Problem-Based Learning: Valuing Cultural Diversity in Science Education with Native Students

MaryLynn Quartaroli & Frederick Sherman

This paper describes a university-based environmental education outreach program that for more then ten years hosted a series of Summer Scholars programs using Problem-Based Learning (PBL) to provide Native American middle and high school students with one-week, on-campus residential science experiences to improve their academic performance in science while bridging mainstream and Native cultural differences in philosophy, values and beliefs.

Much has been written about culturally appropriate education for Native American students (for recent reviews see Brayboy & Castagno, 2009; Castagno & Brayboy, 2008). While acknowledging that Native American tribal cultures are multiple and widely diverse, there are some commonalities of Native American values and behaviors. Gregory Cajete (1999a) summarizes these as an emphasis on cooperation rather than competition, respect for personal differences and for nature, patience and reflective contemplation as a way to truly consider problems, the importance of an authentic and practical purpose for learning and holistic conceptions of knowledge. According to Cajete (1999b) mainstream Euro-American culture contrasts with indigenous ones over issues related to philosophies, values, customs, beliefs and ways of being. As Brewton Berry observed more than forty years ago, "Those who have been involved in the formal education of Indians have assumed that the main purpose of the school is assimilation… it was always the white man's way of life which must set the pattern" (1968, pp. 15-16). Assisting Native students in exploring the differences between their cultural worldview and that of mainstream Western science remains a critical step in promoting student success.

In addition to understanding conventional science as a way of knowing, Native students also require an introduction to the concept of "embedded science" (Fasheh, 1990), which originates in traditional indigenous knowledge. Cajete finds that Native American languages do not include a word for the Western concept of science. Instead, he says,

> the thought process of 'science' which includes rational observation of natural phenomena, classification, problem solving, the use of symbol systems and applications of technical knowledge, was integrated with all other aspects of Native American cultural organizations. (1986, p. 129)

One way to begin this integration within science classrooms is to overlay traditional ecological knowledge onto a Western science curriculum. Important as that may be, this is only a first step (Garroutte, 1999).

From J. Reyhner, W.S. Gilbert & L. Lockard (Eds.). (2011). *Honoring Our Heritage: Culturally Appropriate Approaches tfor Teaching Indigenous Students* (pp. 57-74). Flagstaff, AZ: Northern Arizona University.

In a curriculum development course for teachers of American Indian students, Davison and Miller (1998) focused on creating culturally relevant activities as part of the science curriculum to suggest that the development of these connections helps Native students make sense of what they are learning, both in the context of the culture and in the context of school science. As Nelson-Barber & Estrin (1995) state,

> Many American Indian students have extensive knowledge of mathematics and science…. Unfortunately, a majority of teachers recognize neither Indian students' knowledge nor their considerable learning strategies. Thus, not only is potentially important content knowledge ignored but well-developed ways of knowing, learning, and problem solving also go unrecognized. (p. 174)

Bang, Medin and Atran (2007) endorse this perspective, arguing that the ecologically based way of understanding the natural world can be an advantage when Native children learn science, especially biology. Unfortunately, many Indian students are alienated by classroom approaches that are culturally inappropriate, lack hands-on experiences and assume they have no prior knowledge or skills. Other classroom research shows that simply adding on cultural instruction to the existing curriculum is not necessarily effective (Carrasco & Gilbert, 1999; Hakuta & Gould, 1987). Thus, including a "patch" of tribal stories overlain onto standard instructional practices may not be a sufficient enough modification to ensure the interest or understanding of science for Native American students.

In a study about American Indian identity, cultural values and perceptions of science and technology, James (2006) argues that appropriate alternative approaches to science education and practice can have a positive effect on Native students' achievement in science. One example of an effective science instruction initiative with Native students is an inquiry into the effect of the accidental introduction of the coqui (a type of frog) into the Hawaiian islands developed by the Hawaiian Networked Learning Communities. Its goal is

> to nurture greater environmental awareness by giving students in rural schools the opportunity to investigate real-world environmental issues. By using the tools and skills of scientists and mathematicians to examine local ecosystems, this RSI [rural systemic initiative] is both strengthening the curriculum and teaching something else: Malama i ka 'Aina – an understanding of stewardship within the cultural and environmental context of the Hawaiian Islands. (Boyer, 2006, p. 24)

This inquiry-based science instruction initiative encompasses 37 schools on six islands. Measurable gains were made in 5th and 10th grade math scores (the state science assessment is still in development).

In summary, the following are characteristics of a culturally relevant science education: 1) it explicitly discusses the assumptions of each way of knowing; 2) it does not relegate traditional knowledge to only the social and spiritual worlds; 3) it stresses situated, place-based contexts for evaluating knowledge that is inextricably linked with community values, needs, language and experiences; 4) it explores and addresses the relationships and tensions between Native and Western science; 5) it incorporates active teaching methods; 6) it allows time for processing and responding; 7) it encourages cooperation; 8) it allows students to participate in curricular decisions; and 9) it requires the application of information into daily life, placing science in social and community contexts (Bang, Medin & Cajete, 2009; Cleary & Peacock, 1998; Garroutte, 1999; Gilliland, 1995; Rhodes, 1994). Problem-Based learning (PBL) has the potential to meet these goals.

What is Problem-Based Learning?

In the late 1960s, medical educators at McMaster University in Canada and at Case Western Reserve University in Ohio began using PBL to address the weaknesses in their medical school graduates. Although these students could memorize huge amounts of detail, they were not very adept at applying this knowledge in clinical settings. Since that time, PBL has been used to educate architects, social workers, managers, economists, lawyers and other professionals. Beginning in the 1990s at the Illinois Mathematics and Science Academy, PBL began to be used in public schools, first in science instruction and then across the curriculum.

As an instructional strategy, PBL involves students as stakeholders in the investigation of a significant and interdisciplinary real-world problem, creating an active learning environment in which the teacher acts both as a learner and coach to guide student thinking and inquiry. Students are introduced to the problem before they have learned the necessary content knowledge. They then work collaboratively to define the issues and their learning needs, locating relevant information, questioning and researching to build a deeper understanding, evaluating possible solutions to the problem, choosing a "best fit" solution and reflecting on both the process and the solutions (Delisle, 1997; Lambos, 2004; Stepien, Senn & Stepien, 2000; Torp & Sage, 2002). Throughout the investigation, they "engage in ongoing reflective activities such as journaling, self-evaluation, and group debriefings" (Ertmer & Simons, 2006, p. 41).

What's a "Problem"? PBL scenarios or problems are situated in the students' real world. Ideas for problems might come from community, school, family or social issues, newspaper or magazine articles, literature or movie situations, or from the students themselves. Whatever the source, the traits of a "good" problem or scenario are:

- Complex, ill-structured, and "messy"—not easily solved using a specific formula
- Robust—includes the "big ideas" of one or more academic subjects
- Significant—fascinating and meaningful to the students themselves
- Researchable—changes with the addition of new information
- Boundaryless—incorporates multiple subjects

- Open-ended—does not result in one "right" answer (Lambros, 2004; Stepien, Senn & Stepien, 2000; Torp & Sage, 2002):

Many examples of problems applicable to science and other school subjects can be found on the internet and in the resources listed in the Appendix on page 74. These can be quite diverse, as indicated in this brief list.

- Stop the Frankenfood Monster! (genetically modified foods)
- Sink It to the Bottom (environmental impact of an oil storage tank)
- HELP–H1N1 in High School (public health, epidemics, viruses)
- Should Teresa and Carl Get Married? (genetic diseases)
- Should Our Tribe Build a Casino? (benefits and drawbacks of "gaming")
- Should the Tribe Lease Coal for Stripmining? (environmental impacts)
- There's Nothing to Do (development of a local youth activity center)

The case study discussed later in this paper provides additional examples of environmental problems that have been successfully investigated by Native students.

Why use Problem-Based Learning? Students often ask, "Why do I need to learn this?" Good PBL experiences answer that question by engaging students in real-world content and process skills, making learning much more relevant and authentic. By developing a PBL problem that is of local importance to the community, groups of students have the opportunity to identify and investigate significant and meaningful questions, resulting in more motivated and engaged students.

Because there is potential for different learning emphases within the same problem, students are allowed the flexibility to specialize, thereby avoiding competition for the same answer or solution. As Glasgow (1997) points out, "Projects that offer different roles create slight variations in classroom climate that may inspire certain students to become more engaged when not directly competing with one another" (p. 54).

During the PBL process, students take responsibility and are accountable for their own learning, assisting teachers in providing differentiated instruction for each student. The use of on-going assessments during PBLs allows the students to demonstrate their acquisition and application of new content in authentic ways.

PBL and Academic Standards: Teachers often find the sheer number of state and national standards to be overwhelming to try to accomplish within an academic year. Problem scenarios effectively incorporate multiple standards across many subject areas within one PBL experience. The concepts and skills required to investigate a PBL scenario are likely to be applicable in multiple contexts and are fundamental to the "big ideas" (i.e., concerning change, structure, function, power and authority) across numerous academic subjects.

PBL instruction can move learners along the continuum from novice to expert more rapidly than conventional instructional strategies. Further, it provides teachers with the opportunity to utilize in-depth assessments of students learning, in addition to conventional tests, providing a more complete picture of student progress and performance.

PBL and 21st Century Skills: The Partnership for 21st Century Skills (2004), based in Tucson, Arizona, advocates that every child in America needs 21st century knowledge and skills to successfully face rigorous higher education coursework, career challenges and a globally competitive workforce. So far, 14 states have signed on to this initiative as P21 Leadership States. The knowledge and skills identified as critical for 21st citizens are:

- *Core Subjects/Themes*: global awareness; financial, economic, business and entrepreneurial literacy; civic literacy; health literacy
- *Learning/Innovation Skills*: creativity and innovation; critical thinking and problem-solving; communication and collaboration
- *Information, Media & Technology Skills*: information literacy; media literacy; ICT (information, communications & technology) literacy
- *Life/Career Skills*: Flexibility and adaptability; initiative and self-direction; social and cross-cultural skills; productivity and accountability; leadership and responsibility

Using PBL allows teachers to help their students become successful in most of these areas, including learning/innovation skills; information, media and technology skills; and life/career skills. Depending upon the PBL scenario, many of the core subjects and themes can also be included.

As students work together to define the problem, find and evaluate evidence and reconsider the problem from multiple angles, they develop higher order thinking, problem-solving, collaboration and communication skills. These skills are transferable to all contexts, in school settings as well as in real-life. Research indicates that the use of PBL enhances problem-solving skills and effective reasoning strategies, while increasing long-term student retention and application of knowledge (Goodnough & Cashion, 2006; Strobel & van Barneveld, 2009).

Summer Scholars—A case study

The Summer Scholars programs for Native American middle and high school students are held on the main campus of Northern Arizona University. These programs were cosponsored and co-funded by an environmental educational outreach program of a university institute and by the participating school districts. Between 2001 and 2008, more than 640 students from four southwestern tribes attended 32 week-long sessions, accompanied by over 120 teacher-chaperones. Native American college students serve as assistant instructors and mentors for the Summer Scholars participants. Working in collaborative groups, students explored environmental problems of local, regional and cultural concern, improved their technological skills and built mentoring relationships with college student assistant instructors "developing skills necessary for informed participation in public debate about complex social, environmental, and political issues" (Nelson-Barber & Estrin, 1995, p. 2).

The PBL problems for investigation during these Summer Scholars sessions included such topics as the reduction of visibility at sacred sites, increasing tribal economic prosperity by developing energy production, the use of reclaimed water for snowmaking at a ski resort located on a sacred mountain, forest fire management practices on tribal lands and reducing their school's carbon footprint by designing a "green" school. Students defined specific questions to investigate within these larger topics, in order to make recommendations for resolving these problems.

A case study research methodology (see Hays, 2004; Stake, 1995) was used to examine teaching science in a PBL format with Native American students during the Summer Scholars program. Multiple sources and methods of data collection and analysis were employed. Sources of data included observations, daily and final feedback questionnaires with both ratings and open-ended items, focus groups with students and with teacher-chaperones and assistant instructor written reflections. A review of the final student-produced web pages and PowerPoint presentations for accuracy, depth of understanding and cultural implications or significance provided additional information about the quality and effectiveness of the learning experiences.

On the first day, students were assigned to rooms in campus dormitories, given meal cards for campus dining halls and a research binder outlining the week's agenda and study materials, including a set of daily Problem Logs (adapted from Stepien, Senn & Stepien, 2000) to guide their research. Following the evening meal, students met with the instructional team, participated in ice-breaking activities and were introduced to the problem they are to investigate during the week. At this time, the PBL process is explained, emphasizing that their investigations would be framed by three questions:

1. What do we know?
2. What do we need to know?
3. How can we find out?

Students were assigned to PBL groups of two to six members and began their research with a short homework reading assignment.

The daily schedule for the rest of the week included meeting in the morning as a large group to discuss their work on the problem logs and to be briefed on the day's activities. Throughout the week, students worked in the computer lab, participated in laboratory and other hands-on activities, listened to guest speakers, watched videos and went on field trips related to the problem under investigation. Each evening there was recreational time, in addition to reading assignments and PBL small group work facilitated by the assistant instructors.

For their final presentations the Summer Scholars created web pages or gave PowerPoint presentations to the large group and other visitors, at the end of each week-long session, explaining their recommendations for addressing the problems. On a feedback form, one student praised this final expectation as a strong point of the Summer Scholars program, writing, "I liked when we got to speak on front of the other students." Most of the others expressed fear and shyness, although with encouragement from the staff and their peers, all did complete the activity. To develop these presentations, students could choose to use one of several templates provided by the instructional team, to modify the provided templates to meet their own aesthetic preferences, or to create their own. In addition to the students, teacher-chaperones and instructional team members, the audiences for these final presentations often include other guests, such as school principals or university staff.

Over the years of the Summer Scholars program, students created 437 web pages. A content analysis of these pages revealed that almost all students were able to identify issues of importance relevant to the problem, to list the pros and cons of a possible solution and to justify their recommendation, even though they did not know anything about the issue prior to attendance. As one student explained, "When I first came to Summer Scholars I didn't know anything about prescribed burning. After spending a week studying fire and how it works, I learned that it's good forest management." The rest of the web page supports this student's conclusion, accurately explaining the pros and cons of the practice. In a different year, one student stated on his web page, "I didn't really think Summer Scholars was important until I came and learned something [about energy production from different sources] that I never thought pertained to me before."

In addition to using the information presented during the course of the week regarding the benefits and hazards of a variety of ways to resolve the problems, some students also suggested highly creative ideas. As an example, to address the problem of reduced visibility at the Grand Canyon, one student recommended the use of large solar-powered fans to supplement the wind to move the pollution and haze out of the canyon; another suggested that an air filtering system could be installed on all scenic over-flight aircraft to remove the haze while tourists view the canyon.

The web pages also revealed that students considered important cultural impacts in evaluating options and making recommendations. In the problem related to visibility reduction, students cited concerns about the health and survival of eagles, a sacred bird, or high incidences of respiratory problems on the reservation related to air pollution. One also wrote,

> My grandmother told me that when she was my age she could see Navajo Mountain [a sacred mountain] very clearly, but now all you can see is the silhouette of the mountain. Also back then you could see 80 or 90 miles, now you are lucky if you can see 30 or 40 miles.

On the topic of energy production, many recommended solar or wind generation as having the least impact on the environment, thus protecting community air and water sources. One Summer Scholar noted, "It doesn't pollute the environment, it doesn't destroy the land we live on, it would make the bills a whole lot less for the elders, and it could be powered for anywhere." Not all agreed; another student recommended the use of coal, writing "We have a lot of coal on the reservation which we can use in a power plant…and it's another way to help out the citizens on the reservation by giving them work that can pay a lot of money."

Regarding the use of prescribed burning for forest fire management on tribal lands, one student's web page noted, "Native Americans were probably the first people to use prescribed burning." A second suggested that the use of prescribed burning "helps put Mother Nature back on course." However, one student expressed this cultural concern, "It could burn the medicine plants we use for traditional use."

The investigation into the proposed use of reclaimed water for snowmaking at the ski area on the San Francisco Peaks generated a strong opposition to the proposal. In all cases, the primary reason given was a concern for this sacred mountain. Examples included:

- They don't want to disrespect any of the four sacred mountains
- The San Francisco Peaks don't need mankind to do their job on making snow. In the native way things are made by Mother Nature.
- The Peaks are a sacred home to the Holy people and ceremony plants.
- Not only does our tribe think it's sacred, but 13 other tribes also think it's sacred.
- This is where the Holy Ones emerged to this world. The soil guides our people, it affects how we treat them, it's how we treat ourselves.
- I got a whole new perspective about the whole traditional way and the meaning of the Navajo way.

Not all students agreed. As one noted,

> I think the [ski area] should use reclaimed water because the Native people do not clean and respect the land. If you go on the reservation you will see a lot of trash on the side of the road. So that means that the people do not respect the land.

Of all the problems investigated during the years of Summer Scholars, this issue clearly engaged the students in considering the importance of traditional culture, in addition to environmental and economic impacts of a controversial problem.

At the end of each Summer Scholars session, participants are asked to rate their awareness of the environmental issue addressed during the PBL process and their awareness of science, mathematics and technology, using a scale of 1 to 5 (1 = Poor, 5 = Excellent). As shown in the tables below, teacher-chaperones generally gave higher ratings than students. In all cases, the median ratings were "very good" to "excellent." For awareness of the environmental issue, overall, teachers rated the PBL experience as 4.65; students' ratings were 4.10 (see Table 1).

Table 1: Awareness of PBL Environmental Issue

Point value	Poor 1	Fair 2	Good 3	Very Good 4	Excel-lent 5	Average Rating
Students (n=546)	6	10	126	186	218	4.10
Teacher-Chaperones (n=104)			1	34	69	4.65
Overall (n = 650)	**6**	**10**	**127**	**220**	**287**	**4.19**

On awareness of science, mathematics and technology, teacher-chaperones again gave higher ratings, averaging 4.38; overall students rated the experience as 3.97 (see Table 2).

Open-ended response questions also solicited feedback from students, teacher-chaperones and assistant instructors, providing many examples of positive responses to using PBL to learn about environmental issues and cultural concerns, in addition to those included on the web pages. Students mentioned the importance of being exposed to a wide range of possible solutions, each

Table 2: Awareness of Science, Mathematics and Technology

	Poor	Fair	Good	Very Good	Excel-lent	Average Rating
Point value	**1**	**2**	**3**	**4**	**5**	
Students (n=550)	4	25	129	215	177	3.97
Teacher-Chaperones (n=106)			15	36	55	4.38
Overall (n = 656)	**4**	**25**	**144**	**251**	**232**	**4.04**

having positive and negative consequences. As one student working on the energy production problem wrote, "I have been able to think about the pros and cons of using uranium vs. coal." Others also commented on becoming more knowledgeable about the issues. For example, one stated, "The thing I liked about PBL was that it help[ed] me to understand a little bit more."

Students indicated their appreciation for the opportunity to form their own opinions. For example, one Scholar wrote, "I think that we are allowed to make our own decisions." Or as another described, "At home, my community is very much against pumping water out of the aquifers. I feel like I have to support their beliefs. I will make the decision on my own." Students also became more sensitive to the impacts of their personal decision-making; one stated, "It makes me more aware of how the decisions we make today will affect our families."

The process itself presented both challenges and rewards for the Summer Scholars. Students described using PBL as "challenging" or "a lot of work." Another mentioned that it taught them "how to ask questions." A third noticed, "They made us feel like real scientist[s] by giving us the chance to study for info[rmation]." The PBL process was not easy for all students; as described by one participant, PBL was "okay but you got to think." Although students regularly approved of getting to work together, the small group work to define and refine what they know, what they need to know and how they would find out also presented some challenges. As one student described, “It helps you to know and understand the problem and other people’s personalities.” Another commented on the PBL group process, “You got to listen to other people’s point of view and work together.” Others credited their success in the PBL process to the assistance that they received from the college assistant instructors: “The teachers from [the university] were helpful because they pushed us.”

Teacher-chaperones also responded positively to the PBL learning process. A typical response was, “I really enjoyed the PBL session. I like to see the kids engaged in thinking.” Another mentioned, “[I] have seen PBL being used during teacher certification classes but this is the first [I’d] seen it used with students.” The teacher-chaperones went on to praise the process, writing “Watching the students work together to get their water samples. Listening to them learn from each other and feeling successful because they understood what they were doing today.” Further, “I really think that the students are realizing that they actually practice what they learn in the classroom.” Many recommended, “Keep PBL format for next year.” One went so far as to state, “I plan to implement PBL method in all of my science lesson[s]. This is an excellent way of teaching science.”

Teacher-chaperones mentioned another advantage to the use of PBL during Summer Scholars facilitated by the Native American college student assistant instructors. As one described, “The chaperones felt it was nice to see Caucasians and Natives working together, they also said that the kids see the Natives as role models and this is good.” Another wrote, “I like the way the instructors emphasize personal decision making—this puts the responsibility on the kids instead of having the teachers tell them which energy source to choose.” As one teacher-chaperone wryly observed, “Through the PBL, many of us are learning not to force our opinions on the kids.”

With no expectation that they were to be the sole sources of all information, one teacher-chaperone described the experience, “Teachers were given the opportunity to learn right along students and teachers did not realize these issues because they are too caught up in their own daily lives.” Others concurred. During the exploration of energy production, one wrote, “PBL has got me thinking about using other sources of energy in my community. From discussing energy sources, I have learned that every decision you make has a consequence for someone.” The snowmaking problem prompted this response from a teacher-chaperone, “We saw the pros and the cons during PBL sessions and had to make our own decision on whether [the ski area] should or shouldn’t make snow [using reclaimed water].”

The Native American college student assistant instructors provided additional support for the use of PBL to teach science to Native students. A typical response was, “Overall, the PBL small groups seemed to be a great success. The students all seemed to contribute.” This led one to suggest, “Many come back with a more serious, mature perspective of their education in school.” Not all responses were positive. One instructor expressed concerns, “I found many kids wanted to be told what to do, they weren't used to being in charge of their own learning and they wanted their hand held." One assistant instructor suggested, "gathering [students] in a circle activity such as a debate, would increase student's motivation to research information, make recommendations and work as a team." Others indicated that the final expectation of a presentation did not go far enough toward resolving these real-life problems. One idea was, "I think we need to be asking them, 'OK, now what are YOU going to do in YOUR community?' [emphasis in original]" Another concurred, stating that Summer Scholars needs to be "asking the students to carry some of their new-found knowledge back home to their communities and to commit to some action."

There were other suggestions for improving the learning experiences. Students, teacher-chaperones and rec instructors all called for the inclusion of more Native American perspectives on the issues. One student wrote, "[I] would like to hear more about the Native American issue - an issue that wasn't really brought up even in the articles that were selected for readings were written by Caucasians." A teacher-chaperone agreed,

> [I] would have liked to known why the mountain is sacred to native tribes. Kids did not understand why the mountain is sacred. A way to achieve this could be through readings or having guest speakers who can present on the topic…. I think the students would also greatly benefit from hearing the Native American side or views.

Another chaperone went further, saying, "[I] would like more on the traditional viewpoint because **sponsors** don't fully understand why the mountain is sacred [emphasis added]." An assistant instructor also noticed this same weakness in the program:

> [We need to include] a component to acknowledge the wealth of information that the current natives bring to the table. Maybe this information is not considered "scientific" but it is information that has enabled generations of Navajo, Hopi and other Native people to survive and prosper for hundreds of years in the high deserts in the southwest. We seem only to be pushing the mainstream concept of science to these students. Even if the program feels uncomfortable addressing these issues, it is important to mention that the knowledge of the student's cultures should not be dismissed when they are making recommendations.

Another noticed, "I don't believe they [the students] are familiar with any of the tribes mentioned in the articles and this may have caused further alienation for them." However, program planners recognized that much traditional knowledge is sacred and better taught within the appropriate cultural contexts, such as families or private ceremonies. With this caveat, there is room for improvement to incorporate traditional expertise and viewpoints into the program.

Despite this perception of a bias towards mainstream science, all Summer Scholars participants praised the diverse learning activities scheduled during the week. There was widespread approval of the hands-on lab activities and the field trips. One student suggested, “Can we do experiments (like the ones where [sic] doing) next year because it helps us understand things a little better?” Another noticed, “The program gave me a week full of opportunities that I can’t get at [home school]. Thanks (but it was too short).” Teacher-chaperones also supported the scheduled learning activities; typical responses were, “[I] like how events were planned out and organized with the times on the agenda” and “Activities and hand[s]-on made it easier to understand concepts.” One also noticed, “After doing the field [trip] we were able to make the connections.”

Teacher-chaperones also took the opportunity to participate in the activities during Summer Scholars. They noted a number of benefits, including “[I] learned a lot of ideas or tools to use in the classroom” and “Giving examples of how to teach using hands-on.” They were positively impressed by “the importance stressed on protocols and correct data collection and recording.” Teachers also described having the presenters available for questions from students and teachers as “an additional benefit.”

PBL and cultural diversity

The case study data illustrate student and teacher-chaperone enthusiasm and excitement in using PBL to learn science, although the unfamiliarity of this teaching strategy also generated some anxiety. The PBL problems were personally relevant to the students, addressing timely community issues, thus establishing a valid connection with the learners. Using PBL problems that focused on tribal concerns emphasized the ownership of these issues by the community; the acquisition of knowledge in this context had direct application to the students’ daily lives.

Student engagement in the PBL investigations was holistic, interdisciplinary and hands-on, emphasizing student choice in how and what they learn. This problem-based learning process promoted collaboration between students as they worked in teams, seeking answers to their research questions. During the week, students modeled their behavior on the roles and activities of adults in analyzing and solving problems. Students gathered information by watching, listening and questioning during activities and field trips, in addition to reading information in articles and on the Internet. Responsibility for identifying and refining their specific research questions and their sources of information gave them ownership in the quality of their results.

Students assisted each other in finding information, evaluating the results and weighing multiple considerations before making a final proposal. This was especially true for those groups with members who previously attended Summer Scholars and were familiar with the PBL instructional process. Much of the learning took place in private practice, sharing with other members of their small groups; this reduced the risks of public performance or correction, allowing students to develop confidence prior to displaying their knowledge in their final web page or PowerPoint presentations to the large group.

In their investigations, students were afforded the opportunity to respond to the problems in multiple ways, pursuing information and understanding from different sources. In addition to the “standard” science resources of texts, journals and the Internet, learners went on data collecting field trips and contacted tribal elders, professionals and other community resources via e-mail, telephone, or in person, to seek insights and advice concerning their research questions.

Research cited in Deyhle & Swisher (1997) supports the view that Native American students are much more successful in classrooms in which a strong personal connection is made with the teacher. The role of the assistant instructors as facilitators or guides framed their relationships with the students as informal partnerships. The college student assistant instructors also directed students through hands-on activities that related to the PBL problems. However, these instructors were not the sole authorities or experts; indeed, they learned about the problem along with the students.

The assistant instructors provided less authoritative role models than lead instructors and presenters, critical in fostering student inquiry, freedom and confidence. Because the students had an active role in the development of the questions to be answered and in suggesting resolutions to the PBL problems, they became equal partners in learning, a critical component of Native American student success (Bartolomé, 1994). During the investigations, instructor “talk” was minimized; students had time for processing information and responding in less stressful settings. Communication with these instructors became more open, friendly and supportive. In effect, these assistant instructors took on the role of mentors, reproducing traditional pedagogical practice, gently guiding the students through their inquiries to reach deeper and richer levels of understanding.

The requirement that students make a final presentation of their research results to the large group, including outside guests, met the students’ needs for their learning experiences to be a worthwhile activity, with a practical real-life application in presenting solutions to complex social issues. Working collaboratively, usually in pairs, to develop these artifacts resulted in demonstrating the use of multiple modalities. In addition to itemizing several considerations in support of and in opposition to, their recommendations, students also included art, personal stories and photographs in their presentations.

Challenges in using PBL in classrooms

While the use of PBL as an instructional strategy has many factors in its favor, there are also some challenges in using it in the classroom. These include the changing roles for students and teachers, creating a collaborative classroom climate, maintaining students’ engagement, facilitating concept and cultural integration and time (Ertmer & Simons, 2006). Woodward-Kron and Remedios (2007) also highlighted that students may find PBL experiences challenging if their cultural and language backgrounds are different from that of the classroom.

The adjustment from the "sage on the stage" to the "guide on the side" called for in PBL can be difficult for both students and teachers; parents and administrators may also find this instructional strategy unnerving, as it is unfamiliar. Teachers and students together could develop "rituals" (standard procedures for specific types of activities at different times within the PBL process) to make the transition more comfortable. Teachers can enhance their facilitation skills by observing experienced PBL facilitators (in person or through video/on-line cases), working in pairs or teams and practicing using open-ended questions as prompts and during debriefing sessions with each other, before using these with student groups.

To further assist students in adopting their changing roles as independent and interdependent inquirers, teachers can provide scaffolding by conferencing with at least one student group each class period, by providing graphic organizers [i.e., KWL (What do I **K**now about the subject, what do I **W**ant to learn about it and what did I **L**earn) charts and problem logs] and by verbalizing their own thinking as an example of the process.

A collaborative classroom climate is central to successful PBL instruction. Teachers can assist students by providing structure and examples as they make the transition to working productively together. Moving over time from a PBL instructional model that is primarily teacher-directed, to one in which teachers and students share the inquiry, then ending with student-directed inquiries can eases the transition from teacher-centered to student-centered instruction. Teachers can also assist in groups in establishing culturally appropriate group behavior norms ("how we are going to work together") and learning goals, dividing up project responsibilities, managing deadlines and dealing with group dynamics. Whole-class debriefings during the early parts of the process can serve as models for how small groups can work together. The use of learning contracts or daily group worksheets may also assist in establishing a collaborative mindset.

Students often enjoy working in groups, but they do not always use the time productively. Teachers need to carefully monitor group progress; the use of frequent checkpoints and record-keeping devices (e.g., group folders, goal charts) can help with this. As facilitators, teachers also need to have students articulate what they are learning and challenge them to support their claims by presenting evidence. Keeping students focused on the central question in the scenario and the description of the task keeps the "big picture" visible to remind students why they are working on the activities.

It is easy for students to focus on the details, due dates and project timelines; making sure that they are developing a deep understanding of the content and concepts is the teacher's responsibility. This is a huge challenge in PBL environments. Having students regularly "think" about their findings orally (in small groups or individual conferences) and in writing will encourage synthesis of new content. Sometimes teachers will find that many students have the same misconceptions; a mini-lesson or lecture by the teacher could be an appropriate and efficient intervention at times.

Teachers' time is limited. Many cite a lack of time to develop and implement PBL instruction, especially in a climate of standardized testing mandated by the No Child Left Behind Act. One suggestion is to use "posthole" units, essentially mini-PBLs, to enrich regular conventional classroom activities. These can be incorporated into the academic calendar as a once a week strategy (i.e., every Friday). Another alternative is to use PBL during those times when students have difficulty remaining focused on the standard curriculum (i.e., right before the semester break or end of the year). In a study of using PBL with urban minority middle-school students, Gordon, Rogers, Comfort, Gavula and McGee (2001) noted improved student behavior and increased science performance, even when PBL was used as an enrichment activity during just two percent of the time.

The Appendix provides a list of resources teachers may fine useful to support their efforts to implement PBL in the classroom. The books listed are very teacher-oriented and often provide step-by-step instructions on designing, implementing and assessing student achievement. Up to date research about using PBL in many settings is available in the on-line journal *Interdisciplinary Journal of Problem-Based Learning* at http://docs.lib.purdue.edu/ijpbl/

Summary

There is a tremendous need for Native American and other students to pursue careers in science, mathematics and technology (James, Khoo & Harbold, 1996). Tribal agencies desperately search for tribal members who are qualified for professional positions that are crucial in resolving community problems by making decisions for the benefit of the tribe from both Western and Native perspectives. If the tribes are going to be able to fill these positions, educators must first find ways to develop enthusiastic, culturally and scientifically knowledgeable students. Investigating local tribal community issues using PBL holds real promise for science teachers of middle-school and high-school Native students to facilitate the achievement of these goals. If so much can be gained using PBL during a one-week-long learning experience, even more scientific and cultural understandings could be expected for regular classes on an academic calendar, with additional time to explore and incorporate community knowledge and values, as deemed appropriate by community elders (Carrasco & Riegelhaupt, 2006).

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APPENDIX

Problem-based Learning Resources

Books

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Websites

Interdisciplinary Journal of Problem-Based Learning. Available online at http://docs.lib.purdue.edu/ijpbl/

- Most up-to-date research on the use of PBL across disciplines & grade levels.
- Vol. 1, No. 1 of particular interest to K-12 educators.
- Vol. 3, No. 1 focuses on efficacy of PBL

Illinois Mathematics and Science Academy website: http://pbln.imsa.edu