into early childhood teacher preparation. *Early Childhood Education Journal*, *38*(3), 171–177.

Byrnes, J., & Wasik, B.A. (2009). Picture this: Using photography as a learning tool in early childhood classrooms. *Childhood Education*, *85*(4), 243–248.

California State Board of Education. (2000). *Science content standards for California public schools: Kindergarten through grade twelve*. Sacramento, CA: California Department of Education. Retrieved from www.cde.ca.gov/be/st/ss/documents/sciencestnd.pdf

Cappello, M. (2005). Supporting independent writing: A continuum of writing instruction. *California Reader*, *39*(2), 38–46.

Cappello, M., & Hollingsworth, S. (2008). Literacy inquiry and pedagogy through a photographic lens. *Language Arts*, *85*(6), 442–449.

Coleman, D. (2012). *Guiding principles for the arts, grades K–12*. Retrieved from usny.nysed.gov/rttt/docs/guidingprinciples-arts.pdf

Eisner, E.W. (2002). What can education learn from the arts about the practice of education? *Journal of Curriculum and Supervision*, *18*(1), 4–16.

Flavell, J.H. (1977). *Cognitive development*. Englewood Cliffs, NJ: Prentice-Hall.

Flavell, J.H. (1979). Metacognition and cognitive monitoring: A new area of cognitive-developmental inquiry. *American Psychologist*, *34*(10), 906–911.

Gangwer, T. (2005). *Visual impact, visual teaching: Using images to strengthen learning*. Thousand Oaks, CA: Corwin.

Hoisington, C. (2002). Using photographs to support children's science inquiry. *Young Children*, *57*(5), 26–30, 32.

Housen, A., & Yenawine, P. (2005). *Basic VTS at a glance*. Retrieved from cis.uchicago.edu/outreach/summerinstitute/2011/documents/3-sti2011-basic_vts_at_a_glance.pdf

Jones, A.D. (2010). Science via photography. *Science and Children*, *47*(5), 26–30.

Katz, P. (2011). A case study of the use of Internet photo book technology to enhance early childhood "scientist" identity. *Journal of Science Education and Technology*, *20*(5), 525–536.

Kvale, S., & Brinkmann, S. (2009). *InterViews: Learning the craft of qualitative research interviewing* (2nd ed.). Thousand Oaks, CA: Sage.

Lemke, J.L. (1998). Multiplying meaning: Visual and verbal semiotics in scientific text. In J.R. Martin & R. Veel (Eds.), *Reading science: Critical and functional perspectives on discourses of science* (pp. 87–113). London, UK: Routledge.

Marzano, R.J., Pickering, D.J., & Pollock, J.E. (2001). *Classroom instruction that works: Research-based strategies for increasing student achievement*. Alexandria, VA: Association for Supervision and Curriculum Development.

NGSS Lead States. (2013). *Next generation science standards: For states, by states*. Washington, DC: National Academies Press.

Schiller, J., & Tillett, B. (2004). Using digital images with young children: Challenges of integration. *Early Child Development and Care*, *174*(4), 401–414.

Serafini, F. (2012). Expanding the four resources model: Reading visual and multi-modal texts. *Pedagogies*, *7*(2), 150–164.

Shanahan, L.E. (2013). Multimodal representations: A fifth-grade teacher influences students' design and production. *Pedagogies*, *8*(2), 85–102.

Sinatra, R. (1986). *Visual literacy connections to thinking, reading and writing*. Springfield, IL: Charles C. Thomas.

Stahl, K.A.D., & Schweid, J. (2013). Beyond March madness: Fruitful practices to prepare for high-stakes ELA tests. *The Reading Teacher, 67*(2), 121–125.
Stake, R. (1995). *The art of case study research*. Thousand Oaks, CA: Sage.
Walker, R. (1993). Finding a silent voice for the researcher: Using photographs in evaluation and research. In M. Schratz (Ed.), *Qualitative voices in educational research* (pp. 72–92). London, UK: Falmer.
Yenawine, P. (1997). Thoughts on visual literacy. In J. Flood, S.B. Heath, & D. Lapp (Eds.), *Handbook of research on teaching literacy through the communicative and visual arts* (pp. 845–846). New York, NY: Macmillan Library Reference.
Yin, R.K. (2014). *Case study research: Design and methods* (5th ed.). Thousand Oaks, CA: Sage.
Zwiers, J. (2007). Teacher practices and perspectives for developing academic language. *International Journal of Applied Linguistics, 17*(1), 93–116.

Appendix

Research Methodology and Context

Our qualitative study focused on the use of photography with one teacher, one classroom, and one curriculum, a clearly defined, bounded system that called for a case study design. We also believe case study was the most appropriate method for our inquiry because it allowed for research of a social phenomenon in its real-life context (Yin, 2014) and because our teachers, students, and their environments are so closely intertwined (Stake, 1995). A case study design also allowed for the use of several qualitative methods, including observations, photo-interviews, and analysis of visual and written documents.

Through these methods, we generated data to explore the roles of photography in the geology curriculum during a six-week instructional unit at a school located in suburban Southern California. The school is home for approximately 841 students, 20% of whom are English learners and 14% of whom receive free or reduced-price meals. The 23 fourth-grade students in the study closely match the school's culturally and linguistically diverse demographics. Marva participated in many activities at the school site because of the university–district partnership that she directed. The classroom teacher, a graduate of our partnership's credentialing program, was purposefully selected. She had worked with visuals throughout both her teacher preparation and the four years she had been teaching at the time of this study.

Data Generation: Words and Images

Data sources included observation field notes, transcriptions from the photo-interviews, and the student lesson products. All three data sources generated both textual and photographic evidence.

During the geology unit, students took photographs, wrote journal entries, and created mineral photo booklets as part of and in response to the photo-enriched curriculum. Observations were conducted while students created these projects and participated in science instruction throughout the six-week unit. During observations, students' interactions with and reactions to the visuals in the curriculum were recorded into field notes. While in the classroom, Marva created images that depicted students at work, relevant classroom displays (including the products of shared writing), and images of the scientific artifacts under study. These were included alongside student-made images in a photo-interview kit. We hoped the photographs would serve as a stimulus during the interviews and perhaps add another layer of information from the students. We included student interviews to allow them an active role in the research; we were interested in understanding students' perceptions of the impact of visuals on their learning experiences. Interviews were treated as conversations (Kvale & Brinkmann, 2009) but were loosely structured around a protocol and a photo-interview kit as done in earlier studies (Cappello, 2005; Cappello & Hollingsworth, 2008).

Data Analysis

All data (text and visual) were coded against the same inductive scheme. Data were viewed, read, and sorted until common categories emerged. However, early analysis of the data occurred in the classroom in collaboration with the student participants as part of the photo-interview. During the interview process, students were asked to separate out images that guided their understanding and explain their choices, thus giving students greater voice in their story and providing them a way to reflect on their learning process. In addition, students helped identify categories by creating groups from the photographs they selected. For example, several students created a stack of images they weren't sure were minerals. We later called this *risk taking*. Other students grouped images where they were thinking about science. We called this *metacognition*. This reflexive process empowered the fourth graders as additional researchers, co-constructing our understandings. The student-created categories were then used along with researcher interpretations to analyze the entire data set.