If Indigenous Peoples Stand with the Sciences, Will Scientists Stand with Us?

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Abstract: Indigenous sciences are foundationally based in relationships, reciprocity, and responsibilities. These sciences constitute systems of knowledge developed through distinct perspectives on and practices of knowledge creation and decision-making that not only have the right to be pursued on their own terms but may also be vital in solving critical twenty-first-century challenges. "Science" is often treated as if it were a single entity, free of cultural influences and value-neutral in principle. Western science is often seen as instantiating and equivalent to this idealized, yet problematic, view of science. We argue for engagement with multiple perspectives on science in general, and increased engagement with Indigenous sciences in particular. As scholars focused on human learning and development, we share empirical examples of how Indigenous sciences, sometimes in partnership with Western science, have led to new discoveries and insights into human learning and development.

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For many years, wildlife biologists who observed coyotes and badgers hunting in the same area hypothesized that they were competing for game and speculated that badgers would follow coyotes in hopes of snatching their prey. After further observation, the biologists realized that badgers and coyotes often hunt cooperatively and that this in fact makes them more successful. The logics in these studies mirrored reasoning patterns within some Indigenous communities: that is, Indigenous peoples often focus on and inquire about reciprocal relationships between entities. It is possible, therefore, that different cultural orientations may facilitate different insights into badger and coyote behavior. To further test this insight and place these findings in a cultural context, we removed all the text from a children's book on coyote/badger hunting, asked U.S. college students and Indigenous Panamanian Ngöbe adults to look at the book's illustrations, and listened to what they thought the book depicted. U.S. college students interpreted the story

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as competitive, while Ngöbe adults saw it as cooperative.[1] This study shows that cultural orientations influence how we interpret and explain our observations – both in our everyday lives and when we build systems of knowledge.

Indigenous sciences build knowledge about the world through a distinct set of orienting values, concepts, and questions. These include: What is worthy of attention? What needs explanation? Who is related? How? Why does it matter? Tewa scholar Gregory Cajete has articulated one of the most important concepts of Indigenous science in this way: "everything is related, that is, connected in dynamic, interactive, and mutually reciprocal relationships."[2] This foundational premise shapes Indigenous sciences both in principle and in practice through methods of knowledge building. Cajete goes on:

> The ultimate aim [of Native science] is not explaining an objectified universe, but rather learning about and understanding responsibilities and relationships and celebrating those that humans establish with the world. Native science is also about mutual reciprocity, which simply means a give-and-take relationship with the natural world, and which presupposes a responsibility to care for, sustain, and respect the rights of other living things, plants, animals, and place in which one lives.[3]

As Cajete argues, Indigenous sciences are relationally organized. This has implications for the way humans live and for the responsibilities we carry to each other and to our relatives who make up the rest of nature, including not only plants and animals but also the sun, stars, waters, and land that constitute our ecosystems. This ecological axiom grounds the questions and methods of most Indigenous sciences, fulfilling ethical responsibilities that ultimately contribute to the larger collective good.

In the twenty-first century, climate change will require human communities to adapt and reimagine interdependent relationships with and responsibilities to the natural world and each other. Science will play a critical role in meeting these challenges and developing policy that facilitates the collective good. But what kind of science, and mobilized by whom?

Responding to recent political attacks on scientific inquiry, the March for Science, held on April 22, 2017, drew more than 1.3 million people to over six hundred marches across the United States and around the world. The organizers emphasized the importance of science in policy and decision-making, insisting that they were "championing science for the common good." As a collective social benefit, the organizers argued, science "should neither serve special interests nor be rejected based on personal convictions."[4] "Science" was framed in the singular, as a neutral, value-free practice understood by all.

Among the many banners at the Washington, D.C., March for Science, one read "Let us march not just for science – but for sciences!" The sign was the inspiration of Professor Robin Kimmerer, Director of the Center for Native Peoples and the Environment at the SUNY Syracuse College of Environmental Science and Forestry. Professor Kimmerer herself was an invited speaker at the D.C. rally,[5] where she argued that Indigenous science constitutes an important accompaniment to the dominant paradigm of Western science – one that may be vital in addressing contemporary problems related to climate change and sustainability. Reactions to Kimmerer's argument were mixed. Some critics argued that qualifying terms like "Western science" demeaned science itself, and that talking about an "Indigenous" science was "crossing a line."[6] Many were willing to concede that Indigenous peoples have accumulated substantial knowledge of the natural world (often termed "traditional ecological knowledge"

or TEK by Western scientific communities) but recognize that knowledge as significant only when it has been "verified" by modern science – such as when wildlife biologists confirm the cooperative hunting behaviors of badgers and coyotes.[7] To these critics, there is only one science, which is defined by a scientific method assumed to be transparent and objective and which produces data replicable by other scientists.

Like all human activity, science is not infallible. Humans are cultural beings influenced by the contexts and times in which we live. Colonialism, and the racism that accompanied it, shared a partnership with sciences that used biased, ethnocentric tests and measurements to support claims of colonizers' cultural superiority. Has Western science – and the policies associated with it – been somehow liberated from its ethnocentrism? Unsurprisingly, the answer is no. The mythology of a cultureless, value-neutral science continues to capture the popular imagination as well as that of science itself, and it can and does cause harm to communities. A culturally contingent theory of infant-parent attachment, for example, has been treated as a universal standard and has served as a justification for removing children from families with communal cultural practices (including Indigenous families).[8] Furthermore, the myth of value-free Western science prevails in many school curricula, contributing to the ongoing problem of differential achievement and engagement in science by underrepresented communities – including Indigenous people.

Kimmerer does not call for the "inclusion" of TEK in (Western) science; instead, she calls for a heterogeneity of sciences, which would both value multiple systems of knowing and engage with methodologies developed within different cultural communities. Kimmerer's admonition to recognize multiple sciences is critical. In a way, however, the point has already been conceded in another context: across disciplinary differences within Western science. After all, the United States has a National Academy of Sciences, not a National Academy of Science.[9] Although these sciences do not have clear borders or boundaries, the methods of geology differ from those of sociology; and sociological methods in turn differ from those found in neuroscience or economics. Disciplinary labels themselves conceal substantial variability. The National Academy of Sciences, for example, has more than a dozen divisions focused on different aspects of biology alone. These variations within Western science exhibit differences in worldview (even as they are unified by practices such as being public and subject to replicability). Furthermore, the academy at large has no difficulty recognizing the power of problem-centered interdisciplinary work that crosses boundaries of methodological and even epistemological difference. The National Science Foundation and National Institutes of Health, for instance, provide guides to encourage interdisciplinarity and collaborative research efforts and even earmark funding streams for such research.

Why, then, the resistance to calls like Kimmerer's? Resistance to expanding the possibilities of sciences is often driven by the assumption that one "true" science emerged from the history of Western civilization and that Western ways of knowing are therefore inherently superior. (However, even much of what is popularly imagined to be "Western" originated in China or in the Middle East.) Non-Western peoples, as the subjects of Western conquest and colonialism, are even today inevitably read as less able to observe, deduce, hypothesize, experiment, and make sense of their worlds than their European or European American counterparts. Skeptics of Indigenous sciences frequently assert that non-Western ways of knowing do not aim for objectivity or are incapable of achieving objective knowledge.

We hold that Indigenous sciences are no less objective than Western science; they value truths, not agendas. Indigenous science operates around a set of values, as does Western science. Values enter into the practice of science in all kinds of ways, including decisions about what to study and how to study it, the framework in which findings are interpreted, and how knowledge ought to be shared. "Objectivity" therefore cannot and should not be equated with "value-neutrality." We must pose the question: whose values and whose knowledge systems are accepted as legitimate in a multicultural, multi-epistemological world? The policing of disciplinary borders has been, and continues to be, a constitutive factor in the common sense surrounding "science." We propose that the practice of excluding the values and methods of Indigenous science from science and from society more generally poses significant dangers, not only to Indigenous peoples but to all peoples. Further, these exclusionary practices unnecessarily reify tensions and conflict between communities.

Indeed, Western sciences and Indigenous sciences are not necessarily incommensurable in principle. Indigenous methods sometimes align, diverge, or conflict with Western science and may also be critical complements to it in answering the most pressing questions of the twenty-first century. Engaging heterogeneous sciences – specifically Indigenous sciences – can expand our collective knowledge and are critical if sciences (in their plurality) are to become champions of the common good and adequately respond to contemporary problems.

Imagining science for the common good requires exposing the ethnocentrism embedded within science and science education and appreciating how values guide scientific activity. Achieving commensurability in the sciences will also require the formation of new ethical partnerships with Indigenous peoples, partnerships that prioritize Indigenous self-determination and leadership. If Indigenous peoples stand with the sciences – as we will – will scientists also stand with us?

As Indigenous social and behavioral scientists, engaging both Indigenous sciences and Western science(s), we always consider how to stand with the communities with whom we work. We espouse a two-tiered engagement with Indigenous sciences: first, through foundational knowledge building about human learning and development, and second, through engaging youth, families, and communities in Indigenous science-learning environments.

We also build our scientific pursuit on foundational premises of Indigenous science through a framework of *relational epistemologies*.[10] What do we mean by this? With respect to the more-than-human world, scientists engaging relational epistemologies will:

1. view humans as a part of the natural world, rather than apart from it;[11]

2. attend to and value the interdependencies that compose the natural world;[12]

3. attend to the roles actors play in expanded notions of ecosystems from assumptions of contribution and purpose, rather than assumptions of competition;

4. focus on whole organisms and systems at the macroscopic level of human perception (also a signature of complex-systems theory);

5. see all life forms as agentic, having personhood and communicative capacity (as distinct from anthropocentrism);[13]

6. adopt multiple perspectives, including interspecies perspectives, in thought and action; and

7. weigh the impacts and responsibilities of knowledge toward action.

These relational epistemologies suggest patterned cultural differences in ways of

looking at and making sense of the world. Still, these dimensions may not be equally important for or shared by all Indigenous sciences and thus cannot be assumed to be valid across all Indigenous communities. Also, we recognize the extent to which many "Western" natural scientists have arrived at some of the same conclusions. However, Western science rarely combines all of these dimensions in a coherent and intentional way.

As learning scientists, we are interested in what relational epistemologies look like in the context of knowledge and reasoning. Recently, we have partnered with the American Indian Science and Engineering Society (AISES) to explore the values and orientations of professionally accomplished Native scientists and Native students pursuing STEM degrees.[14] Interviews with Native scientists and scholarship essays written by Native STEM students both highlight the persistent themes of giving back to the community and of education as a process of transformation. These students' choices about what degree to pursue were motivated by both personal experience and the desire to give back to their communities. They strive to acquire knowledge and tools generated from the sciences as a way to contribute to community needs and goals, based on principles of relationality, reciprocity, and responsibility commonly found in Indigenous knowledge systems.[15]

Cultural comparisons can also reveal how Indigenous knowledge systems shape human epistemic actions and behaviors. Broadly speaking, we can make comparisons between Indigenous and non-Indigenous belief to see if there is a systematic variability in knowledge-building practices and frameworks. We conducted interviews with parents and grandparents from Menominee and intertribal urban communities as well as with non-Native parents and grandparents, in which we asked: "What are the five most important things for your children (or grandchildren) to learn about the biological world?" and "What are four things that you would like your children (or grandchildren) to learn about nature?" Almost all the respondents expressed beliefs about the need to respect nature, but their perspectives differed. The European American respondents typically described nature as an external entity, saying things like, "I want my children to respect nature and know that they have a responsibility to take care of it." In contrast, Native American adults were more apt to say that they want their children to understand that they are a part of nature.[16] The distinction between being *a part of* nature versus *apart from* nature reflects qualitatively different models of the biological world and the position of human beings with respect to it.

This sharp difference in orientations is easily demonstrated through a quick Google Image search of the term "ecosystem." In one search, about 98 percent of the illustrations Google returned did not contain human beings and about half of the remaining images depicted schoolchildren as existing outside the ecosystem ("observing it" through a magnifying glass, for example).[17] Despite the efforts of ecologists, environmental historians, and American Indian sciences and philosophies, the dominant cultural view continues to suggest that people are not part of ecosystems. U.S. policies clearly reflect the belief that earth, energy, animals, and plants exist solely as resources for human betterment.

This divide has been a continual topic of interest in our research, which has focused on the broad question of cultural differences in orientations within and about the natural world among Indigenous and non-Indigenous peoples. We operate according to the axiom that peoples' epistemologies are implicitly reflected in their words, actions, and interactions with others in spe-

cific times and places, including the way in which they engage with the rest of nature and with science.[18] We will summarize some of this work as a series of short and suggestive examples, acknowledging that our scholarship derives from leading Native scholars like Vine Deloria, Gregory Cajete, Oscar Kawagley, Linda Smith, and Manu Meyer, among many others.

Our first example is a project in which we asked Menominee and non-Native fishing experts from the same area of rural Wisconsin to sort names of local fish into sensible groups. Non-Native experts tend to sort taxonomically ("these fish belong to the bass family") while Menominee experts are more likely to sort ecologically ("these fish live in cool, fast moving waters"). Non-Native experts describe and value fish in terms of utility to human beings ("good as baitfish") while Menominee experts take a more ecosystem-based perspective, evidenced by such statements as "I don't know much of anything about gar but they are important because everything has a role to play."[19]

In a parallel study, we asked Menominee and European American hunters in the same part of rural Wisconsin to name the most important plants and animals in the forest, how they value each kind, and how important each kind is to the forest: a way of asking about their perception of relationships.[20] Game animals were rated as equally important across communities, but Menominee hunters rated nongame animals to be more important both for themselves and for the forest than did European American hunters. Menominee hunters often said that if something was important to the forest it was important to them. In other studies we found that Menominee children were more likely to spontaneously take the perspective of an animal than were their non-Native counterparts.[21]

In one assessment of attention to context, we simply asked rural Menominee and European American adults to tell us about the last time or a memorable time when they went fishing. Our dependent variable was the number of words spoken before the informant mentioned the goal (the fish). The median number of words European Americans spoke before mentioning fish was twenty-seven; in contrast, for Menominee adults, "fish" was the eighty-third word – a striking difference. In fact, the reason we had to use the median rather than the mean is that several Menominee adults never got around to mentioning fish at all. Instead, they tended to describe the context (the weather, place, and who and what else was present) in detail. Informally, Menominee adults have told us that their goal in telling a story is to put a picture in the listener's head, one that might allow listeners to obtain a first-person perspective on the entire scene.

Such attention to context may be critical to sustainability efforts. In a Menominee community meeting we attended, the discussion turned to the role of research studies in forest-management proscriptions. Research studies were criticized for basing their findings on ideal growing conditions that "do not necessarily apply here because our soils are different and rely on rain, not watering." Vandana Shiva has documented how crops developed for "ideal" growing conditions can lead to profound environmental damage when farmers are forced to distort normal conditions to achieve these ideals by, for example, using unsustainable amounts of water.[22]

Indigenous sciences expand concepts of life, agency, and personhood. This phenomenon manifests in children's reasoning. For example, in a study of the core biological concept of life, we asked children to identify what their elders thought was alive and what their science teacher thought was alive. Native children reported that their elders considered rocks, water, and the sun to be alive.[23] Some dismiss

these differences simply by saying that the elders are wrong about rocks, water, and the sun because they are not, in fact, alive. A more open-minded alternative considers the possibility that the Indigenous elders have a different conception of life, one that is generative from an ecological perspective since these so-called natural inanimates play important roles in ecological relationships.

In addition, Indigenous concepts of agency may define it in terms of relationships and communication rather than on taking humans as prototypical agentic beings and evaluating agency in terms of a supposed index of human intelligence (such as brain size). For instance, from a Western perspective, plants have little agency. This logic has arguably held back emerging research on plant abilities and intelligence,[24] as Western scientists now understand that some plants can recognize and selectively favor kin and that many plants can signal the presence of threats.[25] In line with the cultural differences we have described, however, a study has shown that U.S. college undergraduates still deny that plants can recognize kin, while Panamanian Indigenous Ngöbe adults say they can. Despite significant differences, however, we also find points of commensurability through which Western "science" might actually embrace multiple "sciences." Some branches of ecological sciences and anthropology, for example, are expanding their definitions of life even further than what we have described here to understand interspecies relations and communication, using ideas that have been central to the relational epistemologies of Indigenous peoples.[26]

We have investigated the values and principles underpinning Indigenous sciences; what else do we want to highlight about Indigenous methodologies? It is a commonplace that all good science starts with observation. Like Yogi Berra, who famously stated "You can observe a lot by just watching," many people assume that observation is straightforward. Observation can produce empirical knowledge, though it is easy to forget that such knowledge – and indeed observation itself – is influenced by culture and social practice. In our research, we define observation as a rich multimodal practice, involving the simultaneous coordination of attention, prior knowledge, and explanatory frameworks. Protocols and methods of observation are culturally inflected, as are the values about where and when to observe.[27] For example, when asked whether porcupines help or harm the forest, non-Native hunters commonly noted that porcupines are destructive due to their habit of girdling and killing trees. Menominees know about this effect too, yet some viewed it positively, because tree death opens the forest up to light, which allows smaller plants to grow, which in turn provides ground cover that helps maintain soil moisture. The Menominees' wider observational scope and understanding of causal links with porcupines' behaviors enabled them to see porcupines as contributors to the forest when European Americans did not. Menominee understanding led them to differently value porcupines as members of the forest community.

Many Indigenous communities use this type of dense observation to know, build relationships with, and "story" the world.[28] Such communities are today creating Indigenous science, Indigenous political economy, and Indigenous arts and humanities – reflecting that Indigenous sciences are but one part of Indigenous knowledge systems. Ethnographic research with Indigenous-heritage Mexican and Guatemalan communities has led to the articulation of a useful framework – Learning by Observing and Pitching In (LOPI) – that acknowledges the central role of observation in learning. LOPI, developed by Barbara Rogoff and

colleagues, accounts for understudied dimensions of learning, including who is seen as constituting community, how communities are organized, forms of communication, and the kinds of motives or goals individuals and groups have. Indigenous models of education, such as those described by LOPI, are usually intergenerational and focus on contributing to community. In contrast, Western formal education typically segregates by age and stresses utilitarian individualism. We have built on the LOPI framework to consider the role of land and more-than-human life in learning through observing. (We use the term "more-than-human" instead of nonhuman in a rhetorical effort to break away from human/nonhuman binaries in reasoning, to challenge anthropocentric worldviews, and to draw attention to multiplicities of life.) We view the practice of observation as being central to both Indigenous and Western science, though they may be enacted in different ways or find points of agreement and overlap.

Science educators tend to describe observation in unidirectional terms, saying that humans observe the world around us. Indigenous sciences are more likely to approach observation using a systems perspective, remaining aware that while we observe the world around us, our relatives are also observing us. Humans live as part of a watchful world. Land, animals, plants, and other beings have agency and influence the structure of human interactions, most notably the movement of our bodies in relation to others.

For generations, Indigenous communities and intellectuals have described the roles of motion, mobility, migration, and land in learning.[29] Here, learning is conceived as the work of collective knowledge production across generations in support of activities necessary for sustaining and promoting life.[30] Building on scholarship in Native sciences and perceptions of the environment,[31] we suggest that walking relationships with land are important to knowledge-making processes, especially when it comes to knowing the complex relations in ecosystems. Learning to "read" and "story" land – to make observations and develop explanations based on engaged observation – are critical ways of being in relationship with the natural world.[32]

In one study of this phenomenon, we invited caregivers and young children to go on walks in forest preserves while wearing cameras to capture their walks. After collecting the footage, we synchronized caregivers' and children's videos so that they were layered side by side. The individuals' subjective views paired with the side-by-side synchronized views allowed us to walk along with families and hear/see their stories. Through this multidimensional view, the structure of walks became apparent. Just as conversations have turns of talk, Marin noticed turns of walking, or "ambulatory sequences," which were observable in multiple families' walks. In these sequences, families noticed phenomena, asked questions, and storied their observations.[33]

We have come to think about *walking, reading, and storying land* as one methodology for making sense of physical and biological worlds.[34] Storying land or observations of the lifeworld are iterative processes. They coordinate attention with the development of preliminary theories and the search for evidence. These dimensions are assembled through the layering of discursive, embodied, and ambulatory micropractices (questions and directives, pointing gestures, shifts in movement). They involve a kind of navigation in which people weave their way through emergent understandings of local phenomena. Crucially, the land itself also acts in this process. In forest walks, the trail one follows and the movement of walking are human decisions, but they are influenced by the contours of land and our feet feeling the

ground. Walking along a deer trail feels quite different from walking along a floodplain or a bike path, and what is available for observation differs across these contexts. The "where" and "when" of human activities makes a difference in observations. Place foundationally shapes human activity and figures centrally in the process of knowing.[35]

Kimmerer develops an analogous theory about questions: we do not ask them in a vacuum, but in a context; what we ask, how, and when are all related.[36] Asking questions about relations illuminates answers that true-false questions may not. For instance, Kimmerer explores how reciprocal mutualisms (or symbiosis) between algae and fungus can become invisible in laboratory conditions that facilitate "optimal conditions" for each organism. In such conditions a scientist might focus on the growth and reproduction of the individual. Scientists have become increasingly aware, however, that algae and fungus have coevolved to the point that they cannot survive alone. A more appropriate question might be how relationships themselves shape growth and adaptation.

Indigenous sciences presume that knowledge carries ethical obligations and responsibilities. Relationality matters: it shapes *who* is doing the explaining, *how* they are explaining, *to whom* they are explaining, *why* they are trying to explain, and the impacts such explanations may have. The March for Science actively advocated for science for the public good, holding that science should be applied to policy and contribute to human life. The reliance on a principled attitude toward science is valuable, but in specific instances, Western science continues to be conducted, shared, and used in ways harmful to Indigenous peoples, including in legal attacks on Indigenous sovereignty.[37] Any engagement with Indigenous sciences must recognize how Western "science" is historicized, cultured, and empowered in relation to Indigenous peoples' ecological, political, economic, and social interests. At best, engagements among sciences will help achieve just and ecologically sustainable futures; at worst, they will perpetuate additional harms to Indigenous peoples.

Engagement with Indigenous sciences requires the knower to recognize, cultivate, and support Indigenous peoples and their efforts to create thriving communities. Non-Indigenous scientists, policy-makers, and institutions (especially nation-state governments and educational institutions in their many forms) need to recognize the powerful historical accumulations and institutional structures that have consistently undermined Indigenous communities and ways of life. Engagement with Indigenous sciences will require commitment to transform processes that uphold and assert Western epistemic supremacy. Importantly, this is not intended to suggest that Western epistemic practices have not been productive or should not continue; rather, we object to the insistence on their singularity.

Scholars of education are coming to understand the critical roles of identity and motivation in disciplinary learning, as well as the ways in which disciplinary identities are formed at very young ages. Learning environments must also make the shift to engage heterogeneous ways of knowing as foundational to learning.[38] We are raising new generations of young people who will inherit some of the most challenging problems human communities have ever faced. We need new understandings of relations between humans as well as to more-than-humans and the lands and waters we dwell in.

Humanity is receiving clear messages that our ways of doing are no longer sustainable. Indeed, human responses, adaptations, and reimaginings of interde-

pendent relationships with, and responsibilities to, the natural world may be the central challenge of the twenty-first century and will figure centrally in the stories told to future generations.[39] However, the kinds of relations between humans and other life forms, and the lands and waters we all dwell in, are yet to be determined and enacted in these stories. The role of the sciences in meeting the challenges, developing policy, and shaping the stories of the future is critical. But what sciences? Indigenous sciences may be critical in cultivating the just and sustainable futures that will be part of our survival.

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