Where Are You From? Writing Toward Science Literacy by Connecting Culture, Person, and Place

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ABSTRACT

The ways in which people view the world, and by extension the ways in which they learn, are shaped by cultural context. As educators striving to build scientific literacy among our students, it is critical to bridge the gaps among disparate cultures, traditional ways of knowing, and Western science. Understanding the value of traditional knowledge and welcoming the discourse and novel viewpoints associated with cultural and place-based practices is the first step in opening the door of scientific literacy not only for indigenous students but also for students struggling to find personal relevance in science. Sharing ideas and thoughts is a powerful force in aligning the wealth of knowledge in traditional settings with Western science. This paper discusses the utility of personal science writing as a tool for increasing science teaching effectiveness by connecting science learning with culture. Evidence from students' writing has shown that a variety of techniques are effective in eliciting personal responses and creating personal connections to science learning. Students who participate in personal science writing activities report that they enjoy the products of their writing and benefit from written exchange with the teacher in an environment that is meaningful but not penalizing. Reflective science writings also chronicle content knowledge and bring out hidden misconceptions. In addition, writing provides a venue for students to improve their critical thinking skills and for teachers to gain a deeper, nuanced understanding of their students. © *2014 National Association of Geoscience Teachers*. [DOI: 10.5408/12-413.1]

Key words: traditional ecological knowledge, journal, inquiry, Hawaiian

INTRODUCTION

> *"I ulu no ka lālā I ke kumu."*
> *[The branches grow because of the trunk.]*
>
> *—Traditional Hawaiian proverb (Pukui, 1983)*

Indigenous Polynesian culture places great emphasis on culture and sense of place. Of utmost importance is connection to the past—to the idea that without our ancestors we would not be here. Elements of nature, such as fish, turtles, and rocks, are considered living ancestors. In the Hawaiian tradition of ahupuaʻa, the land, the sea, and the people are all interconnected and dependent on one another.

In her translation of this Hawaiian proverb, "I ulu no ka lālā I ke kumu," Pukui (1983) points out that the connection to ancestry extends even farther—to the incorporation of knowledge and teaching that is passed from generation to generation. Her explanation of the proverb goes on to say that "without our source or teacher we would not be here." She further writes in explanation, "Aʻo mai, Aʻo aku—teaching and learning are the same; it's a two-way street."

In Hawaiian tradition, there is interdependence between teaching and learning and among the past, the present, and the future. Chun (2006, p. 1) described this relationship as follows:

> *"Aʻo is the word for education, but it means much more. It implies to learn (aʻo mai) and to teach (aʻo aku). This sense of receiving and giving supports the idea that relationships and belonging are primary actions in traditional Hawaiian society and culture."*

In other words, both the teaching and the learning not only perpetuate the sharing of knowledge but also encourage the discovery of new knowledge. As cultures that were able to traverse and colonize the Pacific Ocean basin, the Hawaiians and the related Polynesians and Micronesians had sophisticated knowledge systems of navigation, boat construction, agriculture, and social practices that were passed down and taught to successive generations. These peoples' ability to colonize new lands with few provisions also necessitated active learning processes so that they could make sense of their new surroundings and thrive. Therefore, the ability of people to communicate knowledge was fundamental to their success.

Within the context of traditional knowledge, the human element in learning is crucial, especially in communally oriented cultures for which written language is not a primary form of communication. People are both the physical sources and the recipients of information; the human element is integrated with the knowledge base. Unfortunately, this personal connection is often given little recognition in the quest for objective data in the age of written and digital information that is Western science. However, science is fundamentally a human endeavor, and understanding the role and influence of people in investigating, learning, and sharing knowledge is critically important in the development of scientific literacy (AAAS, 1990,

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1993; NRC, 1996, p. 233–236). Thus, as we strive to integrate indigenous culture and traditional knowledge with Western science, connecting people to their learning is not only vitally important but also a mechanism for bringing students of various cultures and backgrounds together in the pursuit of deeper understanding of science and themselves.

Integrating personal connections into the learning and teaching of science can be difficult, however. Many teachers struggle to integrate the logic of science with personal connections that often involve traditions, personal history, family connections, and strong emotion (Hanrahan, 1999). In addition, the magnitude of content, the number of students, the mix of cultures, and the time restrictions in today's science courses make it logistically problematic for teachers to integrate individual students' personal culture and lives with learning about science. Thus, students may have little opportunity to investigate how their cultural world view relates to science class, especially in areas like geoscience, where objective evidence is valued more highly than in social science disciplines. As a result, science often remains clinical, abstract, or isolated within a course or classroom context. This separation of self from learning can hinder student engagement in and ownership of science concepts, especially for those students whose traditional knowledge worldview incorporates both natural and metaphysical phenomena.

Disconnects between culture and science can distract students from effectively learning (Semken and Brandt, 2010). Even those students whose culture is more Western in origin are often distracted from science concepts by personal conflicts or emotion, especially when dealing with topics that have controversial social elements, such as conservation priorities, global warming, evolution, and geologic timescale. These cultural conflicts have a remarkable ability to prevent learning about scientific ideas. Furthermore, because understanding of the world is derived through a complex mix of life experiences that students use to construct knowledge (Falk and Adelman, 2003), even when students successfully understand content in a scientific context, they may have difficulty adopting that knowledge into their belief system or societal practices. Activities that connect sense of place and person provide opportunities for students to learn about and integrate the human element of science with scientific research and discovery. Thus, how students feel, and what they believe, can be used constructively to enhance students' incorporation of science knowledge with their personal worldview and their daily lives, allowing students to use their prior conceptions as resources for cognitive growth (Smith et al., 1994).

To improve student learning in the geosciences, van der Hoeven Kraft et al. (2011) recommends engaging students' affective domain—the intersection of emotion, attitude, and motivation. Personal science writing does this by connecting students with their life experiences, thereby encouraging students to identify geoscience content, as well as the scientific process, as personally meaningful. A main goal of this paper is to provide examples of writing activities that serve as a vehicle of opportunity for teachers to gather information about students' traditional knowledge and cultural beliefs, as well as their scientific misconceptions. To the extent possible, these ideas are offered as a starting point to help teachers integrate traditional knowledge, engage in cultural discussion, make place-based connections, and solicit personal information from all students, even those who are shy or not as forthcoming in class participation (e.g., Koirala, 2002).

MAKING PERSONAL AND CULTURAL CONNECTIONS TO SCIENCE LEARNING

Critical Thinking and Scientific Literacy

The scientific process is rooted in critical thinking and literacy. Literacy facilitates access to knowledge. Literacy allows knowledge to be passed from person to person without the need to see, speak to, or otherwise directly communicate with another person. Although in its narrowest scope, we define literacy as the ability to read and write, the American Association for the Advancement of Science (AAAS, 1990, p. xvii) offers a broader, integrative definition for scientific literacy:

> *"The science literate person is one who is aware that science, mathematics, and technology are interdependent human enterprises with strengths and limitations; understands key concepts and principles of science; is familiar with the natural world and recognizes both its diversity and unity; and uses scientific knowledge and scientific ways of thinking for individual and social purposes."*

Thus, when we talk specifically about geoscience literacy, we are talking about the integration of multiple disciplines and literacy categories, based in a specific context and associated with a particular set of values (e.g., Street, 1984) that enable people to participate in public discourse and understand the facts, vocabulary, concepts, history, and philosophy associated with the geoscience issues of our time (e.g., Hazen and Trefil, 2009).

The geoscience community has developed ocean, climate, atmosphere, and Earth Science literacy frameworks to supplement the National Science Education Standards (NRC, 1996) and inform the newly released Next Generation Science Standards (Achieve Inc., 2013; see also Carley et al., 2008). These literacy frameworks represent the fundamental ideas that researchers and educators feel citizens need to know and understand in order to communicate and make decisions about topics in Earth, climate, and ocean sciences. In addition to content, the frameworks place importance on the connection between humans and the environment, thereby lending support, and providing a point of facilitation, for integrating cultural literacy into the learning of disciplinary content.

Teaching content through a cultural lens involves creating links among reading, writing, and understanding concepts with traditional and scientific ways of knowing. In other words, teaching students to be truly literate requires a balance between cultural and disciplinary ideals. Personal and reflective science writing can be used to tie the traditional aspects of literacy with the scientific habits of mind that are the hallmark of scientific literacy.

The Value of Writing

> *"How can I tell what I think (un)til I see what I say?"*
>
> *—E.M. Forster (1927)*

The goal of personal writing in science teaching is to document students' thoughts and knowledge in a way that provides students and teachers with mutual understanding of background, motivation, and content knowledge (Steiner and Phillips, 1991). Although traditional knowledge is often passed via oral communication, personal writing in science classrooms affords an opportunity for connection of culture and expression of ideas. Connecting tradition and culture with science can change the way students approach science and the study of nature, helping them to maintain cultural foundations while building conceptual knowledge (Dirnberger et al., 2005).

Personal writing helps students take ownership of their learning (Hanrahan, 1999) and facilitates students' learning awareness (Tinberg, 2011). Writing provides a space for students to connect with their culture and their thoughts—to think about what they know and believe, thereby promoting metacognition and purposeful knowledge generation (Pugalee, 2001; McDonald and Dominguez, 2009). Writing also promotes scientific literacy by improving synthesis skills through the construction of a written record (Hettich, 1976; Miller, 1992; Heron, 2003).

Connecting students' outside world with their coursework through writing can thus extend classroom lessons and field experiences, changing the way students interact with geoscience and helping it become an important component of their daily lives (e.g., Dirnberger et al., 2005). The creative aspect of writing also helps students to utilize information and think outside the box of right and wrong answers in a nonthreatening environment (Killingbeck, 2005; Livingston, 2005). Students may be less fearful and have more opportunities to express themselves on paper than they would have orally to a teacher. The opportunity to read student commentaries provides teachers with insight into the lives and minds of students. The most important element in education is often students' relationship and ability to communicate with the teacher through open dialogue such as that afforded by personal writing (Surbeck, 1994; Heron, 2003). Personal writing can also help teachers control the ideas that are discussed in the classroom, ensuring continued focus on learning goals while asking open-ended questions (e.g., about the age of the planet, resource depletion, connections to each student's personal experiences, or even thoughts on a particular teaching strategy) and facilitating the coexistence of traditional knowledge and cultural beliefs with Western science and societal issues.

Integrating Self With Science: Where Are You From?

The integration of self with science strives to elucidate students' customs, traditional legends, and beliefs for students and teachers to observe, acknowledge, and reflect on. The goal is for students' traditional knowledge not only to be expressed but also be to allowed to sit side by side with their study of Western science in a way that the two may complement and inform each other. The first step in this process is for students to recognize the reasons for their beliefs (Tytler, 2002). For example, students can connect with their culture and traditional knowledge. Thus, the practice of personal, reflective writing in science begins by asking and telling where the student is from. This action provides culture and place awareness, is respectful of the host culture and the cultural mix of students, and opens dialogue in the classroom.

The "I am from" activity is inspired by Cooper's course in leadership and by her writings (Stevens and Cooper, 2009). It provides insight into students' personal lives and how their unique backgrounds influence their knowledge and motivation to learn science. In this exercise, students are asked to create an "I am from" poem in which they integrate their ideas about their culture and home lives with their ideas about their school and science lives. Students are given a grid template to generate ideas for their poems (Table I). The grid has prompts and provides a concrete place to begin writing, which can help students to be more comfortable writing a poem. It also makes the process faster. In addition, prompts can be modified to integrate current class topics or experiences. For example, in order to connect place-based experiences in class with students' backgrounds, prompts might specifically ask students to include examples from recent course topics or to compare local geology with geology from their home or other familiar place. After completing the grid, the students organize the ideas into a poem.

Although not traditionally a part of science teaching, the "I am from" poems unite classes and work groups together by helping people to get to know one another. The poems themselves help students share cultural background, connection to family and peers, traditional knowledge, and depth of content knowledge (Table II). In leading this activity, it is helpful to read aloud an example poem to guide the process. Reading an example poem can open the way for students to be comfortable expressing their backgrounds, which they can then share in front of the class or with one another in small groups. These poems have been used to engage and create rapport among students in high school–level and college-level courses, as well as with in-service teachers and professional scientists.

Learning Styles and Motivation: How Do You Learn?

Writing can also be used as an investigation into how learning and teaching are perpetuated in students' culture. An active awareness of student motivation and skills can help teachers organize class activities. This awareness can also be used to help students take ownership and responsibility for their learning. In other words, when both the teacher and the student acknowledge where the student is coming from, accommodations can be made so that the learning environment is more conducive to the student. Alternatively, when the preferred learning environment is not available, students can be supported to increase their skill set and comfort learning in different ways.

As a starting point, teachers can introduce learning ideas from their own culture or from the host culture. Students can also bring in examples from their cultures or complete Western-style learning inventories (e.g., Kolb, 1984) and describe their learning preferences. It may be helpful to have class discussions about the different ways in which people learn. Teachers can ask students to comment in writing about their learning preferences, the influence of their cultural traditions on the way they learn, and the implications of these preferences and traditions on the way they learn science.

Asking students to reflect about their experiences with various teaching and learning styles (e.g., reading, questioning, observing, listening, and doing) or modes of inquiry (e.g., directed, problem solving, open ended, and direct lecture) and then asking students to write about their

TABLE I: "I am from" poem grid example topics for construction of poems, with prompts for students and for scientists and teachers.

	My Place	My Traditional Knowledge	Myself	My Science	My Science History	My Learning
Student Prompts	Geology of my home or other places I have experienced	My cultural background, emphasizing connections to science	My life outside of school, emphasizing personal connections to science, culture, and geology	Science topics I like or have studied	My previous science courses and experience	My school life, current course topics, or recent field experiences
Scientist and Teacher Prompts	Geology of my home or other places I have experienced	My cultural background, emphasizing connections to science	My life outside of school, emphasizing personal connections to science, culture, and geology	Research projects, students, lab, office, work area, or field habitat	Tradition, culture, or philosophy of science	My teaching environment and course goals—tradition, culture, inspiration, mentors, and teaching philosophy

experiences can have a positive effect on classroom culture. A model lesson for this is the Communicating Ocean Sciences 90-minute exercise on the properties of water and how water density affects circulation and weather patterns on our planet (Halversen and Tran, 2011). The exercise consists of four types of learning stations, which all investigate the same concept but each with a different inquiry mode. When asked to write about their perceptions of the exercise and which mode of inquiry they enjoyed most, my 12th grade high school students ($N = 47$) wrote that the exercise helped them recognize their preference for visual, auditory, written, or hands-on lessons. They also reported most enjoying the directed and problem-solving stations (52.5% preferred directed inquiry, and 40.0% preferred problem-solving inquiry). The structure of the preferred activities helped students to, in the words of one student, "know what to look for and (whether they were) doing things right or wrong." However, students also acknowledged the benefit of other inquiry modes, with one reporting, "Less specific (assignments) force me to think more for myself." Furthermore, even though few students picked direct lecture as their favorite form of learning, many wrote that it had value—especially if it came after they were already interested in the subject. One student wrote, "Lecture after hands-on activities made us more interested in the information (because) it was like a puzzle."

These written reflections provided a foundation for talking about the different ways in which people learn and the different ways of knowing about the world. The students' comments also provided a base for discussing the need for my students to take ownership of their own learning, including the ability to recognize and adapt in situations when information is not being offered in a way that is preferable to them. I have used this same set of activities with older audiences (e.g., graduate students, informal educators, formal educators, and research scientists) with similar results. For example, teachers who participated in the University of Hawaiʻi's Teaching Science as Inquiry (TSI) professional development (PD) program had a statistically significant increase in their self-efficacy ($N = 25$, pre-$M = 3.53 \pm 0.85$, post-$M = 4.73 \pm 0.81$, $p < 0.001$; Seraphin et al., 2012). Although the PD comprises additional material, the activity series described here forms the conceptual basis of the TSI PD. By learning and reflecting on the process of learning and doing science, teachers improved their understanding of the scientific process, especially those teachers with lower science content knowledge. The TSI teachers tend to begin the PD with the assumption that instruction not only requires a teacher but also moves primarily from teachers to student. Ultimately, through the progression of the PD, we see teachers move toward the understanding that instruction includes learning facilitated by peers, as well as learning facilitated by the instructor, whereby teachers begin actively planning for student-to-student instruction and allowing students to make their own knowledge and experiences part of science learning.

PRACTICALITIES OF INTEGRATING PERSONAL WRITING INTO CURRICULUM

Write Often and for Understanding

Writing, like other skills, requires practice. Creating a classroom culture of writing and connection to place also

TABLE II: Excerpts from "I am from" poem examples.

I am from the Arctic tundra From the oldest mountains in North America I am from a place where creation stories did not enter scientific ideas Where science was cold and isolated Where plate tectonics was a strange new idea I am from a place where I was fascinated by my first fossil hunting field trip at 11 years old Where ocean fossils grew in my vegetable garden I am from a place far removed from the ocean Where the hills used to be covered by water Where students found it hard to imagine their home looking any different than it does today I am from science textbooks and videos From field trips to old mountains From a classroom with four walls I am now part of a new mountain creating force Part of a mountain that sits on the ocean floor Where the evidence of this force is visible all around me	I am from mountains and forests and rivers From the country and the suburbs From the foothills of Montana From the geometric shapes of the suburbs of California From the force of Pele creating fire in the sea I am from churches, libraries, and computers From a life of books From a culture of technology, inescapably drawn to information of all kinds Searching for meaning in everything I see I am from researching where I was from I learned that the ground used to be frozen I am from Biology, Chemistry, Physics, Astronomy I read of dinosaurs, of paleontology And the history of the earth, and of the planets I am from a land where fossils filled the backyard From sand dunes and smog From an island whose land is just born The ocean shapes the land, my place, myself I have lived here and there, almost everywhere or nowhere I've never known where I am from
I am from Hawaiian ancestors who communed with nature From indigenous knowledge developed over 2,000 years From canoe builders and star navigators From fishermen and planters From surfers and shark riders From warriors and healers I am from a genealogy linking me to the land, waters, and sky and their creatures From scientists who conducted their experiments in harmony with nature From agricultural and aquacultural innovations that marveled the world From a belief that everything has mana, or spiritual energy I am from an ahupuaa that provides self-sufficiency From the misty rains of Kanoelehua, where I farm From the brackish waters of Honoli'i, where I surf and play	I am from a practice of malama aina and malama kai From living simply From taking only what you need From kuleana, preserving our resources for future generations I am from connecting children to the natural world around them From school gardens where children become stewards of the land From teaching reciprocity, respect, and togetherness I am from showing that our actions affect the land, waters, and native species From making science place-based, culture-based and accessible to all From making a difference in my community

takes time. Students need to become familiar with the process and trust that the ideas they share will be appreciated and acknowledged rather than scorned. One of the main elements for success in personal science writings requires grades to be based on quality of thought rather than on right or wrong content. Hanrahan (1999) suggests that (1) students be allowed to say what they like, (2) responses not be judged for accuracy, and (3) students be allowed to express thoughts in the context of their own experiences. When appropriate, a fourth condition of anonymity is also suggested (Hanrahan, 1999). The following three recommendations are based on implementation experience.

Choose Frequent Writing Assignments That Help Build Classroom Content Knowledge

Personal science writing can be used as a frequent, convenient way to keep track of students' ideas, content progress, and hidden misconceptions. A variety of techniques can be used to elicit personal responses from students while contributing to learning goals in the classroom. For example, student interest in new topics can be initiated by prompts that help students make connections to their home lives and to their culture, forming personal connections.

Writing prompts can also help students identify their previously held misconceptions. For example, when high school teachers in the University of Hawai'i's TSI aquatic science PD were asked, after a series of lessons about sand and beach erosion, what they "used to believe" about sand, their comments allowed them to identify and report their prior misunderstanding (Table III; Spalding et al., 2009). This type of feedback is an important information-gathering step for teachers and an important learning step for students. It also reflects the ability of writing to engage students in the learning process by providing the space and freedom for learners to express what they think (or used to think) without fear of failure. Some additional examples of personal reflective writing prompts include:

- Bulleted lists (e.g., ideas, facts, things they have learned, or prior conceptions—things they "used to believe")
- Chapter notes (e.g., summarizing what they have read or learned)
- Comments and opinions on new topics, readings, class projects, or experiments
- Connection to culture (e.g., reporting stories from their family or their traditional history)
- Connection to place (e.g., framing a response within the context of a place—often a place of significance and commonality to the class, such as from a field study or local region, but possibly a place unique to individual students)
- Dialogue (e.g., writing imaginary dialogue between students, with the teacher, with a famous scientist, or to an inanimate object, such as a geologic formation or scientific tool)
- Drawings as an alternative to prose (e.g., drawing about something they read or observed)
- Letters (e.g., explaining a scientific thought to a "colleague," a family member, or an elementary-school student or writing a letter to the newspaper)
- Organizing events (e.g., putting series of processes in their correct, functional order)
- Scenarios (e.g., making a job want ad for a physical, chemical, or ecological process or for a type of matter, substance, or geologic phenomenon)
- Stealing ideas (e.g., each student writing down 10 ideas, facts, hypotheses, etc., about a topic and then "stealing" ideas from others in their group until all students have the best list of 10 ideas they can make)
- Warm-up prompts (e.g., providing a statement or question that students respond to with their prior knowledge, thoughts about, and things they want to know)

Use Culturally Relevant Writing Prompts

The Western process of doing and thinking like a scientist is characterized by the practice of inquiry, which often translates to wondering and asking questions. Questioning strategies are an important part of inquiry science teaching, of guiding students to form their own connections between ideas. The use of questioning techniques, such as Socratic questioning, can aid teachers in leading students through critical thought processes toward conceptual understanding (Chin, 2007).

In indigenous cultures, however, asking questions is often not an appropriate component to the initial part of learning. According to Chun (2006, p. 6), questioning comes at the end of the traditional Hawaiian learning cycle: "Then and only then are questions allowed." Pukui et al. (1979, p. 48) confirms that in traditional Hawaiian patterns of education, "Never interrupt. Wait until the lesson is over and the elder gives you permission." In other words, in traditional Hawaiian learning, a student can ask questions only after observation, listening, reflection, and doing. Thus, for some students, especially those with indigenous cultural backgrounds similar to that of Hawaiians, the appropriate guiding question might be a statement. Indeed, recent discussions among teachers of native Hawaiian students suggested that statements can be used as an alternative to questions for drawing out students' ideas (e.g., Lemus et al., 2013).

TABLE III: Examples from student writings of things they "used to believe" about sand before studying sand in class.

• Sand is only found at the beach
• Only ocean beaches have sand
• All beaches have sand
• Sand is pretty much the same on all beaches
• Beach sand is the same (in composition) as desert sand
• Sand at my home beach is natural (not altered or supplemented)
• Beaches are permanent geologic features
• Sand erosion is always a problem and must be prevented
• Seawalls prevent sand erosion
• Waves (or wind or ice) can't change the shape of sand
• The bigger the waves (at a beach) the smaller the sand grains
• Sand cannot be magnetic
• Sand and rocks are made of different types of matter
• Sand is only (or always) made of quartz
• Sand is only (or mostly) made from living organisms
• Sand is a type of material (rather than an indication of the size of the material; e.g., the size of the grains)
• Knowing about sand isn't important to me personally
• No one actually studies sand
• To study sand, I have to go to the beach
• I didn't know sand could be so beautiful

The challenge to educators is to use statements that effectively guide students' thinking and promote inquiry. In this approach, the teacher offers a factual statement in place of a clarifying, extending, focusing, lifting, or summarizing question and then allows time for the students to consider ideas and provide input. For example, after observations of sand (in the field, in the lab, in photographs, from memory, or a combination of these), rather than asking a clarifying question such as "Why do you think there are different shapes and sizes of sand grains?" the teacher might say, "One of the factors that affects the size and shape of sand grains is wave action." Unlike the question, the statement provides information about why sand grains have different sizes, but this information guides the students' response in a particular direction. The students would then be expected to add additional observations about sand, such as the similarities and differences between beaches with high wave action and those with low wave action. This same statement could also be used to elicit student responses in personal science writing. For example, using the sand grain statement, students might be asked to present their observations and then to infer patterns about dune or beach attributes and the corresponding characteristics of sand.

Provided that students are made aware of and understand their responsibility to contribute to the dialogue, the approach of using statements rather than questions can (1) help direct the learning trajectory, (2) help the student feel comfortable in the learning environment, (3) provide an opportunity for students to share their information and knowledge, and (4) provide an impetus for learning and growth. Thus, just as questioning in patterns of broad and narrowing drives class discussion, the use of prompting statements can help the teacher guide learning, focusing students toward observations and conclusions that are culturally and personally grounded, scientifically accurate, and contextually relevant to course goals. Similarly, fostering an environment in which students themselves are encouraged to make statements and observations, rather than (or in addition to) asking questions, may help students become more culturally literate learners, in addition to helping students order and articulate their thoughts. Learning to make statements can also help students ask more in-depth and open-ended questions (as opposed to those that are answered by yes or no). Ultimately, the sharing of information through statements should prompt students to continue to draw from their personal experience and make connections to classroom learning.

Limit Grading Volume

The time-consuming aspect of using personal reflective writing in science class comes mainly from the logistics and bulk of grading. In order to get students into the habit of writing and to provide them with a benchmark for grading standards, it can be helpful to collect writings frequently at first (e.g., each writing or daily) and then less often (e.g., every few writings or weekly). This time frame can be extended once students are in a pattern of effective reflective writing. To make grading of writing efficient, a variety of other strategies can also be employed:

- Students can self- or peer-grade the presence of entries and the depth of response (using a rubric and checklist of required entries).
- Students can write a reflection on a set (e.g., a week, month, or semester's worth) of their own writings and then tag their favorite writings for grading.
- The teacher can spend time thoughtfully responding to student entries to create a personal dialogue but leave "right/wrong" answers for students to correct themselves.
- If students are writing in a journal, the teacher can stagger collections so that only a few are being graded at a time or can collect journals when the students will not need them for a few days.
- If students are writing in a journal, they can use worksheets and loose-leaf paper when feedback needs to be given to students quickly.

CONCLUSIONS

Connecting people to their learning is a vital component in the quest to integrate indigenous culture and traditional knowledge with Western science. Allowing students to build a worldview that incorporates not only scientific literacy but also cultural literacy can enhance students' connection with their person, their place, and their scientific thinking. Creating links among reading, writing, traditional and scientific ways of knowing can help bring these standards of disciplinary literacy into the classroom. Moreover, although traditional knowledge is often passed via oral communication, personal writing in Western science classrooms provides a unique opportunity for connection of traditional knowledge, culture, and students' expression of ideas. Personal and reflective science writing can thus be used as an accessible way for students to tie the traditional aspects of reading and writing with the scientific habits of mind that are the hallmark of scientific literacy.

These suggestions are based on the theoretical research of others, as well as personal teaching experience, and provide mechanisms for interesting and involving students in science learning and literacy in ways that acknowledge personal experience, culture, and traditional knowledge. The next step is to look more qualitatively and quantitatively at the impact on students' engagement in science, attachment to the scientific process, and integration of science into their personal lives. For example, student surveys about attitudes and behavior will yield insight into the effect of personal writing on students' self-efficacy in science. Comparisons of student retention in science courses focused on personal connections with courses that are "business as usual" will provide quantitative insight into larger-scale impact. In addition, comparison of standardized test scores, grades, teacher feedback, and student work will help assess the extent to which enhancing engagement, attachment, and integration of science and culture improves student understanding of scientific concepts. The working hypothesis is that enhancing place and personal connections in science teaching will improve students' self-efficacy and attachment to science learning, thereby leading to increased retention in science courses, higher test scores, better grades, and higher-quality student work. Writing often and with cultural, and place-based, relevance is therefore recommended as a thinking tool to personally and contextually connect the past, present, and future aspects of teaching and learning.

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