Developing Culturally Based Science Curriculum for Native American Classrooms[1]

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This paper provides an overview of an academically rigorous, culturally relevant and responsive curriculum and instruction model that is based on the Native Science Connections Research Project (NSCRP) and funded by the National Science Foundation. The model is action and inquiry oriented as well as culturally based and integrates or "connects" Native students' traditional culture knowledge with Western science for fifth grade students in public, contract and BIA schools on the Navajo, Hopi, San Carlos Apache and Zuni reservations. One school principal stated, "the NSCRP brings purpose and meaning to what the students are doing because it integrates Navajo thought and content with Western content. It honors who the students are…it [also] strengthened our teachers' self-confidence about using their native language and culture."

As educators we have many responsibilities not only to our students, but also to our teachers to provide them the resources, materials and skills necessary to engage in meaningful dialogue and activities that will deepen their knowledge, broaden their horizons and instill a desire to learn more both inside and outside of the classroom. American Indians have a rich cultural heritage and that heritage has been transmitted orally to each successive generation in song, stories, legends, and history via their native language and traditions. This knowledge provides an understanding of the natural order of existence both personally and communally. Cultural knowledge provides order and understanding both to the individual within the community, but also order and survival within the larger context of the natural environment.

This rich cultural knowledge and the understanding of it is what students bring to the classroom. It is through parents, grandparents, elders and the local community members that children first gain this cultural and environmental perspective. Unfortunately, all too many times, this valuable information and knowledge that students obtain prior to their formal schooling is left at the school house door and not given a place within the classroom. Why is this? Within Native communities there appears to be a disconnect or cultural divide between a native child's environment at home and within their local community and the school (Lipka & Adams, 2004). When the current educational system ignores American Indian students' own traditional teachings nurtured in the home and within the local community, the educational system has lost a valuable educational tool to augment the existing curriculum as critical opportunities to build upon or draw from Indian students' existing knowledge are disregarded and overlooked (Gilbert, 2005; Nelson-Barber & Estrin, 1995).

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Historically, federal education policy stripped Indian children of their language and culture in order to assimilate them into the mainstream society. A number of factors contributed to the suppression and elimination of Native American languages, therefore decreasing the number of fluent Native speakers. According to Reyhner (1992), one major contributor to Native language loss has been coercive assimilative federal policies implemented throughout the educational system. Language and culture are intertwined and cannot be separated. When a people lose their language, they lose their culture and eventually their identity as a people group. Paradoxically, it is this same cultural heritage that for years the federal government was determined to eradicate now is being recognized as a method by which Native students may connect their traditional cultural knowledge with academic disciplines including Western science and have greater success academically vis-à-vis culturally based education.

Culturally based education

According to Demmert & Towner (2003) culturally based education may be defined as approaches that recognize and utilize native languages as a first or second language, pedagogy that incorporates traditional cultural characteristics and involves teaching strategies that are harmonious with the native cultural knowledge and contemporary ways of knowing and learning. Culturally based education includes curricula based on native culture that incorporates legends, oral histories, songs and fundamental beliefs and values of the community. It also includes parents, elders, and community members' involvement and participation in educating native children in the social and political mores of the community. This is similar and reflective of other indigenous learning models which incorporate several of the above mentioned approaches and includes learning approaches that are holistic, a lifelong process, experimental in nature and integrates both the indigenous and western knowledge attributes that shape and influence how students view themselves interdependently and interrelated to the world that forms the foundation of their learning (*Redefining How Success is Measured*, 2007).

The learning approaches that incorporate culturally based education are woefully absent from the curriculum and pedagogy because it has been assumed that if native language and culture is taught it must be taught separately from other content areas which would require additional time and resources to implement successfully within the allotted school day or after school programs. This is even more so with the mandates of the No Child Left Behind (NCLB) Act of 2001 whereas teachers all too often are teaching to the test in this case; reading and mathematics, in order to achieve Adequate Yearly Progress (AYP). It also implies that the curriculum must be developed in isolation from the other subject areas or teaching language and culture as a special, one time project. Rather than compartmentalizing into an "either/or" position, an interdisciplinary approach must be taken. Integrating native language and culture in conjunction with other content areas is not mutually exclusive; instead, it is compatible, complementary and enhances knowledge and academic achievement (Gilbert, 2008b). Therefore,

Native children's ability to learn is enhanced by the integration or immersion of their native language and culture into the curricula in an academically rigorous and culturally relevant and responsive manner. Culturally based education is the full integration and incorporation of specific and consistent cultural ways of thinking and learning into the educational practice. Culturally based education should be integrated in an intentional way, not as add-ons, but deeply embedded in the curricular content of the subject. Regardless of whether a teacher is native or non-native, culturally based education focuses on helping all teachers to be skilled in cultural and linguistic inclusive practices that recognizes and affirms cultural-based strengths in inquiry, problem-solving and learning for the benefit of all students (Gilbert, 2008b).

Culturally based education models

Current research is demonstrating that culturally based education may be successfully integrated into the classroom in a manner that would provide Native students with instruction in the core subject areas based upon their cultural values and knowledge. Math, reading, language arts, history, science, physical education, music, cultural arts and other subjects may be taught in curricula instilled in Native traditional and cultural concepts and knowledge (Gilbert, 2007).

There are culturally based research studies that demonstrate that culturally based education improves students academic achievement and assists in revitalizing and preserving native language and culture. For example, in Alaska, the quasi-experimental study, Mathematics in a Cultural Context (MCC), a culturally based math curriculum shows statistically significant results and modest to strong effect sizes all in favor of rural Alaska Native treatment groups (Lipka & Adams, 2004). Another example of a quasi-experimental study is the Native Science Connections Research Project (NSCRP), a National Science Foundation funded research project. This research study also showed statistically significant results for the Navajo study and an upward trend toward significance in the Hopi results. The San Carlos Apache and Zuni results were inconclusive due to caveats in the research process (Gilbert & Carrasco, 1999). The integration of native language and culture into the existing science curriculum for fifth grade students with four Native nations (Navajo, Hopi, San Carlos Apache and Zuni) was an integral component of the study. This research project established an instruction and curriculum model that builds systematically upon the premise that integrating native language, culture and traditions into the school science curriculum improved student academic achievement and attitudes toward science and science education.

Developing culturally relevant science curriculum

In ensuring that the native cultural science knowledge is "connected" to or incorporated into the existing elementary school science curriculum, curriculum developers must work jointly with local community members to obtain native science cultural knowledge. In developing such a curriculum from a Native American perspective, one must be concerned with the authenticity of the cul-

tural information being collected and presented in the classroom. For example, at the beginning of this project, the researchers, Gilbert and Carrasco, met with the respective tribal leaders to solicit interest in the project and to acquire their blessing to proceed. This is a vital and important first step in working with any tribe/nation. In the majority of cases, when curriculum is written for Native American children, it is typically written by an outsider, someone who is not a member of that particular community and who may not be familiar with the proper tribal etiquette and protocol. Therefore, it is important that curriculum developers contact the necessary tribal representatives to acquire permission and/or to seek their guidance in order to work collaboratively in developing culturally relevant curriculum.

How does one go about gathering this cultural knowledge? Based upon my experiences, it is recommended that this knowledge be obtained from primary resources that include tribal elders, medicine men and women, respected native community leaders and educators, local cultural experts, and parents – grassroots people. As a researcher, educator and an enrolled member of the Hopi tribe in northeastern Arizona, I respect the fact that cultural information acquired through these means, also adheres to tribal intellectual property rights and exercises tribal sovereignty. Therefore, I encourage individuals to have this discussion with their own tribal officials.

For this particular project, native educators, elders, cultural experts, medicine men and women, and other respected adults were consulted and included as part of this process. Utilizing the "grass-roots" approach to developing culturally relevant curriculum is essential to any program. For example, when developing the food and nutrition unit from a Native perspective, medicine men and women were consulted regarding the information about native plants; their uses, gathering locations, and seasons. Cultural experts provided stories, legends, and what students needed to do in order to prepare themselves before and after collecting these traditional native plants. For example, before students carried out the experiments utilizing traditional tea plants, they were taught the importance of thanking mother earth for providing the plants, and after the tea was processed, they were taught to return the tea plants back to the local environment. The teachers and students were also taught only to collect what was required for that particular time so as not to be wasteful.

These grassroots people also assisted in providing guidance as to what topics could be taught in the classroom and what topics were best left to the native community and families to teach. Other considerations included time sensitive matters such as teaching culturally sensitive topics that were seasonal, (e.g., certain traditional stories that can only be shared in the winter) or age appropriate topics. Obtaining the appropriate knowledge and pedagogy is always an important component to any culturally relevant and responsive curriculum.

One of the major components in developing and designing culturally relevant curriculum is that one must also consider his/her own level of expertise and the amount of training s/he has had in teaching science. In general, the majority of teachers who graduate with a teaching degree are likely to have only a minimum

number of science courses. For example, at the beginning of this project, I gathered preliminary data on two issues: 1) how science was currently being taught in the classroom, and 2) what type of science curriculum was being utilized in the school and in the local school district. This data indicated that teachers only taught what they were comfortable in teaching. Several were intimidated by the lack of science knowledge they possessed which was reflected in what they taught and how they taught science. I also found that the textbooks that were being used in the classrooms were outdated and the school districts did not have a cohesive science curriculum from grades K-12th. This was a major concern because it necessitated a decision as to which science curriculum to adopt as part of this research project. Several science curricula were reviewed and it was decided upon the Full Option Science System (FOSS) and Great Explorations in Math and Science (GEMS). The reason these two science curriculum were chosen is because they contained the current national science standards, were identified as conducive to the learning styles of Native children, developed critical thinking and problem solving skills, and fostered parent participation. In addition, the curriculum incorporates a hands-on approach to learning science as well as being teacher friendly. Once the regular classroom science curriculum was selected, then all the participating teachers were trained in how to teach science in the classroom via the Science & Mathematics Learning Center at Northern Arizona University.

During two and half weeks on campus, teachers learned the metric system of measurement, learned how to teach science utilizing the FOSS Food and Nutrition Unit, and carried out the experiments that they later would facilitate with their own students. Once the FOSS training was complete, the teachers identified as the experimental group remained on campus for an additional two weeks and were taught how to teach and integrate the Native Science Connections Supplemental Curriculum (NSCSC) into the FOSS curriculum. They received instruction on cultural sensitivity, taboos in the science classroom, how to "connect" the cultural component to the regular science curriculum, participated in field trips to collect specimens (traditional plants) in the location of their school and community environment, developed plant boards, and received instruction from cultural experts and medicine men and women. Once the cultural component training was complete, the teachers returned to their respective communities to prepare for the academic year.

The FOSS Food and Nutrition Unit was selected as the regular science unit to be taught at the beginning of the school year because this unit is an appropriate unit to teach during the fall semester when local crops are being harvested after a long summer growing season. More importantly, this would be an excellent opportunity at the beginning of the school year to teach Native children about good eating habits and a proper and nutritional diet especially given the high prevalence of diabetes among American Indians.

Teaching the instructional sequence of the Native Science Connections Supplemental Curriculum took eight weeks to complete, with instruction given three times per week. It is highly recommended that in developing your les-

son plans, you include the national science standards, state, and tribal cultural standards (if available). In some cases, Native American cultural standards have been developed and adopted by many tribes in the U.S. For example, in Arizona, the Diné Department of Education has developed the Diné cultural standards. If your tribe/nation has not yet developed cultural standards, I recommend that you consult with your local tribal education department for recommendations.

The Learning Cycle

The Native American way of life deals with the interaction of all the elements of the universe. There is harmony in the Native American perception of learning. This does not mean that Native Americans live a non-troubled life; it means that Native American understanding of life is in reflections to cycles. The cycles of life, nature and the elements are circles without beginning and end.

When examined closely, all types of circles and cycles reflect the Native American perception of wholeness. It is intriguing that the Learning Cycle is indeed relevant to the Native Americans' perception of a natural education, and that this concept parallels learning in this manner (Renner & Merek, 1988). It is also necessary that the concepts and language of Native Americans be included in order for the relevancy of lessons to be made. The native language must be appropriate for specific content areas, the grade level, and the terminology for which it is intended. The Learning Cycle can rekindle the Native American teachings that are natural for learning. It is for these reasons that the Learning Cycle has been adopted for the construction of and is used as a guideline for the development of the NSCRP lesson plans.

Each lesson plan developed adheres to the "hands-on" activities approach if it is to be successful. Teachers need to be knowledgeable in the concepts as a precautionary measure to insure the questions asked or raised may be answered. Renner and Merek (1988) describe the Learning Cycle in such a manner that the students become the main focus of learning:

> The learning cycle, therefore, is not a method of teaching science, the learning cycle comes from the discipline itself; it represents science. If science is to be taught in a manner that leads students to construct knowledge, they must make a quest. The learning cycle leads students on that quest for knowledge. (p. 170)

The students are engaged in observing, measuring, interpreting, experimenting, model building, and predicting as they experience the Learning Cycle. These essential elements of learning science should be constantly implemented in all phases of the cycle.

The Learning Cycle uses "teacher friendly" terminology. Each learning cycle begins with an "Introduction," that allow the teacher and students to get a general understanding of what is already known. In science, the terms of a lesson are interchangeably used with the Learning Cycle such as: Exploration – is labeled Gathering Data; Conceptual Invention is labeled The Idea; and Expansion is

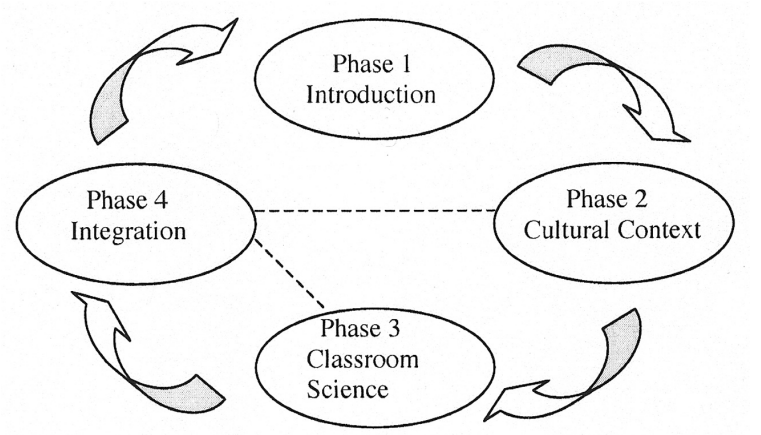
labeled Expanding the Idea. The Learning Cycle concludes with a Teaching Suggestions section providing the teacher additional information to allow diversity, and other alternatives to the concept.

The following is a brief overview of what a lesson plan should include. It includes a format of what may be included, but can also be modified. Again, the appropriateness for the students, the grade and their environment are important.

Developing culturally appropriate lesson plans

The following instructional sequence and design criteria, created for this project functions as a template for all science teachers using the assemblage of modules and lesson which have been designated to integrate a cultural context for teaching scientific concepts to grades K-12 (see Figure 1 below).

Figure 1: Instructional Sequence of the Native Science Connections Supplemental Curriculum



The Loololma Model

Phase One: Introduction/Exploration (Inquiry and Students Perceptions)

Introduction – the purpose of an introduction is to directly or indirectly motivate the students' interest in a concept. This is through dialogue in the child's first language (L1) and second language (L2), through a short excerpt of the lesson without the mention of the concept which could consist of a web-making activity. The introduction needs to be relevant to the Native American child's environment in order for the general purpose of learning to take place. In a sample lesson plan on Nutrients in Native Food Plants, designed for a fifth grade class, the introduction briefly discusses how the Navajo people gathered foods and use native plants for beverages. In this section, is a list of "performance

objectives" eliciting cultural, affective and science objectives. Also included in the introductory phase is a section "getting ready" (teacher preparation), and a brief history of the Navajo people that provide guidance in teaching the lesson. The concepts to be learned are identified as: investigating fats, sugars and vitamin C in native plant foods. The reasoning skills to be developed include: observing, relating, communicating, inferring, identifying and comparing.

Students were encouraged to identify what is known and the procedure begins for learning the "how" of gathering information and data to substantiate the idea they have chosen. Appropriate ways of organizing data for presentations to classmates, family and the community at large are also taken into consideration, discussed and agreed upon. The children use their prior knowledge, gained from others and their environment and learn in a more relaxed classroom atmosphere. At this point, the role of the teacher as a "facilitator" can limit or expand the discussion and activity for the topic depending on the grade, skill and ability levels of the students. For example, if the lesson is on food and nutrition, the teacher can begin the class by talking about traditional Native foods. A graphic organizer (see Figure 2 below) may be used to record the responses from the students in which all answers are to be accepted. Depending on how much information you would like to cover, the time the students spend on this activity will vary. Once the discussion is complete, the graphic organizer should be placed on a wall so that you and the students may refer to it and continue to add to it. This is an excellent opportunity to assess the improvement of your students and how they have progressed in the unit. This phase of the lesson will take anywhere from one to two days to complete. This part of the process requires time therefore; it is necessary to allow adequate time for all materials to be used that will lead to the concept to be learned.

Figure 2: Example of a graphic organizer

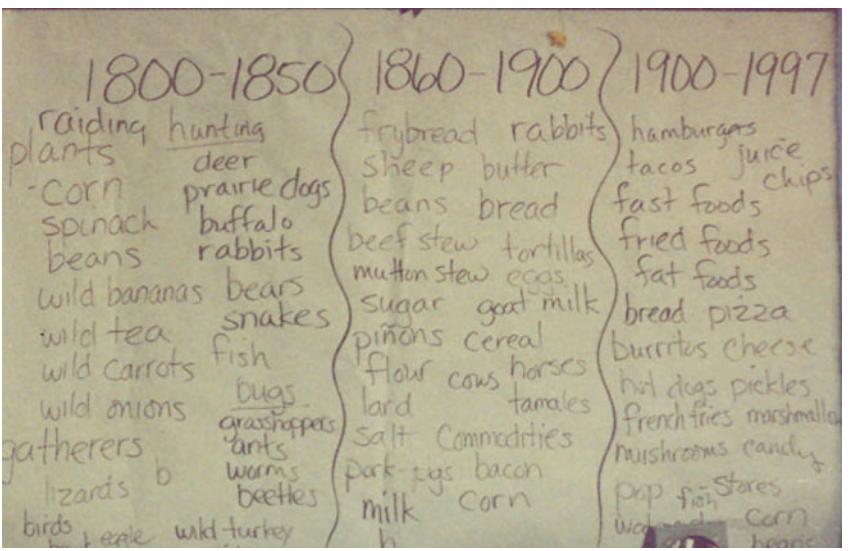
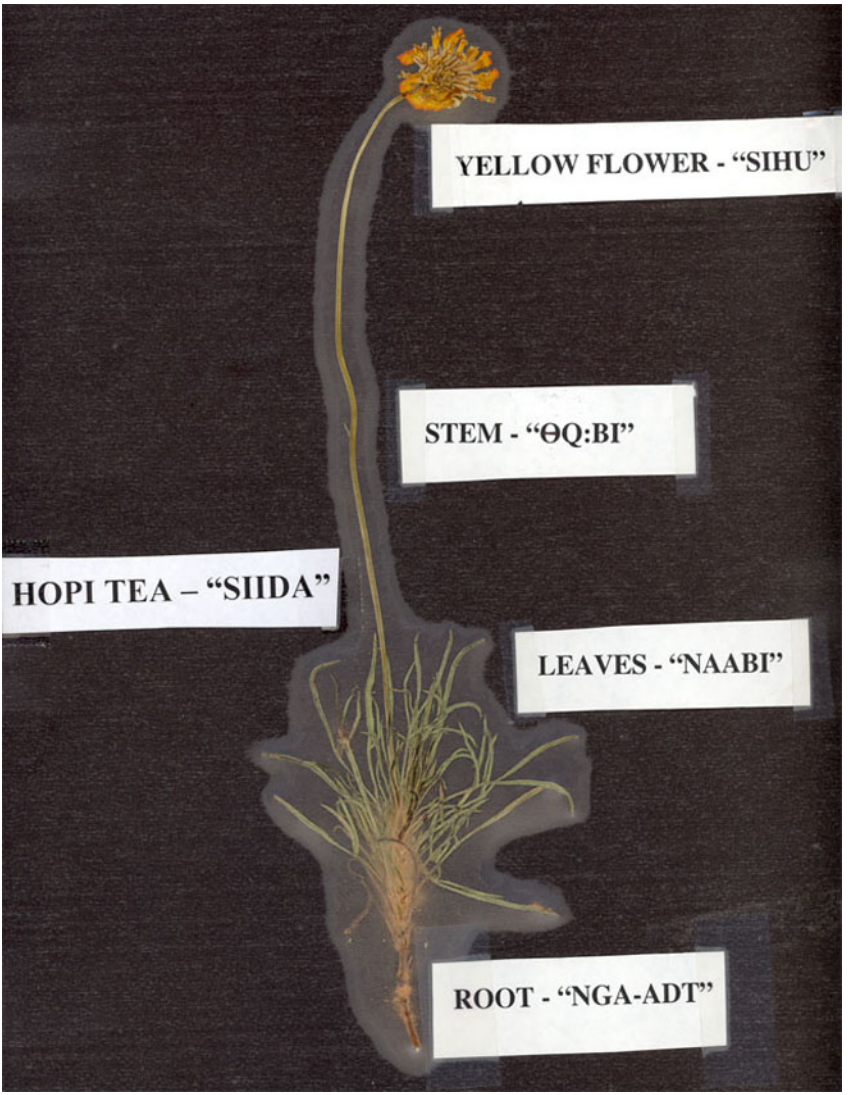


Figure 3: An example of a student's plant board



In addition to the graphic organizer, the lesson plan should include a section on "getting ready" which is in essence the teacher preparation component of the lesson plan. This list includes the materials that the teacher needs to carry out their teaching. For this particular lesson plan, that would include basic essentials, but also pictures of the Food Pyramid, variety of foods from magazines and recipe books, Navajo Tea Plant Boards, Sumac Plant Boards (see Figure 3 above), dried tea, sumac berries, student science journals, and a pre/post quiz. Plant boards facilitate the learning process and include the preservation, labeling and identification of the various plants that are grown within the child's surrounding

environment. The "doing the activity" section highlights questions that you will ask your students in the discussion to engage them in inquiry as well as obtain students' perceptions. The "culminating activity" involves the students drawing a picture of the Navajo tea plant in their science journals and labeling the plant with the words: leaf, stem, blossom and roots. Navajo language labels will be added in phase two. In order to record the progress that students make after teaching the unit, you need to develop a quiz that covers the cultural content that was introduced in phase one. It is recommended that you administer the quiz at the beginning of the unit and at the end upon completion of the unit, utilizing the same quiz as a pre- and a post-quiz. This is an excellent way to determine how much your students have learned.

Phase Two: Cultural Context (Cultural Perspective)

The cultural context is where the traditional Native cultural knowledge as it pertains to the science topic to be studied and which have been imparted in an oral tradition are taught. This includes a vocabulary of specific words in the Native language with English translations. It is recommended that five to eight vocabulary words be selected for each lesson plan in the unit. Additional information in this phase includes traditional Native stories and teachings as well as traditional uses. The class is introduced to the cultural information and teaching on the topic of focus for each lesson and the traditional protocols for imparting information and knowledge are observed and shared. This part of the process also integrates the oral sharing of information and includes field trips in the child's specific surroundings and environment where plants, landforms and other tangible examples within the children's realm or experience can be recognized, identified, explored, explained and their knowledge based on the topic of focus is expanded and amplified. Phase two is established as a building block for the children's sense of knowing, sense of self, sense of place, sense of belonging and a traditional knowledge database on which textbook science can then be integrated. Student cultural sheets are also available for the students so that they may read native stories, legends, and history. In addition, community members visit the classroom and share about their cultural knowledge as it pertains to the lesson at hand.

Phase Three: Classroom Science (Expansion/Scientific Explanation)

During this phase the focus is on communicating concepts, ideas and honing skill exercises taught in science textbooks and/or science kits. An objective way of viewing and learning concepts through teacher classroom lectures including other hands on and inquiry based activities, the written format of textbooks and the use of computer technology and other electronic media to access knowledge and information is introduced to the children at this point. The use of measuring tools, rulers, test tubes, microscopes, telescopes and cameras for recording and monitoring information is also taught here. The western view and approach to learning, teaching and absorbing information about the specific topic becomes the focus of activity. Students are exposed to the process of beginning to think

inductively and deductively. It is here that they begin to hone math skills, and learn to develop an objective view in the learning process by identifying the specific topic for study, the guidelines for gathering data and are taught how to arrange and organize the materials gathered into a format from which observations can be made and conclusions drawn. The students are also taught how to present the materials in report form for the class, family and the community in general.

Phase Four: Integration of Cultural Knowledge (Connecting to Western Science/ Expanding the Idea)

During this phase the students are to organize the newly learned concept with other concepts that are related to it. The terminology of the new concept, at this phase, needs to be utilized more to ensure students are accommodating the learned experiences. It is important to expand with activities that will be well correlated with the concept.

I emphasize that interaction of the students inside and outside of the classroom with the materials and lab equipment is vital. It makes the difference between passive learning and active learning. At the onset of the project, teachers were videotaped teaching science to their students. It was all too common for the teachers to stand in front of the classroom with an open science textbook and ask several students to read sections of the lesson to be studied. After the selected students read their sections, the teacher proceeded to conduct the experiment for the class. The students were then asked to answer the questions at the end of the chapter. Later, after the teachers were trained how to teach science, the interaction with the materials and equipment became central to their learning and students became more engaged in the learning process.

The use of the child's mother language is highly important. The utilization of the child's mother tongue and English was instrumental in the learning process (Gilbert, 2008a). The NSCRP curriculum and instruction benefits went beyond improving the students' science knowledge as English language learners were learning scientific terminology in English through the use of their mother tongue. A science vocabulary dictionary was also developed with respective Native definitions and English translations. In addition, students who were minimally proficient in their native language were encouraged to speak their native language by their fellow classmates who were proficient. Working in cooperative learning groups also is another factor to learning. Students need to interact with one another and learn from each other to become teachers as well as learners in the classroom. This occurred with both the subject matter and the language instruction.

One of the goals of the Native Science Connections project was to create a curriculum of science education materials which is inclusive of and creates a place for traditional cultural belief systems and values while simultaneously amplifying and expanding existing Native American traditional knowledge bases in an interdisciplinary manner. The NSCRP interdisciplinary curricula also incorporated language arts, social studies and mathematic components as well as science.

Conclusion

The need for the development of culturally based science curriculum to become part of the existing classroom science curriculum is a reflection of the movement in native communities to address these important cultural issues and academic performance of young Native American students. The call for a culturally based science curriculum is due to the fact that over the years, the educational system has failed to fully implement these learning approaches that embody the importance of language and culture in the education of Native students. Culturally based science curriculum however may not only improve student academic achievement in science education and other content areas, but also change the students' attitudes in a positive direction that will in turn, help Native American communities maintain their language, culture and traditional "ways of knowing." This cannot be accomplished without the help of first and foremost the local tribal community members, elders, educators, parents and students and secondly the educational system that develops professional and teacher preparation programs to create a high quality teaching force.

The Native Science Connections research project was conducted between 1993 and 1999 and more than a decade later, the Native Science Connections "Loololma" model continues to be implemented by the NSCRP teachers, administrators and curriculum developers. One teacher replicated the Loololma model from an elementary grade level to a middle school level. Her class, at the time, was the only class making AYP at her reservation school and she attributes this to the NSCRP teacher training and professional development she acquired as a participant in this project (E. McCabe, personal communication, September 8, 2006). The principal at one of the participating NSCRP schools is currently a charter school principal and continues to implement the Native Science Connections Loololma model (M. Sorensen, personal communication, March 30, 2010). One of the NSCRP curriculum development specialists who assisted in developing the curriculum for the Navajo module is currently utilizing the Native Science Connections curriculum and instruction model to teach Native culture in the Applied Indigenous Studies department at Northern Arizona University (M. Little, personal communication, April 20, 2010). I also incorporated the Loololma model with the Navajo Bilingual Advantage grant and developed culturally based K-12 curriculum for language arts, social studies and math. These and other NSCRP outcomes demonstrate that recognizing and integrating cultural and linguistic intellectual strengths of Native students in an academically rigorous and culturally relevant and responsive manner improves academic achievement while simultaneously revitalizing and preserving traditional cultural knowledge.

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