Building Ocean Literacy Through Science and Art

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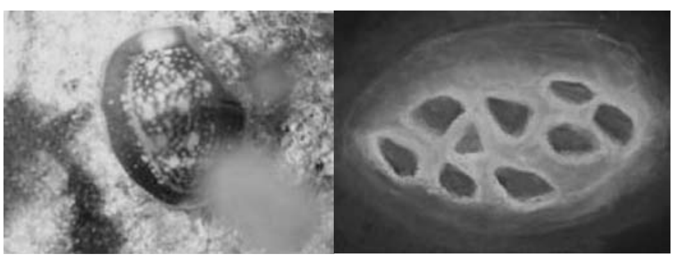
The need for ocean literacy and comprehending the mutual influence of the ocean and humankind is essential (Schoedinger et al. 2006). If we are to prepare a citizenry to face challenges like global climate change and collapsing world fisheries, all students must experience the full practice of science and all that it entails. This includes connecting meaning from scientific information to their personal experience.



Cowries eat algae and play an important role in the intertidal by keeping algae from over abundance. The cowry plays an important role in the natural balance of this marine environment.

FIGURE 1
A student participating in a 9th grade learning showcase

The showcase of student learning (see Figure 1) was prepared by a 9th grade marine science student in Honolulu. The combination of art, language, and scientific knowledge required to produce this artifact exemplifies the type of well-rounded learning that is demanded by students today.

Connecting personal meaning to scientific information helps students become scientifically literate participants in the modern world (American Association for the Advancement of Science 1990). Real-world learning builds problem-solving skills and enhances students' ability to apply knowledge in practical situations (Edelson 1998). Scientific inquiry is the teaching of science by engaging students in the practice of the discipline. Used in conjunction with the Ocean Literacy Essential Principles, scientific inquiry is a powerful tool to build ocean literacy.

Science does not happen in a vacuum. Building ocean literacy through science learning requires a real-word context that involves students in creatively developing and testing ideas (Dass et al. 2005). Instruction that is multi-disciplinary can more effectively build scientific literacy in all students. Science is by nature a multi-disciplinary endeavor and a means to apply many of the skills we want students to develop. The critical thinking skills developed through scientific inquiry can serve students by providing logic and problem-solving skills used in all aspects of their experience. The integration of science with language and visual arts targets the whole brain. Learning in the arts mirrors the goals of scientific literacy by engaging students in both intuitive and analytical thinking (Phillips 2008). Synthesis of information, patterns, and concepts; and incorporation of multiple perspectives and the ability to create meaning from words, symbols, and images are all skills built through arts education. These skills are the same as those sought by science educators.

The *Picturing Science* project, developed by Pacific Resources for Education and Learning (PREL), combines scientific inquiry with language and visual literacy strategies to enhance environmental literacy (Phillips and Rao 2003). *Picturing Science* integrates science, photography, drawing, painting, and writing to create a showcase of student work, as demonstrated in Figure 1. The goals of the project are for students to look at their environment through new perspectives and to engage creatively with scientific process and content. Such use of language and visual literacy strategies are successful in enhancing instruction in chemistry and physics courses (Schonborn and Anderson 2006; Bopagedera 2005; Campbell 2004) and to connect informal audiences to information about conservation biology (Jacobson et al. 2007).

Integrating other subjects into science courses takes time, but the benefits are worthwhile. Integration increases both scientific knowledge and language literacy (Hapgood and Palincsar 2007). Creativity, fostered through artistic endeavors, can permit scientists to approach problems from many perspectives in an open-minded approach, which is the hallmark of science (Creases 2002). Connecting science instruction to other disciplines also makes science more approachable to students who have previously found it to be disconnected from their personal experience (Rudge and Howe 2004). Targeting multiple intelligences provides experiences relevant to diverse learners (Shore 2004). In addition, the novelty supplied by multi-disciplinary activities engages students, while at the same time challenging them to think in new ways (Hess and Brooks 1998). For these reasons, schools nationwide have seen improvements in student performance and motivation by using multiple intelligences (Kornhaber et al. 2004).

Of course, many science teachers may not have had the opportunity to enhance their own artistic skills. The so-called visual art activities highlighted in many multi-disciplinary science activities are really nothing more than craft projects to provide three-dimensional or graphic representations of science concepts. These activities do little to foster the creative and analytical skills built through high-quality arts instruction that we also seek to build in students of science. To truly integrate language and visual arts with science instruction, students must have the opportunity to learn, practice, and apply the skills of each discipline. This means that teachers who want to use an instructional model like *Picturing Science* also need these opportunities. Working with art educators can deepen one's professional understanding of how to integrate visual strategies that help foster scientific learning.

THE *PICTURING SCIENCE* MODEL APPLIED TO PROFESSIONAL DEVELOPMENT

A partnership between art educators, literacy specialists, and marine science educators applied the *Picturing Science* model to ocean literacy. This partnership, between PREL and the University of Hawai‘i's (UH's) Curriculum Research & Development Group (CRDG) and Sea Grant Hanauma Bay Education program, hosted a workshop at the Hanauma Bay Education Center on O‘ahu, Hawai‘i. The goal of the partnership was to provide Hawai‘i educators with teaching strategies to fully integrate scientific, visual, and language literacy. The June 2007 workshop also served as a pilot project to examine the methods and feasibility of conducting this novel professional development opportunity.

The venue for the workshop was the Hanauma Bay Education Center. The first established marine preserve in Hawai‘i, Hanauma Bay is also a major tourist attraction currently visited by one million visitors each year. These visitors participate in a mandatory education program consisting of an orientation video with a message of preservation and safety before entering the water. Although a smaller portion of total visitors are Hawai‘i residents, Hanauma Bay is also a popular visiting place for school groups. The conservation and education missions of Hanauma Bay made it an ideal location for a workshop targeting ocean literacy.

We planned the workshop to integrate and provide time for science, arts, and literacy instruction, and discussed how each planned activity from all three disciplines would support one another. All activities that we included in the workshop framework were chosen to integrate with the other workshop components and to support the theme of ocean literacy at Hanauma Bay. We envisioned the workshop to have an equal focus on science and art. During the course of the workshop itself, we continued to adjust our teaching strategies as ideas emerged from the participants on how different activities could support both science and art instruction.

We publicized the workshop through the Hawai‘i Science Teachers Association network. The workshop was attended by 10 educators with diverse backgrounds (see Table 1). The majority of the workshop costs were funded by the UH Sea Grant Hanauma Bay Education program, who provided participants with all workshop materials and resource books. We held the workshop on three consecutive summer weekdays so that the teachers would not have to secure substitutes or give up a Saturday.

WORKSHOP STRUCTURE

The *Picturing Science* model has been piloted in several school sites in Hawai‘i, Micronesia, and American Samoa (Phillips and Rao 2003), and at the core of each *Picturing Science* project is a science theme that emphasizes issues of the local environment and culture. For the *Picturing Hanauma Bay* workshop, our theme was the coastal environment of Hanauma Bay Nature Preserve. All workshop activities showcased what students in a *Picturing Science* unit would do. We took participants through every activity we expected them to conduct with students in a full *Picturing Science* experience.

The first portion of the workshop was devoted to developing skills needed to ask and answer a scientific question about Hanauma Bay. This scientific question became known to participants as the "essential" question that provided the context for all of their activities during the three days of the workshop. Participants developed scientific vocabulary, content knowledge, and process skills through scientific inquiry structured around the core theme. Language and visual arts instruction all centered on the essential question as a context for instruction and as a problem to be solved through effective written and visual communication.

TABLE 1
Backgrounds of Educators Attending Picturing Hanauma Bay workshop

School characteristics	Subject area	Number of participants
Public elementary	Integrated	2
Private elementary	Integrated	1
Public middle	Science	1
Public middle	Social studies	1
Public high	Science	3
Informal education	Science	2

The process of developing the essential question began the process of building or supplementing the teachers' own scientific investigation skills. Our foundation for teaching about scientific inquiry is the *Teaching Science as Inquiry (TSI)* model developed at CRDG. *TSI* is a supportive, skills- and content-based experience that builds gradual and sustained implementation of inquiry skills into classroom practice. The *TSI* model also promotes deep understanding of content and the process of science. This deep understanding allows teachers to more successfully conduct authentic science within their classrooms, and to help students build their own scientific habits of mind (Pottenger et al. 2007). The *TSI* professional development model takes teachers themselves through the process of scientific inquiry by engaging them in the same activities they might conduct with students and breaking those activities down into their instructional components.

To engage participants in the formulation of the essential question, we first clarified what constitutes a scientific question. We asked them to identify scientific statements (hypotheses) and nonscientific statements (opinions) and to redevelop the opinion statements into hypotheses, if possible. This activity highlighted how questions are asked and answered within the scientific discipline. We then presented a sample problem. Participants formulated and tested a hypothesis to explain the observed phenomenon that some soda cans placed in a bucket of water sink while others float. Together, we then discussed the process they used to solve the problem.

The soda can problem provided all participants with a common experience to move forward with developing their own essential questions. We engaged them in a concept mapping activity around the central idea of "What's special about Hanauma Bay?" Participants used the ideas and connections from this concept map to formulate their own essential questions about Hanauma Bay that they would be answering during the remainder of the workshop. The unique environment of Hanauma Bay connected to Ocean Literacy Essential Principles #2: The ocean and life in the ocean shape the features of the Earth; and #6: The ocean and humans are inextricably connected. We focused on these aspects of ocean literacy in the development of our essential questions. After compiling the concept map, participants formulated hypotheses about the environment at Hanauma Bay. In breakout groups, they began the process of designing a small study around their essential question.

The essential questions provided the thematic platform on which all other activities of the workshop were built (see Table 2). All of the activities focused on the interface of science, visual, and language literacy by connecting, gathering, evaluating, and communicating information about the essential question. For example, one of the visual literacy activities emphasized the critical skills needed to evaluate a piece of artwork. Participants worked through five steps of art criticism to assess and make meaning of a work of art. In doing so, they had to verbalize their initial response to the work and report, without inference, details of the piece and describe artistic techniques. They then interpreted the work in context of knowledge about the artist or culture that produced it and, finally, evaluated the piece. These skills allowed participants to focus their observation skills to approach a work of art with an objective and critical eye, and to synthesize information to make an evaluation of the piece. These skills are similar to those used by scientists to gather and evaluate information about the natural world. We then applied those same careful observation and evaluation skills from the practice of art criticism to the observation of a natural artifact. Using these strategies, we integrated all science, visual, and language literacy activities used throughout the workshop.

The integration of the different literacies through *Picturing Science* emphasizes the well-rounded mental processes used by critical thinkers. Scientific and visual art disciplines both emphasize observation and curiosity. Taking the opportunity to think creatively and to approach a problem from a new perspective is vital to doing good science. This integration happens throughout the course of the workshop, like when participants determine what objects or environments they will take pictures of in response to their essential question. They then select and download digital photos as the foundation for a drawing or painting. Incorporating a variety of artistic techniques emphasizes observation and careful representation of what is seen along with artistic interpretation, allowing for objective focus on alternative views or explanations (see Figure 2). These skills are also emphasized in the scientific process.

In addition to the visual arts, *Picturing Science* focuses on language literacy. Writing helps encourage critical thinking (Butler 1991; Prain 2006), and scientists use writing to help them improve the content and clarity of their own thinking and communication (Yore et al. 2006). Writing also provides an opportunity for students to reflect on their learning and to capture ideas they may have about what they've learned to extend the experience (Burns 2004). Strategies to develop student writing include brainstorming descriptive words, phrases, and analogies prior to writing about each picture. The students' written documents emphasize use of

TABLE 2
Sequence of Activities Presented at
Picturing Hanauma Bay Workshop

Activity	Goal	Literacy
Hanauma Bay talk and video	Background information on bay, unique environment, and pressures	
Asking and answering scientific question	Formulating and testing hypotheses	Science
Concept map	Developing the essential question	Science
Visual research through drawing	Drawing what you see, detail drawing	Visual art
Digital camera instruction	Creative and varied methods of photographing objects	Visual art, Technology
Scientific observation and description	Careful observation and detailed description, objective interpretation	Science
Brain-based activities	Objective interpretation of evidence, alternative explanations	Science
Hanauma Bay observations and photo taking	Careful observation to answer the essential question	Science, Visual art, Technology
Scientific error	Awareness and elimination of scientific error	
Making meaning from art	How to observe art in ways that parallel scientific observation and description	Visual art
Oil pastel techniques	Art production technique	Visual art
Transferring digital photos to laptops and making oil pastel art from photo	Applying artistic technique	Visual art, Technology
Developing and administering a sociological survey	Examining scientific questions in social context	Science, Social studies
Interpreting and communicating results	Examining data patterns, supporting hypotheses, use of evidence, clear communication	Science, Language arts
Making words from images	Developing a written description of visual art	Language arts
Video on natural art and building of personal piece	Introduction to another form of visual art	Visual arts, Language arts
Compilation and sharing of showcase projects	Putting together scientific data, visual product, and written caption to form a showcase of work	Science, Visual arts, Language arts

FIGURE 2
Photographing, downloading, and transferring a visual image

analogy and metaphor, descriptive language, and connections to humans, as well as the larger environment. These writing activities are valuable assessments of learning because they require students to demonstrate content synthesis and application. The use of multiple intelligences within assessment also leads to a more comprehensive and objective assessment of what each student has learned (Ochanji 2000).

In Picturing Science, students are instructed in writing creatively about their photographs and drawings as they are guided through the process of developing concepts and words about their images (see Figure 3). They bring language to their art through the production of "photojournalistic" captions, combining metaphors with scientific facts. Such writing allows students to present all they know, as opposed to the limited knowledge demonstrated on tests that are usually in response to specific questions (Rockow 2008). By adopting such strategies that emphasize the relationship of the essential question to applications that are relevant, learning goes beyond rote memorization (Watters and Watters 2007). Workshop artifacts are located at: *http://www.prel.org/picturing-science/hanaumabay/index.asp.*

This can on the ground represents the message that visitors need to protect and preserve the environment by throwing away trash and leaving the natural world as we find it.

FIGURE 3
The final project of a *Picturing Hanauma Bay* workshop participant

TEACHER RESPONSE TO *PICTURING SCIENCE*

The *Picturing Science* model is flexible and therefore ideal for a range of grade levels and content areas. Figure 4 is a summary of the evaluations provided by the diverse group of educators who participated in the 2007 workshop. Even though participants ranged from elementary to high school teachers and included informal educators, they consistently ranked the usefulness and overall quality of the workshop as being extremely high. Following the summer workshop, two participants returned with their students to continue school projects connected to their essential questions. One participant also built a website around his project.

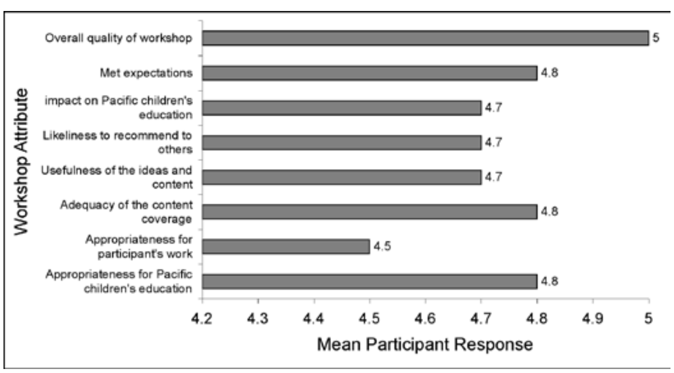


FIGURE 4
Evaluation responses

Teacher comments indicated that we had successfully integrated the science, visual, and language literacy components of the workshop:

- *Amazing!! So informative and engaging. Encourages me to look outside the box, look at the world from different perspectives. Didn't know I could actually draw and write something that others can enjoy!!*
- *I have now got in hand a model for integration of art, English, science, and technology. (I didn't know how to use a digital camera or how to download the pictures.) Wow! What a treasure . . . now it is up to us to use what we have learned to serve our kids better. Thank you all so much for everything. I appreciate it very much!*
- *It was never dull! My brain was working.*
- *The presentation of material was sequential and methodical, one lesson building upon the one before. Many of the assignments were hands-on and of practical use for a teacher in the classroom. . . . There were a lot of aha's for me, and I'm excited about doing this with my kids when the new school year starts. I will be framing the art we have done and use them as exemplars.*

SUMMARY

Picturing Science provides an engaging, multi-disciplinary model of instruction that can foster meaningful ocean literacy. By combining instructional strategies that engage the whole brain, we put science into a more complete human perspective. The thematic nature of the program demonstrates how many different ways of thinking can contribute to the essential question. By bringing together art and science, creativity and intuitive thinking combine with evidence-based analytical thinking. These skills are used in both endeavors to their mutual benefit.

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PHOTO CREDITS

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Figure 3: Photo and Drawing Courtesy of Mark Shanahan

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MARE: Marine Activities, Resources & Education (Lawrence Hall of Science):
http://www.lawrencehallofscience.org/mare/

Wyland Clean Water Challenge Art Contest 2008–2009:
http://www.wylandoceanchallenge.org/index.cfm?mid=4&sid=11