

Pauline W. U. Chinn
Sharon Nelson-Barber *Editors*

Indigenous STEM Education

Perspectives from the Pacific Islands,
the Americas and Asia, Volume 1

Sociocultural Explorations of Science Education

Volume 29

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Pauline W. U. Chinn • Sharon Nelson-Barber
Editors

Indigenous STEM Education

Perspectives from the Pacific Islands,
the Americas and Asia, Volume 1

 Springer

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Sharon Nelson-Barber and Pauline W.U. Chinn, co-editors, dedicate these two volumes to the wisdom of ancestors and elders, known and unknown who passed down guidelines for living in a sustainable, resilient world.

Hawaiian proverbs, ‘ōlelo no‘eau, convey the importance of nānā i ke kumu, looking to the source, the wisdom of the past to inform how we, ‘imi ‘ike, seek knowledge and interpret current phenomena to make decisions and, mālama i ka ‘āina, care for the lands that sustain us. The ethic of care is bound together with aloha, love, and kuleana, responsibility to maintain sustainable, resilient social ecosystems in which humans are a part of, not apart from the world.

Mālama i ka ‘āina, “respect and care for the land,” the third ‘ōlelo no‘eau was a Hawai‘i Department of Education science content standard until it was removed on the advice of external reviewers because it was too cultural (Chinn 2011). Ironically, it and other ‘ōlelo no‘eau among the nearly 3000 collected by M. Kawena Pukui (1983) are

now a rich resource for Hawai‘i’s science educators as recognition grows that all teaching and learning is cultural.

We further recognize the wisdom in sayings that relay dynamic processes of complex systems coupled with the values and behaviors needed to maintain sustainable, resilient communities and ecosystems. The next two ‘ōlelo no‘eau (ibid) specifically address this relationship.

He ali‘i ka ‘āina; he kauwā ke kanaka; The land is chief; man is its servant. Land has no need for man, but man needs the land and works it for a livelihood.

Ua mau ke ea o ka ‘āina i ka pono, The life of the land is preserved in righteousness.

Since its appearance in 1845 on the coat of arms of the Kingdom of Hawaii (1810–1894) to the present, this has been Hawai‘i’s motto.

Given the special circumstances of today’s world, we also reflect on particularly salient messages delivered by two prominent Native knowledge keepers—one contemporary and one from the past—who remind us to

collectively amass strength from the past and to bring it forward to impact the future.

Remember that you are all people and that all people are you—Joy Harjo

It is memory that provides the heart with impetus, fuels the brain, and propels the corn plant from seed to fruit.—Joy Harjo

I see a time of Seven Generations when all the colors of mankind will gather under the Sacred Tree of Life and the whole Earth will become one circle again.—CrazyHorse

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Foreword: Indigenous Peoples, Culture, and Place-Based Science Curricula

An Indigenous Sense of Place

In the face of the rapid transformation of the Earth by science and technology and the challenges of ecological crisis and climate change that have begun to unfold, leading thinkers are exploring alternative cosmologies, paradigms, and philosophies in search of models that sustain Nature rather than destroy it. Many of these thinkers have found that Indigenous epistemologies offer profound insights for cultivating sustainable relationships to one's place and one's spiritually integrated perceptions of Nature to address what has now become a global crisis of ecological relationships.

Indigenous Peoples' inherent identification with their *Place* presents elegant alternative paradigms for practicing the "art" of relationship with the natural world. Indigenous Peoples have consistently attempted to maintain a harmonious association with their lands in the face of tremendous pressures to assimilate. Traditionally, Indigenous Peoples have demonstrated in multiple ways that their lands and the maintenance of ecological integrity are key to their physical and cultural survival. The importance that Indigenous Peoples attribute to "connecting" with their *Place* is not a romantic notion that is out of step with the times. It is rather the quintessential ecological mandate of our time! Wherefore, certain time-honored philosophies have guided my thinking for some time.

Indigenous Peoples express a relationship to the natural world that can only be called "ensoulment." The ensoulment of nature is one of the most ancient foundations of human psychology. This projection of the human sense of soul and the various archetypes contained within have been termed "participation mystique" (Abt, 1989).

For Indigenous Peoples participation mystique represents the deepest level of psychological involvement with one's land and, in a sense, also reflects a "soul map," so to speak. The psychology and spiritual quality of Indigenous behavior, with its reflections in symbolism, are thoroughly "informed" by the depth and power of their participation mystique and their perception of the Earth as a living soul. It

is from this orientation that Indian people believe that they have “responsibilities” to the land and all living things and to each other. In the Indian mind, spirit, and matter are not separate, they were one and the same.

Indigenous Peoples project the archetypes which they perceive in themselves into the entities, phenomena, and places that are a part of the natural environment which they encounter. Indigenous Peoples traditionally understood the human psyche and the roots of human meaning as grounded in the same order which they perceived in Nature. They experienced Nature as a part of themselves and they as a part of it. They understood themselves literally as born of the Earth of their Place. That children are bestowed to a mother and her community through direct participation of “earth spirits” and that children come from springs, lakes, mountains, or caves embedded in the Earth where they existed as spirits before birth were widespread Indigenous perception. This is the ultimate identification of being “Indigenous” to a place and forms the basis for a fully internalized bonding with that place. It is also a perception that is found in one variation or another among the traditions of Indigenous people throughout the world, including the archaic rural folk traditions of Europe.

The archetypes of being born from the earth of a place and the participation of “earth spirits” in human conception are universal among Indigenous people. Indeed, this perception is reflected throughout the myth, ritual, art, and spiritual traditions of Indigenous people because in it is a biological reality that our whole human development is predicated on our interaction with the soil, the air, the climate, the plants, the animals of the “places” in which we live. It is this perception and projection of inner archetypes into a Place that forms the spiritually based ecological mindset that establishes and maintains a correct and sustainable relationship with place. This orientation is, in turn, reinforced by a kind of physical “mimicry” and a reflection of a kind of “geo-psyche” that often takes place when a group of people live in a particular place for a long period of time. There is an interaction between the inner and outer realities of people that come into play living in a place for this extended period of time. Our physical makeup and the nature of our psyche are formed to some extent by the distinct climate, soil, geography, and living things of a place. Over a few generations of humans adapting to place, certain physical and psychological traits begin to self-select and the development of mountain people as distinct from desert people as distinct from plains people begins to unfold. Though it is not as apparent now as it was in the past, Indigenous Peoples of the world reflect physical and psychological characteristics that directly result from generations of interaction with the geographies and ecologies of their respective regions.

But people make a place as much as a place makes them. Indigenous people indeed interacted with the places in which they lived for such a long time that “their landscape became a reflection of their very soul.” So phrases such as “Land of the Hopi,” or “Land of the Hawaiians,” or “Land of the Māori,” etc. have a literal dimension of meaning because there was a co-creative relationship between the Indigenous people and their lands. Through long-term experience with the ecology of their lands and the practical knowledge that such experience brings, they interceded in the creation of habitat and the perpetuation of plant and animal life toward optimum

levels of bio-diversity and biological vitality. Indigenous groups literally managed their territories in ecologically sustainable ways.

In the USA, the relationship between Indigenous Peoples and their environments became so deep that separation from their home territories by forced relocation constituted, literally, a loss of soul for the whole generation. Indigenous people were “joined” with their land with such intensity that many who were forced to live on reservations suffered a form of “soul death.” The major consequence was the loss of a sense of home leading to profound “homesickness” with all its accompanying psychological and physical maladies. As one elder put it, “they withered like mountain flowers pulled from their mother soil.”

Traditionally, the affinity of Indigenous peoples with their lands symbolized their connection to the spirit of life itself. The loss of this foundation led to a tremendous loss of meaning and identity, which only now is being revitalized by recent generations. The loss of homelands took such a toll because inner kinship with the world is an ancient and natural extension of the human psyche. The disconnection of that kinship can lead to a deep rift between the inner and outer consciousness of each individual as well as the group. It also brings with it a range of social and psychological problems, which ultimately can only be healed by reestablishing the meaningful ties that have been lost. Reconnecting with nature and its inherent meaning is an essential healing and transformational process for Indigenous people.

The Indigenous *sense of place* and the importance of being in harmony are embodied in our cultural traditions. Our collective experience with the land, integrated by our myth and ritual, expressed through our social structures and arts, and combined with a practiced system of environmental ethics and spiritual ecology, gave rise to a deep connection with our Places and a full expression of ecological consciousness. We have an important legacy of traditional environmental education for sustainability, which we must again revitalize for ourselves and for the generations yet to come. We have been entrusted with an important package of memory, feeling, and relationship to the land that forms a kind of “sacred covenant.” Our sacred covenant with the land bids us to strive to educate ourselves about our traditional forms of sustainability- oriented, environmentally based education. Our covenant bids us to reclaim our heritage of living in a harmonious and sustainable relationship with the land, thereby fulfilling a sacred trust to the land that is an ancient part of this covenant.

Today, because of immersion in modern education and society, fewer and fewer Indigenous people have the opportunity to engage the land, its plants and animals, in the ways that our ancestors once did. The Peoples’ experience with the land was the cornerstone of traditional Indigenous education. Sustaining a people, a culture, a way of life through generations of living in a *Place* truly was both the medium and the message of Indigenous education. Place-based environmental education created from the perspective of Indigenous people themselves must once again become one of the collective priorities of modern Indigenous education. Indigenous people must take a leading role in place-based environmental science education, as Western society begins to finally realize that it must forge a new ecologically based cosmology, complete with new stories and new expressions and applications of science and

technology. Western society and education must once again become Nature-centered if they are to make the kind of life-serving, ecologically sustainable transformations required in the next decades. The ecologically sustainable models historically developed by Indigenous Peoples could form the basis for creation of needed educational models. However, we as Indigenous Peoples must reassert our sacred covenant with the land. As I have stated elsewhere, the places we inhabit are an extension of our collective Indigenous minds. It is this place that holds our collective memory. It is this place with its unique natural spirit that provides us with meaning and defines us as distinct Peoples of Place (Cajete, 1994: 23).

Indigenous Place-Based Science Curricula

Research in planned cultural approaches to teaching and learning science has been moving from its formative stages to new and more creative expressions. The real strength of current research lies in the fact that synchronistic lines of thought and similar conclusions are beginning to appear throughout the literature. This has in turn stimulated the formation of networks of researchers and other interested groups at the local, regional, national, and international levels. Place-based education in science reflects an evolution of thought related to self-determination, community education, and a renaissance of Indigenous identity.

These volumes, edited by Pauline Chinn and Sharon Nelson Barber, present the research and stories of various scholars, teachers, and community members who are researching or participating in the development of place-based science education in Indigenous communities. The synopses of a cross-section of chapters below offer glimpses into the nature of the material. For example, in “Integrating Place, Indigenous and Western Science: Implications for Teacher Agency, Expertise, and Identity,” Pauline Chinn describes how Hawaiian language newspaper articles can be used for Earth Science curriculum development as a way of integrating Indigenous and Western science while simultaneously enhancing teacher agency and reinforcing Hawaiian identity and sense of place. In this way, Chinn advocates for national and local recognition of Indigenous science, technology, and values that can support resilient social ecosystems and provide support for place-based teacher education, teacher agency, and curriculum that reveals polyvocal perspectives.

In the chapter, “Utilizing Indigenous Knowledge Systems and Western Science in Science Education,” Daniel Lipe discusses the need to include Indigenous Knowledge systems as their own science-based worldview. He advocates that as a matter of sustainable necessity Indigenous Peoples have developed their own science-based understandings over generations and in their places. By relating this history and through the telling of his own story of becoming a teacher-researcher, he shows how connecting home cultures with those found in school settings can help to engage under-represented diverse populations.

Linda Furuto examines “Mathematics Education on a Worldwide Voyage: Engaging Values and Placed-Based Curriculum to Support College, Career, and

Community Readiness.” She describes the ways in which students participating in the voyage of the *Hokule’a* learn mathematics grounded in the experiential place-based orientation of Hawaiian voyaging and wayfinding. The voyage provides opportunities to learn as well as hands-on experience from both ancient and modern science, technology, and mathematics in ways that bridge these forms of scientific knowledge and ways of knowing the natural world.

In her chapter, “Implementing Place-Based Practices for Biodiversity Conservation and Sustainable Use in a Regional School in Thailand,” Thai educator Nantana Tapamat, describes ways in which students in a rural Thai village who engage with place-based education show increased sense of place, scientific and social skills, and a deeper sense of self-efficacy through working with villagers on water quality projects, botanical gardening, and environmental networking.

Chuukese educator, Margarita Bernard Cholymay, LJ Rayphand, and James Skouge outline the importance of place- and culture-based education for Chuukese people in “Way finding: Túúttúnnapen Chuuk – Indigenizing Chuukese Education.” They describe how this educational intervention addresses the urgent need for cultural maintenance and also how it functions as a counter to the historical colonial educational model that has failed to serve the immediate and future needs of Chuukese students. Place-based education processes promise to better serve the cultural, social, and scientific needs of the Chuukese people.

Megan Bang, Jasmine Alfonso, Lori Faber, Ananda Marin, Michael Marin, Douglas Medin, Sandra Wasman, and Jennifer Woodring report findings of their research regarding “Perspective Taking and Psychological Distance in Children’s Picture Books: Differences Between Native and Non-native Authored Books.” They discuss ways in which the orientations and illustrations of nature conveyed in these books connect with students’ understandings and perceptions of intimacy with the environment. This work shows that the range of devices employed by Native illustrations support actions such as taking multiple perspectives and systems level thinking strategies that are important for scientific reasoning.

In their respective chapters, “Researching Māori and Māori-Medium Science Education” and “Forum Kaupapa Māori Science: A Science Fiction?” Georgina Stewart and Elizabeth McKinley explore why the number of Maori students taught through the Kau Papa Maori model has not increased the number of Maori students successfully completing courses of science studies and therefore should be taught science in both Maori and English to enhance their viability for success in Science fields of study. They point out that since teachers of science are never provided with a paradigm of science teaching other than the Western paradigm, they are fated to repeat a similar outcome of student success whether they teach in Māori or English. Should teachers receive firm grounding in both Western and Maori paradigms, they could more likely compare and contrast both ways of knowing and better bridge these knowledge bases for better teaching and student learning of science.

In her chapter, “‘Imi I ke ‘Alanui, To Find the Way,” Native Hawaiian science teacher, Napua Barrows, offers an auto-ethnography that recounts her journey to become a science teacher and advocate for place-based science education through processes of community organization. Keys to her success include teaching

Hawaiian values and knowledge as a Hawaiian resource teacher and leading a community-based organization focusing on teaching children through cultural experiences, stories, and real-world applications that utilized tools in both Hawaiian and Western science traditions.

The stories and research that comprise these volumes of *Indigenous People, Culture and Place-Based Science Curricula* make an outstanding contribution to the literature in culturally responsive science education. They weave stories, research, experiences, and curricular initiatives together with notions of sustainability of people, culture, and place, and are infused with Indigenous-inspired thought and reflection. As such, they both challenge and refresh more traditional approaches and thoughts regarding science teaching and curricular design. As we collectively face the environmental, social, and cultural challenges of the twenty-first century, these volumes are a pleasure to read, and exciting to contemplate in terms of the potential of place-based science for Indigenous and non-Indigenous students, teachers, and communities.

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Gregory A. Cajete

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Preface

From their first contact with European explorers and settlers, many Indigenous peoples have experienced changes that have impacted their health and well-being, cultural practices, and access to resources supporting sustainable lifestyles. In North America and Hawai‘i, Indigenous languages and traditions were the targets of colonial education systems that sought to assimilate Indigenous children into the dominant culture. Today, as science educators seek to address the legacy of academic discrimination, a lack of knowledge about Indigenous ways of knowing and doing increases the complexities of designing and implementing externally conceptualized programs for Indigenous students.

The need for science educators to deepen their knowledge of Indigenous ways is particularly urgent when climate change is being felt on local through global scales. The sixth IPCC Assessment report (2022) delineates the vulnerabilities and impacts of climate effects on humans and ecosystems. The report includes Mirian Jerez’s (2021) policy brief that conveys both the perils of climate change to Indigenous peoples who make up about 5% of the world’s population and their promising role as “stewards of global biodiversity who effectively manage an estimated 20–25% of ... areas that hold 80% of the planet’s biodiversity and about 40% of all terrestrial protected areas and ecologically intact landscapes” (p. 1). This builds upon the International Labour Office’s (2017) statement that Indigenous peoples are “fundamental partners and crucial agents of change for achieving effective climate action, sustainable development and green growth ...[due to] their unique knowledge” (p. 23).

Current thinking in sociocultural theory and the learning sciences argues for an ecological approach that locates educational accountability in “the real world” of students’ knowledge and experience. This ecological approach finds central importance in aspects of learning that have gone unrecognized, such as relationships, contexts, languages, tools, and practices based on community knowledge (Nelson-Barber & Johnson, 2016). Carol Lee (2008) would say that these elements demand innovative approaches and offer great potential for creating more equitable, empowering, and sustainable change for communities and individuals.

Now that more Indigenous teachers are joining the work force, there will be more cultural role models whose instructional approaches in learning and systems of problem solving are directly linked to their Indigenous students' cultural experiences. However, generations of colonization, displacement, and language suppression mean even Indigenous teachers need strategies to reconnect to their ancestral knowledge, places, and practices (Chinn, 2012). Research demonstrates that when content areas are taught or learned in defined cultural contexts, students have increased opportunities to relate to them and find them meaningful (Castagno & Brayboy, 2008). This is engaging and empowered education for both teachers and students.

Mainstream education offers categories of strategies, but does not offer specifics for how to provide “equitable learning opportunities” for Indigenous and nondominant student groups. It recognizes important points of entry but offers little insight as to how these function in practice:

What's missing:

- Culturally relevant pedagogy
- Ancestral knowledge
- Cultural connections to place
- Language revitalization
- Community involvement and social activism
- Multiple representations of knowledge and multimodal experiences
- School support systems including role models and mentors of similar racial or ethnic backgrounds

Contributors to the volume masterfully illustrate many ways to prepare educators to intentionally shape the experiences of their students as lifelong learners and global participants, who are grounded in and enriched by their places and cultures.

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Acknowledgments

These two volumes would not be possible without the contributions of 66 authors, the majority Indigenous, who shared their perspectives on Indigenous STEM education and research that respects the places, knowledges, practices, and language of the first peoples of the land. Our deepest gratitude goes to them for trusting us to convey their voices and work.

The co-editors, Pauline W. U. Chinn and Sharon Nelson-Barber, would also like to recognize the elders, mentors, and life experiences that led to this collaborative endeavor. The seminal work of our colleagues Dr. Glen Aikenhead, Dr. Ray Barnhardt, Dr. Greg Cajete, Dr. Oscar Kawagley, and Dr. Jerry Lipka has been particularly impactful to the field as well as our trajectories, and we greatly appreciate their contributions to these volumes.

Pauline acknowledges Dr. Isabella Kauakea Aiona Abbott for helping her weave together the strands of *ōlelo Hawai'i* (Hawaiian language), STEM, and inquiry from Native Hawaiian perspectives. The first Native Hawaiian to earn a PhD in natural sciences, member of the National Academy of Sciences, born in 1920 in Hana, a sugar plantation town in rural Maui to a Hawaiian-Chinese mother and Chinese immigrant father, Dr. Abbott's Hawaiian upbringing established deep cultural roots that informed her work at Stanford and the University of Hawai'i at Mānoa. When asked her thoughts on Hawaiian inquiry for a project with teachers (Chinn et al., 2011), Dr. Abbott replied with an *ōlelo no'eau* "*Ua lele ka manu*, The bird has flown" (Pukui, 1983). She heard her mother saying it when she looked for something that "could right under our noses but overlooked." Pauline credits her father, Edwin Y.H. Chinn, a science educator as introducing the land as a mentor through fishing, hiking, gardening, and foraging.

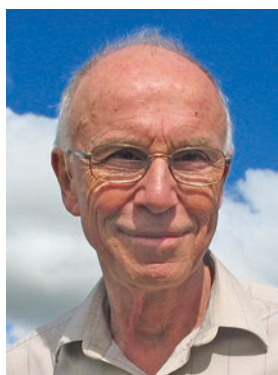
Sharon also stands on the shoulders of generations past. She extends special recognition to her forebears: Wilbur Bailey Nelson, Harvey Arthur Nelson, Lila Tibbs Nelson, Andrew Thad Harris, Callie Nelson Harris, and Gladys Harris Nelson who modeled their land-based pedagogies and provided the strong, sustaining spiritual and ethical foundation that continues to guide her way.

When constantly and thoughtfully observed, the land is a generous teacher. The guidance from mentors to seek what is overlooked but can be found has nourished both Pauline and Sharon through the considerable time and effort required to compile these insightful contributions into two volumes.

Glen Aikenhead

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Editors and Contributors

About the Editors

Pauline W. U. Chinn's great-grandparents arrived in Hawai'i when it was the Kingdom of Hawai'i and Hawaiian was the official language. Following annexation by the United States, Hawaiian language was forbidden as a language of education and government. As a secondary science teacher in Hawaii's public schools, she used science textbooks from the continental U.S. except for Plants and Animals of Hawai'i, a class for non-college bound students. Creating place-based curriculum intersected her experiences of fishing, hiking, and gardening with western biology frameworks. Seeing students in this "terminal" class become engaged as their lives and places entered the curriculum led to doctoral research exploring the roles of culture, gender, language, and power in underrepresentation of kanaka ma'oli, Native Hawaiians in science, technology, engineering, and mathematics (STEM). At the University of Hawai'i at Mānoa, her teacher education and professional development projects in Hawai'i and American Samoa funded by the U.S. Department of Education and the National Science Foundation support research and education to develop teacher leaders who develop, place-based, culturally sustaining, inquiry-oriented curricula inclusive of diverse and underrepresented students. This work led to developing an Interdisciplinary M.Ed., Sustainability and a Graduate Certificate in Sustainability and Resilience Education.

Sharon Nelson-Barber, a sociolinguist and Senior Program Director at WestEd, has lifelong personal and professional experience in Indigenous communities. Her interests in STEM began early on as she accompanied her father and grandfather while subsistence hunting and fishing. Much of her research, funded by the National Science Foundation, centers on understanding ways in which students' cultural backgrounds influence how they make sense of mathematics and science education. She also conducts studies aimed at developing more equitable assessment and testing methods that account for cultural influences. She closely collaborates with other Indigenous researchers and community partners across the US, the Northern Pacific islands of

Micronesia, and parts of Polynesia. She is co-founder of POLARIS (Pivotal Opportunities to Learn, Advance and Research Indigenous Systems), a research and development network that promotes healthier communities by integrating Indigenous perspectives for thriving education futures. An ongoing project convenes Indigenous elders and scientists to document technical solutions to climate change from both Indigenous and western academic perspectives, and heighten international attention to the need to preserve cultures and societies amidst rising waters.

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Part I

Introduction: Culture, Language, Knowledge and Place as Foundation for Learning

Ray Barnhardt

The seven articles contained in the first section of *Indigenous STEM Education: Perspectives from the Pacific Islands, the Americas, and Asia*, focus on “Culture, Language, Knowledge and Place as Foundation for Learning.” While these articles highlight current science, technology, engineering and mathematics initiatives drawn from the Pacific Islands, Americas, and Asia, their relevance is applicable to Indigenous settings throughout the world. The intersect of Indigenous knowledge and western science has emerged as a powerful focal point for educational reform over the past three decades, reshaping many realms in our understanding of the world around us. Inherent in the research reported here are the constructs of culture, language, knowledge and place as they form a foundation for Indigenous educational advancement.

A refrain commonly heard in conversations among Indigenous people is in reference to the challenges associated with “living in two worlds,” one being the locally-derived Indigenous world with which they are intimately associated, and the other being the externally-defined world that has enveloped their existence. The tensions between these two worlds have been at the root of many of the problems that Indigenous people’s have endured throughout the world for several centuries as the explorers, armies, traders, missionaries and teachers have imposed their world view and ways of living onto the peoples they have encountered in their quest for colonial domination.

In recent years, Indigenous people have begun to reintegrate their own knowledge systems into local educational policies and practices as a foundation for connecting what students learn in school with life out of school. This process has sought to restore a traditional sense of place while at the same time broadening and deepening the educational experience for all students. Some of the strategies employed in

this educational restoration effort include the role of local elders, traditional values, cultural camps, experiential learning, language immersion and cultural standards. The research topics described in the following articles serve as the basis for a pedagogy of place that shifts the emphasis from teaching *about* local culture to teaching *through* the culture to derive insights about the immediate places they inhabit and their connection to the larger world within which they are making a life for themselves.

As Indigenous scholars reassert their world views, knowledge systems and ways of knowing in search of a proper balance between the “two worlds,” they offer insights into ways by which we can extend the scope of our educational systems to prepare all students to not only make a living, but to make a fulfilling and sustainable life for themselves. The articles presented here offer some rich examples of how the Indigenous peoples of the South Pacific and SE Asia have established a rich research agenda of their own to begin to reconcile these tensions and accommodate the differences between their ways of life and those of their western neighbors. In so doing they are able to strengthen their voices and contribute to their own diverse cultural histories and traditions. At the same time they offer strategies for overcoming the tendencies toward replication of uniformity that are so deeply ingrained in the bureaucratic structures associated with colonization, and in the process institute a more locally-grounded, place-based approach that has the potential to integrate “the best of both worlds.”

One of the primary vehicles for promoting a pedagogy of place has been the development of Indigenous research methodologies and political documents such as the United Nations Declaration on the Rights of Indigenous Peoples that guide scholars into the use of the local environment and cultural resources as a foundation for all learning. A key incentive for such practices has been the sponsorship of science, technology, engineering and mathematics (STEM) initiatives in which researchers work with resident elders to identify topics of local interest and develop projects illustrating the use of “science” in everyday life in the surrounding community and environment. The STEM themes contained in the enclosed articles have been drawn from accumulated knowledge derived from living on the landscape over many generations. Many of the research topics described in the articles provide intriguing opportunities for scholars to test the scientific principles imbedded in the local Indigenous knowledge compendium.

The research topics described in the enclosed articles are a reflection of the Indigenous view of the world as well as that of the collaborating scientists, incorporating both culturally accurate and scientifically valid principles and practices. This is a learning process in which the researchers and elders are all eager and willing participants, and we now have results that provide numerous examples of integrated science/culture themes that clearly illustrate the ways in which an extended period of experiential inquiry in a traditional environment can serve as the stepping stone and foundation that moves us toward in-depth understanding of the world around us.

One of the beneficial outcomes of the research described in these articles is the generation of locally-based STEM resources suitable for use in Indigenous settings that can be made available throughout the world via technology. Access to these resources can be expanded to include materials in various thematic areas relevant to communities in the Pacific Islands and beyond. In documenting and sharing culturally relevant publications and educational materials such as those reflected in the enclosed articles we can reach beyond the surface features of Indigenous cultural practices and illustrate the potential for comparative study of deep knowledge drawn from both the Indigenous and western worlds.

The knowledge and skills derived from thousands of years of careful observation, scrutiny and survival in a complex ecosystem readily lends itself to the in-depth study of basic principles of biology, chemistry, physics and mathematics, particularly as they relate to areas such as botany, geology, hydrology, meteorology, astronomy, physiology, anatomy, pharmacology, technology, engineering, ecology, topography, ornithology, fisheries and other applied fields. Such interdisciplinary research topics provide an instant relevance and can be used extensively in schools and community settings. It is the ready availability of these resources that provides educators the impetus to revamp their curricula and integrate the place-based approaches to education that have been championed through STEM initiatives.

Another area in which culturally grounded STEM initiatives can impact school/curriculum interactions is in the use of technology to extend and deepen learning opportunities for Indigenous students. As illustrated in the range of research topics described in the enclosed articles, collaborative research provides opportunities for scholars to focus on any aspect of their local culture/community/region and assemble the information in a multimedia format to be shared with the community through the use of technology. Culture- and place-based research topics engage students in information gathering and compilation processes that simultaneously enhance learning of subject matter, technology applications and cultural knowledge, with the results often of direct interest and service to their communities.

The articles describing on-going research in the Pacific region illustrate how culturally relevant research has been developed by scholars from various Indigenous contexts around the region. The results include life histories, genealogies, place names, language documentation, uses of local flora and fauna, subsistence practices, community histories, traditional arts and crafts, mapping projects and weather knowledge.

The primary thrust of the research described in these articles is to create a place for integrating Indigenous knowledge in STEM education. The outcome of this research can best be summarized by the following statement taken from the introduction to the *Alaska Standards for Culturally Responsive Schools*, published by the Alaska Native Knowledge Network:

By shifting the focus in the curriculum from teaching/learning *about* cultural heritage as another subject to teaching/learning *through* the local culture as a foundation for all education, it is intended that all forms of knowledge, ways of knowing and world views be recognized as equally valid, adaptable and complementary to one another in mutually beneficial ways (ANKN, 1998, p. 3).

While much remains to be done to fully achieve the intent of Indigenous people in seeking a place for their knowledge and ways in the education of their children, they have succeeded in demonstrating the efficacy of an educational system that is grounded in the deep knowledge associated with a particular place, upon which a broader knowledge of the rest of the world can be built. This is a lesson about “living in two worlds” from which we can all learn.

Reference

Assembly of Alaska Native Educators. (1998). *Alaska standards for culturally responsive schools*. Alaska Native Knowledge Network/University of Alaska Fairbanks. www.ankn.uaf.edu/standards/



Ray Barnhardt is professor emeritus of cross-cultural studies and rural development at the University of Alaska Fairbanks, involved in Indigenous education teaching and research since 1970. At UAF, he served as director of the Cross-Cultural Education Development Program (X-CED), the Small High Schools Project, and the Center for Cross-Cultural Studies. He co-directed the Alaska Rural Systemic Initiative with Frank Hill and Oscar Kawagley. His research interests include Indigenous education and knowledge systems, institutional adaptations and alternative approaches to management and organization, and include research in Canada, New Zealand and Iceland.

Chapter 1

Native Science and the Cosmos



Gregory A. Cajete

Abstract This essay presents perspectives of the history and traditions as it relates to the collective visioning of the night sky by Native Peoples of the Americas. Perspectives of cosmology, relational philosophy, and the cosmic journey as viewed through “Native Eyes” are presented. These perspectives have been drawn from numerous sources to create an overview of the nature of Native Astronomy. Each example presents a window into the world of Native Astronomy and is intended to give the reader an interpretive overview of the rich and extensive heritage of this area of Native Science.

Keywords Native science · Ancient astronomies · Relational philosophy · Natural community · Sense of place

In this chapter I have used only researched examples from previously published works on Native astronomies. There are many examples that are still intimately related with ceremonial life of certain groups of Native American tribes that exist whose need for cultural privacy I have tried my upmost to honor and respect.

Portions of this chapter have been adapted from a talk given at the Institute of American Indian Arts in Santa Fe, New Mexico on January 23, 1989, which formed the basis for a chapter in previously published work: Cajete, Gregory A. (2000). *Native Science: Natural Laws of Interdependence*. Santa Fe: Clear Light Publishers.

The terms *Native Science*, *Native Astronomy*, *Indigenous Peoples* are capitalized to add emphasis and to convey an active and evolving identity. (The term *Native* or *Indigenous* is used as the larger inclusive group term while *Tribal* refers to specific contexts, both terms are capitalized as an honorific designation. The term *Native American* is used when referring specifically to a Tribe which resides in the United States).

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