Native Americans and Science: Enhancing Participation of Native American in the Science and Technology Workforce Through Culturally Responsive Science Education.

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Abstract:
A major issue which directly impacts participation of Native Americans in the science and technology workforce is the lack of preparation in science and math. This lack of preparation has many causes but one of the most prevalent is the lack of culturally relevant curricula which engage Native American students in the learning of science in culturally meaningful ways. This article describes the development and implementation of a culturally responsive science education curriculum model at the Institute of American Indian Arts in Santa Fe, New Mexico from 1974-1994. This approach to teaching and learning science based on the cultural orientations of students predates many of the current STEAM initiatives that have gained attention in recent years. The culturally responsive science curriculum developed at IAIA is explored as a case study which may shed light on how to engage more Native American students in science and to become more prepared to participate in science and technology related professions.

A Personal Introduction

I am an educator of Native American people. What I have been doing and where provides context for understanding what is meant by indigenous science, and the role I play as a Native American educator. I am a Tewa Indian from Santa Clara Pueblo which is one of six Tewa speaking villages north of Santa Fe, New Mexico. Each of these Pueblos is autonomous but is related to others through custom and language.

Growing up in a community with other people of your culture who are related or are living in a similar way, I didn’t realize my difference. I didn’t really understand that it made a difference until faced with the bias of mainstream society and as I began to interact with other cultural groups in college. It was then I realized how different Native American people were, and how we viewed life and education in some very distinct ways. It was these realizations of difference that made me decide to go to a college that was not far from my home, and which allowed me to maintain constant contact with my community and culture.

After graduating from college in 1974 with a degree in biology and sociology, I began to teach high school science at the Institute of American Indian Arts in Santa Fe, New Mexico. The Institute of American Indian Arts (IAIA) opened in 1962 under the auspices of the Bureau of Indian Affairs. The purpose of the IAIA was to evolve a context in which the artistic potentials of young Native American people from all over the United States could be cultivated and expressed. In many ways the IAIA was an experiment in cultural education which focused on
using cultural and contemporary arts as a primary vehicle helping Native people learn about themselves, their culture and their identity and at the same time be trained in an art vocation. After its opening in 1962, the Institute became famous as a model school as it was recognized by UNESCO as being one of four culturally based schools of note in the world.

For five to eight years it was indeed a shining light in the world of Native American education. But, as is the case when an entity is connected with the US government, and especially with the Bureau of Indian Affairs, it was vulnerable to the winds of political change. In the late seventies the Institute fell on difficult times and was moved from its original campus to The College of Santa Fe, where it became a “tenant” of that college. In 1988, Congress enacted new legislation entitled the American Indian Arts and Development Act, which chartered the IAIA as a public/private entity with its own direct congressional funding. Today, due the enormous efforts of many people, the IAIA enjoys a new state of the art campus and has regained its former status as a premier Native American Tribal College (see: www.iaia.edu).

At that time I started teaching at IAIA in 1974, the school had a junior and senior high program as a feeder program for the two year Associate of Fine Arts degree program in the college. During my first year of teaching, I realized that many of the ways of teaching and approaching science, or so called text book science, were not appropriate for many of my students. My students came from all over the United States, from urban environments, rural environments. Some were very traditional in terms of their upbringing, others were not. All had a common thread and that was an interest and a willingness to explore the arts. They also possessed a common alienation from science educational approaches they had experienced in reservation and public schools. Charged with making a program work for these students, I put aside the textbook methods I had learned in college and created new curricula from the ground up based on my own creative thoughts, my experience as a self-taught artist and the passionate input of my students. It was a great learning experience in that I allowed myself the creative space to explore the possibilities of cultural responsive and arts oriented science curriculum design. It was a space that would not have been allowed in most other schools. I explored and created with the students a process that allowed them to learn in ways they felt good about.

The curriculum evolved over a number of years. It began with the introduction of Native uses of plants in a health science class I was teaching, and it grew into a full developed culturally responsive science program. Its story is a story of creation, of the process of interaction in science, art and culture and the integration of those aspects into the expression of a curriculum—a learning, teaching process that actually works well for native students who wish to understand and learn about their lost heritage as it relates to science. The curriculum evolved around the idea that every Indigenous culture has an orientation to learning, and that orientation is metaphorically represented in its art forms, its way of community, its language, and its way of understanding itself in relationship to the natural environment that contexts or cradles it.

I realized a solution to this issue of student alienation from science would require an extension of the cumulative influences of Native science, cultural education and the creative process. The insights gained from research in these areas and their implications for the way science is communicated to Native American students form the orienting basis for this work.
The Social Cultural Foundations of Science

Science is social and cultural, as well as an individual process of thought and has been utilized in some form by every human cultural group. The processes and products of science and their intimate relationships with human culture form an important part of education.

Research in the area of scientific knowledge transfer in an educational setting based on a cultural perspective is only now being pursued. Much of the work concerns the study of the relationship between scientific and artistic thinking in terms of characteristic brain functioning. The most recent research in this area comes not from science educators but from individuals studying split brain characteristics, cultural learning, creativity, art, cognitive psychology, linguistics, holistic health, theoretical physics and cultural anthropology.

The scope of study in cultural anthropology encompasses literally all human activities — including science. Cultural anthropology is one of the few Western disciplines which attempts to understand a given aspect of a culture as a whole, from the inside, and on its own terms. It is this basic characteristic of the methodology of cultural anthropology which lends itself most readily to the understanding of the realities of Western culture through the “other’s” eyes.

Individual attempts to investigate how cultural processes of classification and perception affect scientific thought have been led by anthropologists like Benjamin Whorf and Magorah Marayama. Marayama and others have approached researching science as a cultural system. Through the examination of the ideas of traditional societies, they have begun to widen the parameters of understanding the nature of scientific thought and knowledge.

One of the major insights into the cultural perception of “separate realities” came about as a result of the field work of Benjamin Whorf (1956) among the Hopi Indians of Arizona. Whorf hypothesized that thought is intimately related to and even guided by a people’s language. Implied is the idea that “realities” are different from one culture to the next. In a very real sense we are all wrapped up in our own cultural blanket by our language, worldview and perceived reality, and directly perceive and order the world in reference to this schema. Whorf proposed that Hopi terminology for certain aspects of physical reality reflected a better description of that reality than did modern Western terminology. The implication here is that Western structuring of reality through language does not represent the exclusive legitimate perspective of reality.

The research of a number of scholars indicates that there is a “mismatch” between the perspective from which science is traditionally presented in American schools and the general cultural and individual learning styles of Native Americans (Cajete 1999). After pointing out that "...a system of classification and the conceptual reason for that system as well as behavior in reference to this system forms the essence of ‘science’ in every culture..." Edward T. Hall (1976), in Beyond Culture, adds: "Western science tends to overemphasize the process of classification at the expense of information about the organism...which has led Western thought to be predominately preoccupied with specifics to the exclusions of contexting within wholes.”
Further, Hall questioned the taken for granted logic of science by asking, "How can integrative systems of thought be developed from a classification system that fragments and never gets around to putting things together in wholes?"

The research of early researchers in this area, Richard Blakeslee (1980) and Bernice McCarthy (1980), exemplifies the insights developed for applied psychology in an educational context. In his book, The Right Brain, Blakeslee summarizes what was then known about the characteristic thought processes associated with the right hemisphere of the brain, processes often reflective of the patterns of thought associated with many Native American learners (Blakeslee, R. 1980). Bernice McCarthy's highly innovative "4-Mat Model" allows for more holistic and integrative approaches to teaching to learning styles with right-left mode techniques. It addresses the innate individual differences in learning styles which directly affect knowledge transfer.

I would go one step further than McCarthy in pointing out that not only are there differences in learning styles of individuals that reflect right/left brain processes, but there are socio-cultural differences as well. Science in most American schools is presented from a perspective that is heavily oriented toward what McCarthy labels the "type two left-brain learner," a learner who is highly analytical, objective, verbal, structured, and parts oriented. Native American students tend to be intuitive, subjective, non-verbal, synthesizing and oriented to wholes. This research which was conducted in the late 1970’s and early 1980’s, and the later work of Howard Gardner (1985) may be viewed as relatively simplistic by today’s standards of brain research but they were on the right track in that they recognized that human learning was much more complex and multidimensional and therefore required much more comprehensive and integrative approaches to teaching.

In January, 1975, the American Association for the Advancement of Science Board led by Margaret Mead, passed a resolution that formally recognized the contributions made by Native Americans to the various fields of science, engineering and medicine, and supported natural and social science programs in which traditional Native American approaches and contributions to science, engineering and medicine were the subject of serious study and research.

Based on this mandate, Dr. Rayna Greene, director of the project on Native Americans in Science for the AAAS, advocated research and development of culturally-based science. Through various studies, insights into the unique problems and perceptions of culturally-based science programs have emerged. Dr. Greene summarized:

"... the lack of Indian participation in science is as much due to an alienation from the traditions of Western science as from a lack of access to science education, bad training in science, or any other reasons conventionally given for minority exclusion from scientific professionalism. Contrary to the general insistence of Western scientists that science is not culture bound and that it produces good, many native people feel that science and scientists are thoroughly Western, rather than universal, and that science is negative" (Greene, 1981: 8).

A difference in perception exists in a science that is directly related to the cultural nature of the society from which it originates. This must be seriously addressed if Native Americans are to increase their active participation in the field of modern science.
The study of the ethno-science of the Indians of North America is a valuable tool for understanding the cultural influences in science and a way for Indians and non-Indians to gain valuable insights about themselves and the unconscious cultural conditioning of their perspectives of natural reality.

The ethno-science of each tribe or cultural region is unique and characteristic of that group or geological area in that it reflects adaptation to a certain place. However, “strands of connectedness” and similar patterns of cultural thought begin in the northern polar regions of North America and extend all the way to the tip of South America. The mythical paradigms of the Trickster, the Sacred Twins, the Earth Mother, the Corn Mothers, the Thunderbirds, the Great Serpents, the Culture Hero, Grandmother Spider Woman, Tree of Life — all exemplify the interrelatedness of Indian cultures. All are extensions of the process of “science” in that they reflect a cultural interpretation based on observation of phenomena and processes inherent in nature. They represent a very primal and artistically metaphoric way of perceiving — a distinctly Native American way of viewing the world (Cajete, G. (1994).

Until relatively recently, the arts, the hard sciences and the social sciences were presented as totally discrete entities in most American school curricula. Indeed, in many American schools they still are. Such an approach has tended to fragment the human cultural systems being examined, thus perpetuating a distorted perspective of the arts, the sciences and culture in the minds of many students. This approach has been particularly unfortunate for Native Americans.

The fact that science is presented entirely from the Western cultural perspective in most American schools can create a very real psychological conflict for a student raised in a different cultural tradition. It is this conflict and resulting alienation that forms the basic impetus for this work.

As is true with all primal cultures, science as a process of perceiving was completely integrated with all aspects of Native American cultural systems. The process of teaching and learning science today becomes a matter of discovering the products and determining how and why these early thought processes evolved into these paradigms within the context of each tribal culture and environment.

When one begins to interpret and translate the symbolic language, art, dance, music, ritual and other cultural wrappings through which these paradigms have been transmitted, one realizes that they reflect perceptive and sophisticated ideas about the essence of nature and the universe. Research by scientists Fritjof Capra, David Bohm and others into underlying concepts of many ancient philosophies reveals that many primal sciences have incorporated understandings into their systems that are only now being explored by the most advanced research in Quantum Physics (Cajete, 2000).

Preliminary attempts are now underway to explore the philosophical foundations and ritual practices of primal cultures using the perspectives gained from ecology, the creative process, split brain research, linguistics, theoretical physics, anthropology and Jungian and archetypal psychology. This re-examination has great potential in that it presents a method of
transformation and interpretation of these important paradigms of Native America in the context of the 21st century.

Science as a Cross-Cultural Discipline

Very few studies have seriously explored the unique and culturally conditioned learning characteristics of Native Americans. Until the relatively recent interest in field sensitive vs. field independent orientations by some minority group learners, few researchers had focused upon the notion that the most effective way to educate was to develop teaching and learning strategies around distinct learning styles. Based on the concept of “cultural deprivation,” the predominant notion has been to change the learning style through “educational reconditioning” so that students would conform to the mainstream educational system. From the earliest missionary attempts through the boarding school era to the present stage of public school education, Native American education has been dominated by attempts at “reconditioning” Native American learning styles.

Fortunately, with the introduction of self–determination in Native education and the concurrent trend of cultural revitalization, this situation is beginning to change. In order to continue such a movement toward a more culturally relevant and learner sensitive education, some very important factors must be considered.

Significant learning is directly related to the degree of personal relevance the student perceives in the educational material being presented. The basis for such a premise stems from the idea that motivation toward any pursuit is energized by one’s own constellation of personal and socio-cultural values. In the Native American social psyche this constellation of values has very ancient and well-developed roots. It is because of this embeddedness that Native American social personalities remain so durable and relatively visible through layers of acculturation. Understanding and utilization this cultural constellation of values is a key to motivating learning in Native American education.

Since the turn of the century, Native Americans have experienced various levels of acculturation. Acculturation developed configurations of language and culture characteristic of the changes a particular Native American group underwent. For instance, many Native American students can be classified as being "English dominant," which has ramifications for teaching science. For while many are English dominant, they have been exposed, through home and community, to various levels of thought concerning the ways in which their particular tribal groups have traditionally viewed the natural world. There is often a real identification with both the cultural and linguistic revitalization of their particular cultural group. This sense of identification with tribal roots can provide a prime source of motivation to learn about science as it relates to an individual's heritage.

In addition to students rediscovering their tribal identities, there are students who are more completely bilingual and bicultural. These students generally want to continue to learn and live within the context of both cultures. Instruction in bicultural science for these students constitutes a real enrichment of their attitudes toward science and reaffirms cultural ties and identifications
with their tribal groups. Bicultural science instruction for these students provides a means of bridging the sometimes great differences in mindset concerning natural phenomena.

Knowledge of core cultural values of Native Americans and an understanding of how such values differ from the values implied in American education is essential in bicultural education. Some much of the core values of a person’s culture they have internalized is highly dependent upon individual circumstances and can even alternate as dominant tendencies toward valuing in the same individual during different phases of his or her life. Human cultural valuing is a dynamic, evolving process, and human cognitive development does not fit neatly into categories. The many and diverse examples individual cultural valuing illustrate the variety of value sets characteristic of all Native American cultures and individuals in contemporary American society. The transition of values has a direct effect on Native attitudes toward education. Core cultural values of Native Americans and their influences on attitudes and behaviors are relatively submerged since such values tend to operate at the subconscious level.

These values, however submerged, invariably affect the outcome of their educational pursuits. If the student can be made aware of cultural values of his/her people, learning will follow. Showing the student how what is being presented in a particular area such as science is relevant to or enhances the understanding of those cultural values will help him/her to learn. Therefore, a student's values play a key role as psychological “energizers” for the positive evolution of self-image.

The accelerated rate of change since World War II has increased the inconsistencies in worldview and cognitive fabric of Native American life resulting in much intrapersonal tension. This conflict has given rise to a variety of emotional and social problems whose ramifications are poorly understood. But a subtle, well-integrated and consistent cognitive map and world view is conducive to healthy concepts of self and positive social adjustment. The opposite is usually apparent when there are acute or chronic inconsistencies and conflict between the internal constellation of values and those of the external social environment.

Cultural content will facilitate educational goals and the development of students both intellectually and socially. Bringing core cultural values from the subconscious to the conscious sets the stage for the creative synthesis and interpretation of those values in a new and psychologically rewarding context.

The following selected, idealized Native American core cultural values underlie contrasts between traditional Native American and non-Native American values and associated behaviors and attitudes. These are not meant to reflect the wide variations within the Native American population related to levels of cultural assimilation nor the differences between Native American cultures (American Indian Education Handbook, 1982).

**Personal Differences**

Native Americans traditionally respected the individual differences in people. Not interfering in the affairs of another and verbalizing one’s thoughts or opinions only when asked are common Native American expressions of this value. That others return this courtesy is expected by many Native Americans as an expression of mutual respect.
Quietness
Quietness and being still are values which serve many purposes in Indian life. Historically the cultivation of this value was survival oriented. In angry or uncomfortable social situations many Indians remain silent. This may be viewed as indifference by non-Indians, when in reality it is a very deeply embedded form of Indian interpersonal etiquette.

Patience
In Native American life the virtue of patience is based on the notion that all things unfold in their own time. Like silence, in earlier times patience was a survival virtue. In social situations patience revolves around respect for individuals, group consensus and “the second thought.” Overt pressure on Indian students to make quick decisions or responses without deliberation should be avoided within most educational situations.

Open Work Ethic
In traditional Indian life, work revolves around a distinct purpose and is done when it needs to be done. The non-materialistic orientation of many Indians is directly reflected by this value. Only what is directly needed is accumulated through work, which is always tied to a specific job. In formal education, a rigid schedule of work for work’s sake (busy work) needs to be avoided since it tends to move against the grain of this traditional value. School work must be shown to have a direct and immediate purpose.

Mutualism
In earlier time’s mutualism as expressed through cooperation was a basic survival value. As a value, attitude and behavior, mutualism permeates everything in the traditional Indian social fabric. “Solidarity” (group security and consensus) is highly valued. In American education the tendency has been to stress competition and work for personal gain over cooperation; the emphasis on grades, personal honors, etc., are examples. With Indian students this tendency must be modified by incorporating cooperative activities on an equal footing with competitive activities in the learning environment.

Non-Verbal Orientation
Traditionally, most Indians have tended to prefer listening rather than speaking. Talking for talking’s sake is rarely practiced. Talk, like work, must have a purpose. Small talk and light conversation are not especially valued except among very close acquaintances. In Indian thought words have primordial power so that when there is a reason for their expression, it is done carefully. In social interaction, the emphasis is on the affective rather than verbal. This is an important consideration in lesson presentation and planning in that activities like a class discussion or too many questions should be avoided. It is because of this general characteristic that many Indian students feel more comfortable with the lecture/demonstration method. Inquiry approach, role playing or simulation are still valuable if presented with full understanding of this characteristic.

Seeing and Listening
In earlier times, hearing, observation and memory were important skills to develop since all aspects of Native American culture were transferred orally or through example. Storytelling,
oratory, and experiential and observational learning were highly developed in Native American cultures. In an educational setting the use of lecture/demonstration, modified case study methods, storytelling and experiential activities can be highly effective if presented from a Native American perspective. A balance between teaching methods that emphasizes listening and observation as well as speaking is important.

**Time Orientation**

Time and its use have traditionally been considered relative. In the Indian world things happen when they are ready to happen. Time was relatively flexible and not structured into compartments as it is in modern society. Because the structure of time with its precise units is a hallmark of the traditional American curriculum, this conflict becomes a problem. The scheduling of activities, fixed class hours and measured time allotment for lesson presentation of Western curricula can precipitate disharmony between the traditional Indian learner and the material being presented. The solution is to allow for flexibility and openness in terms of time within practical limits. Traditionally, Indians oriented themselves to the present and the immediate tasks at hand. This orientation stems from the deeply embedded philosophical emphasis on Being rather than on Becoming. Present needs and desires tend to take precedence over vague future rewards. Although this orientation has changed considerably over the last forty years, vestiges are apparent in the personality matrix of many Native Americans. Learning material presented should have relevancy for the time and place of each student.

**Practicality**

Indians have the tendency to be practical. Many Indians have less difficulty comprehending educational materials and approaches which are concrete or experiential than those which are abstract and theoretical. Learning and teaching should begin with numerous concrete examples and activities to be followed by discussion of the abstraction.

**Holistic Orientation**

Indian culture, like all primal cultures, has a very long and well-integrated orientation toward the whole. This is readily apparent in various aspects of Indian culture, ranging from healing to social organization. Presentation of educational material from a holistic perspective becomes an essential and very natural strategy for teaching Indian people.

**Spirituality**

Religious thought and action are integrated into every aspect of the fabric of traditional Native American life. Spirituality is a natural component of everything. As a general educational tool, this presents a good advance organizer for concept presentation in that all aspects of Indian culture are touched by it. Discussion of the general aspects of spirituality and religion is an important part of the curriculum, although care must be taken to respect the integrity and sacred value of each tribe’s religious practices and inherent privacy. Ideally, all discussions of Native American religion should be kept as general and non-specific as possible. Specifics should be discussed only in the proper context and with the necessary permission of that particular tribe.

**Caution**

The tendency toward caution in unfamiliar personal encounters and situations has given rise to the stereotypical portrayal of the “stoic Indian.” This characteristic is closely related to the
"placidity" and quiet behavior of many Indian people. Such caution results from a basic fear regarding how thoughts and behavior will be accepted by others with whom they are unfamiliar, or in a new situation with which they have no experience. Within the educational context, every effort should be made to alleviate these fears and show that the student’s subjective orientations are accepted by the teacher. The class and lesson presentation should be made as informal and open as possible. An open friendliness and sincerity are key factors in easing these tensions.

**Classroom Discipline**
Among most Indian people, the cultivation of self-discipline is valued. Behavior is regulated through group and peer pressure. Withdrawal of approval, shame and reflecting unacceptable behavior back to the individual are the main forms of punishment in the traditional Indian context. In the classroom, direct and demeaning personal criticism in front of others is considered rude and disrespectful and can lead to “loss of face” and complete withdrawal and alienation by the student. A clear understanding of the consequences of behavior is a must for teachers.

**Field Sensitive Orientation** (Group orientation, social relationships)
A significant number of Native Americans have a tendency to express field-sensitive behaviors as opposed to field-independent behavioral characteristics. This tendency has direct implications for the learning styles Native Americans tend to exhibit.

**Border Crossings**
The notion that Western science is a subculture of Euro-American society has begun to influence mainstream science educators, opening the way for a contemporary Indigenous expression of education through cross-cultural science curriculum tailored to needs.

Learning Western science requires Native students to cross cultural borders, from the familiar contexts of peers, family and tribe, to school, school science and the actual world of science. The notion of border crossings is an anthropological metaphor which implies that students do not leave their home culture behind when they enter this cultural landscape called “School Science.” In a sense they are on a mission to learn about a new territory to gain knowledge and understanding that they may use back home toward their own self determined and practical ends. These practical ends include preparing for a career and economic development, environmental responsibility and cultural survival at the community level (Akinhead, 1997. p.1).

In interactions between Indigenous cultures and the subculture of Western science, profound conflicts arise. Their orientations differ in terms of: survival vs. power over nature and other people; coexistence with the mystery of nature vs. attempting to explain the mystery of nature away; the search for intimate relationship with nature vs. decontextualized objectivity; and accommodation, intuitive and spiritual vs. reductionist, manipulative and analytical ( Ibid. p. 6).

In summary, “Indigenous knowledge of nature tends to be thematic, survival oriented, holistic, empirical, rational, contextualized, specific, communal, ideological, spiritual, inclusive, cooperative, co-existent, personal, and peaceful” (Ibid, p.7).
This essential orientation difference challenges Native American students as they attempt to cross the borders into the subculture of western science as represented in schools. If the teaching and learning of science is supportive of the student's culture orientation, “enculturation” is the result.

If the teaching and learning of science is at odds with the student’s cultural orientation, the result is “assimilation” forcing students to abandon or marginalize their way of knowing to reconstruct a new (generally dysfunctional) way of knowing. Unfortunately, the latter is more often the case (Ibid, p.10).

The essential question is: How can students from indigenous cultures learn non-Native subjects like science without being assimilated harmfully by the underlying value structure?

“First Nations students should develop the facility to cross from everyday sub-cultures of peers, family, community and tribe into the sub-cultures of school science, science and technology.” (Pomeroy, 1994, 13).

“Students and teachers should become cultural border crossers” (Ibid, p.50).

Yet, “Crossing over from one domain of meaning to another is exceeding hard” (Hennessey, 1993, p. 9).

Students generally get very little help doing this kind of border crossing. Few teachers are inclined to assist students, and if they are, they have few resources for being trained in this kind of cross-cultural negotiation.

Four worlds for student transitions have been identified. These include: a congruent world which supports smooth transitions, a different world which requires transitions to be managed, diverse worlds which lead to hazardous transitions, and highly discordant worlds which cause students to resist transitions and in which they become virtually impossible. (Phelan, 1991).

Costa (1995) divided minority students in science classrooms into five basic categories:

1. “Potential Scientists” cross borders into school science so smoothly and naturally that the borders appear invisible;

2. “Other Smart Kids” manage their border crossing so well that few express science as being a foreign subculture;

3. “I Don’t Know Students” confront hazardous border crossings but learn to cope and survive;

4. “Outsiders” tend to be alienated from school so the border crossing in school science is virtually impossible; and

5. “Inside Outsiders” find the border crossing almost impossible because of overt discrimination within the school.

Helping students develop the skills for “raiding Western science for practical ends and achieving goals defined by first nations science education” must be a key aim in the development of science curriculum for Native students.
Determining what kinds of skills and knowledge are appropriate for "First Nations students" to learn with reference to economic development, environmental responsibility and cultural survival is the next step of developing such a comprehensive process. Sound integrated education that helps students be flexible and adaptable and enhances their ability to train on the job is the most strategic form of science education.

Jenkins (1992) argues that using science in everyday situations requires changing knowledge into new forms which can be applied to problems and issues at hand. Restructuring scientific knowledge into new forms for Native contexts requires knowledge of both a different cultural orientation and a different approach to teaching and learning science. Essentially, Native knowledge comes already contexted and ready for use, Western scientific knowledge does not. As this is the way Western science is taught in school, it is no wonder that many students cope by developing a view of science as apart from their real lives. An approach which integrates scientific, technological and indigenous knowledge into real life situations and issues has the best chance of being effective. Participatory research is one way of accomplishing this.

MacIvor (1995) proposes that an integration of selected science and technology content in an indigenous worldview requires coordination with relevant economic, social and resource needs. One might apply a cross-cultural Science-Technology-Society (STS) model which has been used by science educators in third world countries. STS is a dedicated student oriented, critical and environmentally responsible approach to science, and it decontextualizes Western science in the social and technological settings relevant to students (Bingle and Gaskell, 1994; Solomon and Akinhead, 1994).

Applying an anthropological approach from an indigenous perspective to the teaching and learning of Western science is another possibility since this promotes "autonomous acculturation, (or) intercultural borrowing or adaptation of attractive content or aspects." This would be a more constructive and culturally affirming alternative for Native students than assimilating, or enculturating themselves to Western science. Students may act as anthropologists learning about another culture. Like cultural anthropologists they would not need to accept the cultural ways of their “subjects” in order to understand or engage in some of those ways (Akinhead, p. 26).

Combining the STS approach with that of "the student as anthropologist" in the context of an indigenous perspective and community reality can form an ideal foundation for indigenous students learning science. The teacher's role is to learn to act as kind of cultural broker who assists students in handling cultural negotiation and conflict between views. Essentially, students act as “cultural tourists” in a constructive way and teachers take on the role of “tour guides” and “travel agents” as they help students cross the cultural knowledge borders between science and their own worlds.

The development of such a curricular approach can further be facilitated by studying the students' community reality and using that as a foundation for relevant and meaningful themes, then comparing that foundation with the subculture of Western science.
Western science education is often most at odds with the diversity of socio-cultural environments from which students come. For example, learning to hunt in Native American society is a programmed sequence of observations and experiences tied to a process which might include:

1) Learning the habits of the animal hunted (mythology, listening and observation);
2) Learning to track, read appropriate signs and stalk the animal (observation, intuition and reasoning);
3) Learning the appropriate respect and ritual to be extended to the animal hunted (learning a mindset);
4) Learning to properly care for the carcass of the animal once it has been taken (an ecological ethic, technology); and
5) Learning to fully utilize the various parts of the animal taken (technology).

These processes require teaching techniques ranging from formal instruction to experiential learning. All of these teaching/learning situations are directly related within a particular contextual framework necessary for conveying these forms of knowledge. Learning is directly tied to the job to be completed. It involves teaching to accomplish a specific goal. One observes and learns from that which one seeks to do. It is a high context learning process and the potential teachers and situations are numerous and multi-dimensional.

Native American cultural education evolves around the problem of learning how to do something. By contrast modern Western education evolves around frames of reference which prepare students for possible future needs and tasks deemed important in a modern industrial and technological societal complex.

Within most typical American educational situations, what is learned is laid out in a distinct linear pattern. All that is to be learned is hierarchically mapped beginning with objectives to be reached in each grade level and moving to more specific units and individual lesson plans, each of which has objectives and associated learning activities. This highly structured and programmed approach is designed for easier teaching of large numbers of students and for consistency in what is learned. Yet, if one views this approach in terms of addressing individual student learning styles, many problems become apparent.

Much of modern education imposes a preconceived psychological pattern of the “right and wrong ways to do things.” This pattern imposes societal will on all those who participate in American public education. In the process many students are denied use of their innate repertory of intelligences and cultural styles of learning. Ability to learn by simply doing, experiencing and making connections will be significantly diminished through such a homogenization of the educational process. We must begin to explore ways to open up the teaching and learning of science in ways that engage the participation of all students particularly Native American students if we are to in turn increase their participation in science and technology fields.
References:

Note: Portions of this essay have been adapted from a previously published work:


*These characteristics have been quoted or otherwise adapted from the *American Indian Education Handbook*, American Indian Education Unit, California Department of Education, 1982.


