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A Resource Guide for Embedding Multicultural Capital into the Secondary Science Classrooms of Central Washington

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A RESOURCE GUIDE FOR EMBEDDING MULTICULTURAL CAPITAL INTO THE SECONDARY SCIENCE CLASSROOMS OF CENTRAL WASHINGTON

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ABSTRACT

A RESOURCE GUIDE FOR EMBEDDING MULTICULTURAL CAPITAL INTO THE SECONDARY SCIENCE CLASSROOMS OF CENTRAL WASHINGTON

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The multiple aspects of multicultural education were researched and are here-in compared and discussed. Through research it was found that although much research exists on multicultural education, little or no multicultural resources are available for secondary science specific to Central Washington. Implications for multicultural education, science education and the integration of the two are discussed. A collection of lessons, websites and teacher tools were merged into a resource guide that can be used for local lesson planning. Practical ideas are offered to the inexperienced multicultural science educator.

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INTRODUCTION

We live in a diverse society, both on a local and global perspective. As teachers we have a unique responsibility to our students to prepare them to live in this diverse world. Science teachers have a large responsibility in this area that often goes unaddressed. According to the position statement of the National Science Teachers Association (NSTA, 2000):

> Children from all cultures are to have equitable access to quality science education experiences that enhance success and provide the knowledge and opportunities required for them to become successful participants in our democratic society. Curricular content must incorporate the contributions of many cultures to our knowledge of science. (p. 1)

Debates abound as to how to go about teaching science to all children in a meaningful and culturally responsible way. A few truths about teachers and students rise to the top of the historical research, but even these truths are not universal.

All children have their own understandings on which they base what they learn. These preconceptions dictate what and how a person will learn any subject. For example, in a science class on beneficial plants a middle-class Caucasian student may mention aloe, a Native American student camas, and a Hispanic migrant student saguaro cactus. All students have knowledge of the topic, but their knowledge is different based on their cultural background. All answers are equally valid and scientific, but may not be the answer found in the textbook. It is essential for a teacher to take this cultural capital and use the information to their advantage. This cultural knowledge leads to conceptual understanding.

Conceptual understanding is essential to science learning. If a student understands the concepts, whether it is in a native language or in English, they will better understand the subject matter. Students all have a conceptual framework to which they will attach all newfound knowledge. If the knowledge seemingly does not fit in their framework, they will discard it, or they will memorize it just long enough to take the test and then they will revert back to their old way of thinking. There are many methods to help students achieve the desired result of understanding. Much research has been done on this subject on a general level or in other large cultural groups. Little locally based research reaches the hands of the teachers in South Central Washington.

It is important to realize that Central Washington is a culturally diverse community. Educational Service District (ESD) 105 serves five counties. The largest of these is Yakima County. Yakima County is six percent Native American and thirty-six percent Hispanic. Thirty-two percent of the population speaks a language other than English at home and seventeen percent of the population is foreign born (US Census, 2000). All of these numbers lay well above the national averages. In Yakima County there are school districts that are eighty percent Hispanic with sixty percent not speaking English at home. There are other districts that are sixty-seven percent Native American. Educators have a responsibility to address multicultural education. Our students' cultural capital is great and currently largely ignored.

The problem is that secondary teachers in ESD 105 lack the resources to teach multicultural science. Both OSPI and ESD 105 have programs in place to address multicultural math, reading and literacy but none for science at the secondary level. Wonderful things have been done through Evergreen State College to address Native American Reading. The LASER program, which addresses inquiry science, is available for elementary school teachers but secondary teachers are not included in this program. Much is being done to address English as a Second Language needs and migrant education. The issues of English Language Learners (ELL) and Migrant student learning are both addressed through the Migrant Education Regional Office (MERO) and the State Transitional Bilingual Program (STBP). There are many, many resources available for helping a student achieve English proficiency. The PASS program is available to help migrant students finish their education in a timely manner, even if they move often. The Office of Secondary Education for Migrant Youth (SEMY) in Sunnyside, Washington monitors this program. SEMY has many programs dedicated to migrant youth. But little is being done about multicultural education. Though some students speak another language, that is not all their culture consists of.

Further, little is being done to formally address multicultural science education in Washington state. OSPI lumps multicultural education under migrant education. There is one workshop offered by MERO, upon request, which addresses cultural competencies. They also have another workshop on cooperative learning and its importance in multicultural education. MERO has a lending library with some resources for multicultural education. OSPI has guidelines for the evaluation of instructional material for bias, set forth in 1996. No programs or direct mention of multicultural education in references at the state or local level, other than those noted, are apparent.

PURPOSE

The purpose of this project is to provide multicultural resources to secondary science teachers in Educational Service District 105 of Central Washington. The result will be a resource guide of references and specific lesson plans for secondary science, middle and high school, in ESD 105. The guide will focus on Hispanic and Native American cultures, and other local capital. It will provide secondary science teachers with little previous exposure to multicultural education with an easily understood and easy to navigate resource.

LIMITATIONS

The resulting resource guide, while specific to ESD 105, could be used in other areas of the state and possibly other states. Some of the strategies entailed will be able to be used cross-disciplinarily and others may be used in other grade levels. The greatest use however will be to those teaching science classes at the middle or high school level in South Central and Eastern Washington. It is assumed that, given a short training, a multiculturally inexperienced teacher could use the guide to integrate a few multicultural science lessons into their curriculum. A more experienced teacher should be able to integrate the lessons presented into their regular classroom activities. It is also assumed that the resource guide could act as a reference for replacement lessons.

DEFINITIONS AND ACRONYMS

EALR - Essential Academic Learning Requirement Washington's measurement of student learning.

ESD - Educational Service District, in this paper most commonly refers to ESD 105 serving Central Washington.

ELL - English Language Learner

ESL - English-as-a-Second-Language

GLE - Grade Level Expectation

HPL - How People Learn. In this paper, synonymous with How Students Learn, both published by the National Research Council.

IK - Indigenous Knowledge

LASER - Leadership Assistance for Science Education Reform The program helps educators (Kindergarten through Sixth grade) teach science using inquiry-based science.

LEP - Limited English Proficiency

MERO - Migrant Education Regional Office. Focused on enhancing the learning success of migrant students with services designed to promote the advancement of the "whole child" inclusive of home, school and community. Local office located in Yakima, Washington.

Migrant Student - As defined by federal Public Law 103-382 Section 1309(2): "[A] child who is, or whose parent, spouse, or guardian is, a migratory agricultural worker, including a migratory dairy worker or a migratory fisher who, in the preceding 36 months, in order to obtain or accompany such parent, spouse or guardian . . . to obtain temporary or seasonal employment in agricultural or fishing work, has moved from one school district to another . . . "

Multicultural Education - Education and instruction designed for the cultures of several different races in an educational system. This approach to teaching and learning is based upon consensus building, respect, and fostering cultural pluralism within racial societies, and social justice within communities. Multicultural education acknowledges and incorporates positive racial idiosyncrasies into classroom atmospheres.

NRC - National Research Council

NSTA - National Science Teachers' Association

OSEP - Office for Special Education Programs

OSPI - The Office of the Superintendent of Public Instruction

PASS - Portable Assisted Study Sequence. Offered by SEMY. The program offers fully accredited high school courses that can be completed by a student semi-independently.

QTI - Questionnaire on Teacher Interaction

SEMY - Office of Secondary Education for Migrant Youth. Serves middle school and high school migrant students and educators. The office administers programs to ensure that migrant youth have an opportunity to graduate. Located in Sunnyside, Washington

STBP - State Transitional Bilingual Program. With the involvement of parents, educators, and community, is committed to address the unique needs of students from linguistically and culturally diverse backgrounds and to help them achieve the high content and performance standards expected of all students in Washington State.

TEK - Traditional Ecological Knowledge Both the science of long-resident oral peoples and a biological sciences label for the growing literature which records and explores that knowledge.

TIMSS - Trends in International Mathematics and Science Study

WMS - Western Modern Science or White Male Science Science institutionalized in Western Europe and North America as a predominately white male, middle-class Western system of meaning and symbols.

CHAPTER II

REVIEW OF LITERATURE

MULTICULTURAL EDUCATION

Depending upon whom one asks, the push for multicultural education has been around for hundreds of years. Unfortunately, the cultures that were taught were greatly European in origin and most often all other cultural groups were forced to assimilate to these few. This case proved true in Australia, South America, French-Africa, India, North America and other places. In the early 1900's it became apparent to many people around the world that assimilation education did not work well for many populations. Booker T. Washington gave speeches, as did W.E.B. Du Bois, about multicultural education in seeming conflict to one another (Noel, 2000b). Washington encouraged assimilation while Du Bois did not. Du Bois encouraged Negroes to strive for political power, civil rights and higher education for Negro youth (in Noel, 2000b).

In the late 1960's the term "Multicultural education" came into use in articles published by several now famous authors particularly James Banks, who at the University of Washington published articles on African-American education in the late 1960's. This push for multicultural education naturally followed the civil-rights movement and the desegregation of American schools. Banks (1979) discussed the difficulties of defining multicultural education in his article "Shaping the Future of

Multicultural Education." He notes how sexism, racism, culture and ethnicity are often lumped together by educators into one category.

In Banks' early works he divided multicultural education into levels 1 through 4. In his later work he identified the four levels: contributions approach, additive approach, transformation approach and social action approach. Token examples of Native Americans at Thanksgiving, books about Chinese fireworks, Taco Tuesday in the lunch room or Martin Luther King Jr. Day fall in the first two categories, the 'Heroes and Holidays' approach (Banks, 1999). Banks argues for a transformation approach at the minimum and a social action approach as the best option (1995). In these approaches a person learns to think from the perspective of another culture and critically thinks about a social situation. Diversity becomes a basic premise which a person acts upon (Banks, 1999). Banks states in a 1979 article, "A major aim of multicultural education should be to educate students so that they will acquire knowledge about a range of cultural groups and develop the attitudes, skills, and abilities needed to function at some level of competency within many different cultural environments" (p. 239). Geneva Gay (1994) puts it well, "Multicultural education means learning about, preparing for, and celebrating cultural diversity – or learning to be bicultural" (p. 4). This idea of cultural competence is a theme that runs throughout most of the literature on multicultural education.

King, Sims & Osher (1999) noting the goals of the National Agenda for Achieving Better Results for Children and Youth with Serious Emotional Disturbance, a publication of the Office for Special Education Programs (OSEP), claim that in order to meet the diversity strategic goal of the National Agenda, an educator must understand the idea of cultural competency. Cultural competency was definitely not a new idea in 1999, but it was still a hard concept to define. They define it as being able to apply your knowledge of a culture's normal pattern of behavior to yourself in the appropriate setting (Kings et al., 1999).

Some of the most quoted definitions of cultural competency come from health care fields. Cross, Bazron, Dennis, & Isaacs (1989) define cultural competence as "a set of congruent behaviors, attitudes, and policies that come together in a system, agency, or amongst professionals and enables that system, agency or those professionals to work effectively in cross-cultural situations" (p. 4). Davis set an operational definition that is used by many health care facilities and mental health providers: "cultural competence is the integration and transformation of knowledge about individuals and groups of people into specific standards, policies, practices, and attitudes used in appropriate cultural settings to increase the quality of services; thereby producing better outcomes" (1997). These definitions work if one is a business, social service provider or educator. While all educators know they are in a service field, they often forget the lessons they could have, or should have, learned from other service fields. The idea that educators need to integrate knowledge of other cultures and their norms into classroom practices should be an easy concept to accept. However, the transformation of knowledge into practice is always a difficult one in fields of education.

One of the troubles that American educators have with cultural competency is ignorance. Many teachers do not intentionally reject multicultural education but rather confuse it with globalism (Ukpokodu, 1999). Banks (1999) defined globalism as emphasizing the cultures and peoples of other lands, whereas multiculturalism deals with those groups' experiences in the United States. Ukpokodu (1999) seemingly conflicts herself because she speaks of multicultural education as "transforming the curriculum through thematic units wherein historical and contemporary events, issues, and concepts are taught and viewed from multiple perspectives that reflect the diversity within our society" but later in the same article states that "true multicultural education exists when it is not an isolated activity but an integrated daily experience" (p. 299). Even the experts in the field still struggle with reaching beyond the additive approach and into transformative experiences for students.

Most American educators start their educational psychology training with learning Piaget's ideas on development. Piaget taught that development is primarily an individual matter. Then they discover Vygotsky, who focused more on how social interactions affect development. A child's development will take different paths depending on their social interactions. These pathways are affected by the child's race, class, sex, culture, length of time in the US and schooling practices (Trumbull, Greenfield, & Quiroz, 1996). John Ogbu, an anthropologist, suggested in 1978 that there are basically two types of minority groups in the U.S.: voluntary & involuntary. Involuntary minorities include Native Americans and most African Americans. These groups were historically forced into assimilation and often oppose the education system because they feel they may be forced to give up a part of their culture. Voluntary minorities are primarily immigrants, including refugees. Voluntary immigrants have different views of the education system. All of this changes however with the length of time in the United States. Latino school achievement may actually decline with successive generations as the children begin to see themselves as involuntary minorities (Trumbull, et al., 1996).

Another factor that comes into play in multicultural education is that of individualist versus collectivist culture. The dominant American perspective favors individualism. The American school system rewards those who perform well individually. Teachers draw attention to and reward children on an individual basis for their individual academic achievements. Teachers chastise children for talking too much or accuse them of 'cheating' when they share answers. Many groups such as Native American and traditional Mexican cultures do not prize individualism. In the American school system a child is rewarded for questioning, for debating, and for arguing their case with a teacher. These behaviors are frowned upon in many cultures. In the American school system a child is expected to do their own homework sitting in a quiet undisturbed place at home. They are expected to get their answers from books and other reference materials. In traditional Mexican, Native American, Korean, Hawaiian, Arab and Chinese cultures, to name a few, these expectations would be considered absurd. Collectivism is the norm in these cultures. A child would never be expected to isolate themselves. A child would also be expected to ask an elder for knowledge, rather than going to impersonal reference material first. In collectivist cultures the child may also have responsibilities to the family that come before individual school work. All of these things must be taken into consideration by the teacher interested in incorporating multicultural education into their classroom. (Klug & Whitfield, 2003; Sleeter & Grant, 1988; Tiffany, 2003; Trumbull, et al., 1996).

The good news is it's not as difficult as it may seem. As Aikenhead (1996) describes, integrating multicultural aspects into teaching can be an easy or a problematic 'border-crossing', depending on your own personally philosophy on teaching. Human beings are constantly crossing borders from one culture or belief to another, or choosing not to cross them. Some are difficult to cross, like a teacher who believes in norm-references assessment switching over to criterion-based assessment (Luft, 1999). Others are easy like merging constructivism and the new research by the National Research Council on *How Students Learn: Science in the Classroom* (NRC, 2005), with multicultural education.

The merging of multicultural education and constructivism was approached by Mathison and Young in 1995. Constructivism bases itself in psychology and anthropology; it says that students construct their knowledge based on their previous experiences. Constructivists also believe that when people learn they connect these new bits of knowledge to what they already have (Brooks & Brooks, 1993). This aligns with the beliefs of multicultural education, which emphasizes the culture and subculture(s) of the student and how these affect their learning. Combining these with the key findings on *How People Learn* (NRC, 1999) can be an easy, non-problematic border crossing. The three key finding of *How Students Learn* are: 1. Students come with preconceptions. 2. All knowledge must be attached to a conceptual framework if a student is to retrieve and use the information. 3. Metacognition is an essential part of the learning process (NRC, 2005). A huge part of multicultural education is learning a student's preconceptions and building upon them, which is also the main tenet of constructivism.

MULTICULTURAL SCIENCE EDUCATION

The National Science Teachers Association (2000) claims the following tenets when addressing multicultural education:

- Schools are to provide science education programs that nurture all children academically, physically, and in development of a positive self-concept;
- Children from all cultures are to have equitable access to quality science education experiences that enhance success and provide the knowledge and opportunities required for them to become successful participants in our democratic society;
- Curricular content must incorporate the contributions of many cultures to our knowledge of science;

- Science teachers are knowledgeable about and use culturally-related ways of learning and instructional practices;
- Science teachers have the responsibility to involve culturally-diverse children in science, technology and engineering career opportunities; and
- Instructional strategies selected for use with all children must recognize and respect differences students bring based on their cultures. (p. 1)

We have been challenged to do all of these things, which are in concordance with the beliefs about multicultural education as a whole as set forth by James Banks and Geneva Gay (Banks, 1979; Gay, 1994). The National Science Standards also include tenets of culture: "Science in our schools must be for all students: All students, regardless of age, sex, cultural or ethnic background, disabilities, aspirations, or interest and motivation in science, should have the opportunity to attain high levels of scientific literacy" (NRC, 2000). The National Research Council defines scientific literacy as:

> . . . the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity. It also includes specific types of abilities. . . Scientific literacy means that a person can ask, find, or determine answers to questions derived from curiosity about everyday experiences. It means that a person has the ability to describe, explain, and predict natural phenomena. Scientific literacy entails being able to read with understanding articles about

science in the popular press and to engage in social conversation about the validity of the conclusions. (p. 1)

In order to help students become scientifically literate, we must reach them where they are and help them move forward in their thinking skills. Different cultures around the world have different customs when it comes to curiosity and finding answers to questions. For multicultural education purposes we can help students realize that there are multiple valid paths to take to seek knowledge. For some students this insight may come easily. For other students this will be a true "border crossing".

Aikenhead and Jegede (1999) argue that students enter classrooms with their own unique combination of cultures. Science classrooms in America also have their own culture. When a child enters a science classroom it is like crossing a border into a foreign country. For some children their culture closely matches that of the science classroom and the crossing is easy, for others it is not (Aikenhead & Jegede, 1999). An educator must help these students adjust to their new 'science classroom culture' and learn to function in it. Only when the student is comfortable with this crossing can they truly become scientifically literate, as suggested by the NRC and the National Science Teacher's Association (NSTA).

How educators help students reach scientific literacy depends upon multiple factors. A big piece of the puzzle is the definition of science. Some argue that science is universal. Cobern and Loving (2001) offer a long definition of science which they call the "Standard Account":

1.0 Science is a naturalistic, material explanatory system used to account for natural phenomena that ideally must be objectively and empirically testable.

1.1. Science is about natural phenomena.

1.2. The explanations that science offers are naturalistic and material.

1.3. Science explanations are empirically testable (at least in principle) against natural phenomena (the test for empirical consistency) or against other scientific explanations of natural phenomena (the test for theoretical consistency).

1.4. Science is an explanatory system – it is more than a descriptive ad hoc accounting of natural phenomena.

2.0 The Standard Account of science is grounded in metaphysical commitments about the way the world "really is". These commitments take the form of necessary (or first order) presuppositions.

2.1. Science presupposes the possibility of knowledge about Nature.

2.2. Science presupposes that there is order in Nature.

2.3. Science presupposes causation in Nature.

3.0 Nevertheless, what ultimately qualifies as science is determined by consensus within the scientific community. (pp. 58-60)

Their definition suggests that WMS is in hegemony over other 'so-called science', including TEK and IK as defined by Snively and Corsiglia in 2001 (Cobern & Loving, 2001). Snively and Corsiglia define Traditional Ecological Knowledge as "a rich and well-documented branch of indigenous science known to biologists and ecologists" (2001). They argue that the standard scientific account has led to many sustainability and environmental problems across the globe and that infusing TEK back into school science education may help to alleviate future problems. Many researchers speak to the debate between Universalists and relativists including Atwater, 1995; Cobern and Loving, 2001; Matthews, 1994; Siegel, 2002; Snively and Corsiglia, 2001; and Stanley and Brickhouse, 2001. Some argue that science is so universal that considering the beliefs of indigenous people would be against the very essence of science (Matthews, 1994). These researchers argue that TEK cannot be included in science because most of TEK includes some aspect of local indigenous religious beliefs. This blend of local history, religion and science is, in the researchers mind, incompatible with the standard account definition of science. Others argue that science is relative, and that local knowledge must be taken into the generally accepted body of knowledge that is called science (Snively & Corsiglia, 2001; Stanley & Brickhouse, 2001). These researchers argue that all knowledge is constructed by real individuals on a local level, and that their knowledge is just as valid and valuable as that of WMS. Stanley and Brickhouse add to their claims the idea that Western Modern Science itself is not without religious, political and other historical influences. They site the differences in eastern and western thinking and how these differences have influenced WMS, being primarily of Western European origin. Most of the researchers seem to take the middle ground, including Siegel, Atwater, and Cobern and Loving. They suggest a blend of WMS and TEK be taught in schools, although their reasoning for a blend comes from different positions. This blend would honor the contributions of all cultures to mankind's knowledge of the world and how it works. These researchers see the knowledge gained from TEK as an equally valid domain of knowledge as is WMS. They argue that if educators adopt Aikenhead's idea of border crossings in science they can easily guide students back and forth between TEK and WMS and thereby gain a greater level of scientific literacy as recommended by the National Research Council (Atwater, 1995; Cobern & Loving, 2001; Siegel, 2002; and Snively & Corsiglia, 2001).

MULTICULTURAL EDUCATION AS IT RELATES TO STUDENTS AND LEARNING

The transition from a student's real world life and the science classroom is a border crossing for most students (Aikenhead & Jegede, 1999). The student's level of flexibility, playfulness, and feeling of ease in their science classroom will determine how well a student fits into the culture of science. Some students will survive a science class by going through the motions and memorizing key terms for short periods, this is described as "Fatima's rules" by Larson in 1995 (Aikenhead & Jegede, 1999). Students who do not follow Fatima's rules fall into categories described by Costa in 1995 (Lee, 2003).

Lee (2003) describes the work of Costa concerning how students come to the science classroom in four categories: prospective scientist, "other smart" kids, "I don't know" students and outsiders. The prospective scientists are the 10% that would succeed in science if you locked them in a closet with a fifty year old textbook, their culture closely matches the science classroom. The other three groups represent 90% of American high school students. The outsiders are the hardest group to reach on the far side of the continuum from the prospective scientists; they are the ones that drop out either physically or mentally from science class (Lee, 2003). The middle two groups can learn through different styles of collateral learning as described by Jegede in 1995 (Lee, 1999). In collateral learning a student can learn a concept and place it in their conceptual framework and long-term memory (as described in HPL), whether the concept agrees or disagrees with their previous knowledge (Lee, 1999). There is a continuum to collateral learning ranging from parallel, or compartmentalized, collateral learning to secured collateral learning. When a child reaches secured collateral learning they no longer divide the new-found knowledge into a separate compartment from their previous knowledge but find ways to make the new knowledge make sense and fit within their conceptual framework (Aikenhead & Jegede, 1999). This has to happen if a child is going to make sense of their IK, TEK and WMS. To keep a child from shutting down in the face of this daunting integration task, they need scaffolding.

There are different ways a student may deal with apparent conflicts within their framework; most students revert to a form of parallel collateral learning called a "truth will out device". This device was described by Bajracharya and Brouwer in 1997 (Aikenhead & Jegede, 1999). In this situation a learner makes a conscious decision to accept both forms of the knowledge and adopts a perspective that the 'truth will out'. This is a similar way that many people deal with seeming conflicts between religion and science (p. 270). If a teacher is aware of the different facets of collateral learning they can help students identify the types within their own learning. Through journal writing, and through a dialectical process of weighing the two sides of the knowledge, a student can fit knowledge into their conceptual framework (p. 282).

Learning styles play a critical role in a multicultural classroom. Many of the tribes of the Pacific Northwest value a visual based form of learning (Swisher & Deyhle, 1989). These students are encouraged to learn by observing things. Most of this observation is accomplished silently on the part of the learner. These students are also encouraged to learn a process or procedure by observing it being performed correctly by an adult. When the child has mastered the task mentally, then they may practice it in private. They should be relatively adept at the procedure before they attempt to perform it in public (p. 1). This is in conflict with the way science is done in most schools.

In the American school system a student is encouraged to try, fail and try again until they get it right, with input from the teacher as to how they could improve. This pattern of learning may not work for many students (Swisher & Deyhle, 1989). But, with the help of teacher modeling and more wait time in the classroom it could be different. Abdi (1997) provides a similar suggestion:

> Visual and concrete demonstrations can be helpful when making a point or teaching a concept. The cooperative learning approach can foster cooperation

> among students from diverse backgrounds. Teachers can set an example of cooperation by complimenting students for their diverse views, praising them for their unique skills, and exercising understanding and compassion. (p. 37)

By helping students learn to work with others we can encourage cooperation and understanding that will serve them far into the future. In the meantime, it can help us achieve the content goals that we set for our students.

MULTICULTURAL EDUCATION AS IT PERTAINS TO TEACHERS AND TEACHING

There are many schools of thought with regard to multicultural teaching including those of Stanley and Brickhouse (2001), Corsiglia and Snively (2001), Aikenhead and Jegede (1999), and Siegel (2002). These researchers go back and forth over what aspects of Western Modern Science (WMS), Indigenous Knowledge (IK) and Traditional Ecological Knowledge (TEK) should or should not be included in the current American Science curriculum. They banter back and forth about universal truths, about relativism, pluralism, etc.. There are so many conflicts that it is hard to decide what to believe and who to follow. What to include in science education and how much to include it becomes a controversial subject, akin to the inclusion of religion in science (Cobern & Loving, 2001). Cobern and Loving argue not against including other perspectives in a science classroom, such as IK and TEK, but whether these ways of knowing can truly be defined as science. Cobern and Loving agree that IK and TEK are valid domains of knowledge, as are art, humanities and literature, but they are not science and therefore should be taught either as a coordinated unit or a correlated set of ideas (p. 61). Whether a science teacher in Central Washington believes that TEK and IK are science or not, they can still incorporate aspects of multiculturalism into their teaching.

Cross, Bazron, Dennis and Isaacs list a person's response to cultural differences along a continuum from cultural destructiveness to cultural proficiency (1989). By self assessing an educator, or any person for that matter, can figure out what they need to do to better help the people they serve. There are six levels to Cross, et al.'s continuum: 1) cultural destructiveness, 2) cultural incapacity, 3) cultural blindness, 4) cultural pre–competence, 5) cultural competency, and 6) cultural proficiency.

Gary Howard posts in his book *We Can't Teach What We Don't Know: White Teachers, Multiracial Schools,* the idea that most teachers are either at the level of cultural incapacity or cultural blindness (1999). The characteristics of cultural incapacity include: subtle messages to minorities that they are not welcome or valued and generally lower expectations (Cross, et al., 1989). A teacher can be at this level without even being aware of it. Much of this comes from the upbringing of the person. Cultural incapacity does not have to be directed at a different race or culture; often it is directed at a subculture – such as recent immigrants. Being raised in a family with power or in a dominant role to others can make this attitude seem perfectly normal to an individual.

Cultural blindness is thought by many people to be an acceptable way of thinking. One can often hear a teacher say "I treat all my students the same, regardless of their race." These people may be well intended and believe that the approaches traditionally used with the dominant culture will work for all cultures (Cross, et al., 1989). Howard (1999) in particular argues against this 'equal treatment' because not all children are the same (p. 24). Children come to us with a wealth of knowledge they gained from their home life (NRC, 2005). This previous knowledge affects their learning (Aikenhead & Jegede, 1999). Being culturally blind and ignoring all of these dynamic parts of a child cannot help a teacher to serve that child's learning needs.

Cultural pre-competence is a temporary state that an educator should move through with further training and education. In this stage a teacher realizes that they have a weakness in serving culturally diverse students and attempts to remedy the weakness (Cross, et al. 1989). Teachers in this phase sometimes lack information about where to go next or even what knowledge and information they are lacking. With assistance from the school administration, or an internal drive to find more information, teachers can move from this phase to the next phase of cultural competence.

Cultural competence as described by Cross, et al. (1989) is closely aligned with James Banks' Transformation approach to multicultural education (1995). A person in either of these situations is aware of another individual's culture, subculture, microculture and the norms and needs of these. These norms and needs are valued and considered in all of their interactions. Banks' Social Action approach and Cross, et al.'s cultural proficiency level are also closely aligned. In both of these, cultural competency is taken to another level where action is taken to alleviate social injustice or some other social challenge through the acknowledgment and knowledge of the cultural differences. When it comes to educators, one would hope they function in, and try to teach their students to function in, these realms. (Banks, 1979; Cross, et al., 1989; Gay, 1994)

Multicultural Education Applied to the Classroom

Hands-on, Minds-on inquiry can help students develop science knowledge in context, making it meaningful and relevant (Brown & Abell, 2007). In order to accomplish this in a classroom there are many things that a teacher must take into consideration. The first thing is the environment of the classroom, both the physical arrangement and the 'culture' of the classroom. Safe environments are essential in the science classroom. A student must feel comfortable in making mistakes and in taking risks (Atwater, 1995). This feeling of safety is largely dependent on the student's relationship with the teacher. A study by Evans and Fisher (2000) took the four quadrants of interpersonal behavior as measured on the *Questionnaire on Teacher Interaction* (QTI) as suggested by Wubbels, et al. and altered it to fit teachers. They included eight levels of social interaction between teachers and students. Dominance versus submission and opposition versus cooperation were the main dimensions on which interactions were measured (Evans & Fisher, 2000). Wubbels, as mentioned in Evans and Fisher (2000) claims that strict leadership and friendly behavior are positively related to student learning outcomes. Social interactions vary among cultures, but the dominant and cooperative quadrants and their combinations were the most positive student-teacher interactions in the majority of the countries surveyed. When a teacher can lead their students through learning in a helpful manner, the gains will be greatest.

The NSTA has been promoting fewer science topics in more depth. This recommendation is shadowed in the newly submitted Washington State Science EALRs. A large part of the new EALRs focuses on the critical thinking and problem solving skills necessary for a student to actually do science. This echoes the NRC's statement: "simply asking students to follow the steps of "the scientific method" is not sufficient to help them develop the knowledge, skills and attitudes that will enable them to understand what it means to "do science" and participate in a larger scientific community" (NRC, 2005). Promoting critical thinking and investigative skills can help students not only understand science but how to discover the world around them, including their own culture (Madrazo, 1999). According to Bryant (1996), "Multicultural education embraces cooperative learning, constructivism, questioning techniques, strategies of inquiry, creative and critical thinking, and authentic assessment of student performance" (p. 30). If teachers approach the NSTA recommendations for covering fewer science concepts in more depth with the goal of being sensitive to cultures, we can help students grow into scientifically literate citizens and productive members of their own cultural group.

Mary Atwater points out in a 1995 article that: "Monoethic classrooms also need to be multiculturalized" (p. 45). She speaks to how these students, in order to be good citizens in the world need to understand that not all communities are like theirs. "People who speak with accents are not only capable of learning good science, but are also producing new science knowledge" (p. 45). They need to be taught to function in and understand other cultures. Thus, whether a classroom has multiple cultures represented or not, the educator can still make it multicultural.

MULTICULTURAL EDUCATION AND THE SCIENCE CURRICULUM

Finding a prepackaged curriculum that will meet a school's individual multicultural needs is virtually impossible. Each community has its own unique blend of cultures, subcultures and microcultures. Fortunately, curricula designed over the past ten years have gone in a direction that parallels the need for multicultural education. The new materials that are available conform to the ideas of constructivism as set forth by many researchers in the 1980's and 1990's, most notably Brooks & Brooks (1993). This in combination with the NRC's research on how people learn most effectively has resulted in some new curricula that help a student integrate what they already know with newfound knowledge and help the students make it make sense. Making science make sense is essential according to Cobern & Loving (2001). A student can make sense of science in many ways depending upon their background knowledge. New curriculums are designed to help a teacher learn about their students' background and understandings.

When it comes to subject matter, Sanfeliz and Stalzer (2003) speak of the curriculum suggestions of B.W. Bybee in 1993. Bybee suggested that the curriculum should reflect the values of the person, and the knowledge of the person for whom it is intended. Specifically, Bybee suggests four ways curriculum and instruction should guide learning. It should guide learning towards: 1) understanding and fulfilling basic human needs; 2) maintaining and improving the physical environment; 3) conserving natural resources; and 4) understanding the interdependence of people at the local, national and global level (Sanfeliz & Stalzer, 2003). By selecting curriculum that meets these suggestions, motivation becomes easier. Students gravitate towards their favorite subject, themselves. When they see how a science topic can relate to themselves, their environment, their community, their future, students become motivated to learn about that topic. "Student motivation and engagement in the learning process increases when students recognize that what they are being taught matters" (Ignas, 2004). As interactions with the environment and natural resources are an elemental part of Indigenous knowledge, these aspects are easily integrated into the multicultural classroom.

Multicultural Education and Assessment

Alternative assessment forms are the preferred method when it comes to multicultural science education. The use of science notebooks has been pushed by the National Academies and the National Science Teachers Association. The use of notebooks promotes metacognition, HPL key finding number three, and also attaching knowledge to a conceptual framework (NRC, 2005). Notebooks allow a student to explore what they are learning and how it relates to what the already know. Notebooks can be a place for writing, drawing, observations and other activities. Notebooks offer a teacher a way to see how a child progresses throughout a unit or longer. Most of the new research based materials, including those by BSCS, It's About Time, Foss, Science and Technology for Children (STC), and Science Education for Public Understanding Program (SEP-UP) include the use of notebooks. Notebooks can be a great tool for making science education multicultural because they offer students multiple ways to show what they have learned and also allow them to explore these new ideas in relation to their current knowledge.

Another method of assessment for teachers to use in a multicultural classroom is the checklist. Checklists can include a myriad of desired results. Checklists of a particular state's learning objectives around the ability to do science can easily be made. These checklists should include things such as: ability to work in a group, use of data, reasoning, quality of observations, drawing conclusions, contributions to group work, ability to use equipment, etc. These checklists could be as simple as observed vs. not observed or they could use a Likert scale if the teacher wishes to take it a step further.

Some of these checklists revolve around performance tasks. Much of science education in America today focuses on the ability to do science. The National Standards focus on both understandings about inquiry [science] and the ability to do inquiry [science] (NRC, 2000). The idea that students should be able to 'do science', and not just know about it, is a critical idea for our country's economic future. When the Trends in International Mathematics and Science Study (TIMSS) results came out in 1995 the United States lagged behind other developed countries in science and mathematics performance. On the 2007 report, released in December of 2008, the United States seems to be catching up (NCES, 2008). A lot of the gain is likely due to the national shift towards the standards' ideas of inquiry and the emphasis on science for all (NRC, 2000).

The focus on ability to "do science" has several avenues of performance. The traditional performance tasks are achievable for all students. Learning how to use a microscope, a thermometer and other forms of science technology are rarely threatening for a student. Performance tasks can also be in the form of projects. Projects can provide a venue for a teacher to measure a students understanding of how to 'do' science. These sorts of assessments fit well into the constructivist model as well as multicultural education, if the student's prior knowledge fits into the project. Performance tasks can also be more abstract in nature, involving critical thinking skills and other thinking skills as described in the National Standards (NRC, 2000).

In regard to written assessments Siegel, Wissehr & Halverson (2008) present a framework for writing written assessment questions to be more equitable for ELL students and culturally diverse students. They do not encourage the dumbing down of questions, but rather emphasize making assessments comprehensible, challenging and supportive of students in their thinking (p. 44). Much can be done with assessments by simply changing the style of the question. Changing a multi-part question into a statement with separate bulleted questions can help elicit the response a teacher is looking for. Also, including graphic organizers in the first part of a long response question can help a student sort their knowledge before answering an essay style question (p. 45).

Another assessment consideration must be subject matter. Children come to school with knowledge. They also come without some knowledge. A teacher needs to evaluate this before they create a science assessment for the classroom. Mousetrap cars are a popular subject for science assessment questions on motion and power. How many students have actually seen and played with a mousetrap and understand where its power comes from? Teachers cannot eliminate all bias from the classroom, but they can try to adapt to their students and those students' background when creating (or using supplied) assessments.

Table 1 identifies many forms of assessment available to a teacher (Emtech, 2000). Some forms of alternative assessment may be more appropriate for elementary school teachers, but all can be adapted for high school use. By using alternative assessments a teacher can meet not only the multicultural needs of the students but cater to their multiple intelligences as well.

Table 1
Methods of Alternative assessment

•Art work	•Inventions	•Notebooks	•Problems solved
•Cartoons	•Internet transmissions	•Oral reports	•Puppet shows
•Collections	•Journals	•Original plays, stories, dances	•Reading selection
•Designs and drawings	•Letters	•Pantomimes	•Recipes
•Documentary reports	•Maps	•Performance, musical instrument	•Scale models
•Experiments	•Model construction	•Poetry recitations	•Story illustrations
•Foreign language activities	•Musical compositions	•Photos	•Story boards
•Games	•Musical scores	•Plans for inventions	•Performances

MULTICULTURAL EDUCATION FOR SPECIFIC CULTURAL GROUPS

Multicultural Education and Hispanic Students

Hispanics are the largest growing population in the United States. Sanfeliz and Stalzer (2003) state that "Hispanics . . . are a growing population with strong scientific potential if U.S. teachers consider the culture and interests of these students as motivational tools in preparing lessons" (p. 64). Motivation comes from relevance in this example. Including Hispanic professionals in the classroom can also show students the relevance of science and math education. Outreach to parents and involvement in the community can also act as motivation for students in the science classroom (p. 65). Finding this bit of relevance will help any class succeed.

Using cooperative learning techniques also helps Hispanic students, as most Hispanic cultures are collectivist and not based on the individual. Working in small groups to find group success is normal behavior for traditional Mexican society. Using this understanding in the classroom can help everyone succeed. If the students are second language learners allowing cooperative groups will help them not only develop their science skills but also their language skills (Fradd & Lee, 1999 as mentioned in Brown & Abell, 2007). Other studies emphasize allowing the children to use their home language in addition to English in class (Lee, et al., 2005). Providing key terms in both languages and allowing journal writing in both languages can help the student develop necessary skills.

As Hispanic students are taught science it is important to consider which generation they are a part of. First generation immigrants, in general, have different social norms and learning styles than second and third generation (Lee, et al., 2005). Socioeconomic status can also have an affect on the students learning (p. 880). Some Hispanic cultures "do not encourage them (students) to engage in inquiry practices of asking questions, designing and implementing investigations, and finding answers on their own" (Lee, 2003). The child's cultural norm also sets adults as the authoritative source of knowledge. A teacher needs to use their relationships with their students to help the students cross that border into the American science classroom. It often begins with teacher-explicit instruction and leads throughout the year to student-exploratory inquiry (p. 465). Not all Hispanic students will need this level of scaffolding, but the recently immigrated students probably will.

Language proficiency can definitely distort a teacher's perception of a child's mastery of science content (Luykx, et al., 2007). What a child can write in English and what they understand about science are usually two different things. Written assessments can be an ELLs downfall. Written assessments often also have embedded cultural influences or biases. The vocabulary, genre-specific meanings (e.g. conclusion), and literal and conceptual meanings of phrases can cause a student to misunderstand a question (Luykx, et al., 2007). Alternative forms of assessment can help a teacher see what the child has truly learned.

Multicultural Education as it Relates to Native Students

Cajete (1999) explains that Native American education traditionally is holistic practical education. Every lesson, or series of lessons, has a practical application. A student is taught everything they need to know along the way to accomplish the task, although much of this learning is done by observation. Critical thinking, careful observation, and curiosity are fostered in Native American education (Cajete, 1999). West Virginia University echoes this in their publication on teaching science to Native Americans, where they suggest "Hands-on cooperative learning experiences and holistic teaching that promotes mental, emotional, physical, and spiritual well-being in each student" (WVU, 2004). This is echoed in the Indian Education/Title I/Community Outreach Office's 2000 publication of the proposed Indian education plan for Washington State. The Indian education plan states in it's preface "while the state standards stipulate what students should know and be able to do, the cultural standards are oriented more toward providing guidance on how to get them there in such a way that they become responsible, capable and whole human beings in the process" (p. 2). Truly, multicultural education for native students should focus on the whole person.

Rigor, relevance and relationships are the new three R's of education. If these three are all met by a teacher and subject matter, then Native American students should find success in science education. Science, as it is learned in the classroom, often seems irrelevant to students. With the exception of the ten percent of students that Costa called prospective scientists, students just don't see how science relates to them (Lee, 2003). Snively and Corsiglia (2001) state "The argument from worldview theory is that for some students it is not that they fail to comprehend what is being taught, it is simply that the concepts are either not credible or relevant". If educators want students to become scientifically literate citizens they need to make science relevant.

Weaving some elements of TEK into science education can help students to see where science is relevant to their lives. Whether one believes it should be taught as a coordinated topic, an alternative way-of-knowing, a sub-topic, or fully integrated into the curriculum, TEK can augment science education areas with high Native populations. Recently the United Nations Convention on Biodiversity called for recognition, protection and utilization of TEK (Kimmerer, 2002). Because TEK is being used in the international science community to help solve problems with sustainability, it is crucial that students be educated in the perspectives of both WMS and TEK (Snively & Corsiglia, 2001). Jegede's educational research suggests that discussing Western Science and TEK in an open manner enhances learning and encourages understanding of both views (Sutherland, 1999). With this in mind, educators can justify the relevance of TEK in our science classroom. The added dimension of making the curriculum more rigorous is also of benefit. Training students to consider more than one perspective helps them to become better critical thinkers and also helps them to achieve higher levels of scientific literacy as the National Research Council calls for.

Working with TEK in the classroom has other benefits. TEK teaches not only biological and ecological information, it teaches in a framework of respect, reciprocity and responsibility (Kimmerer, 2002). In many North and South American cultures there is an understanding that there is responsibility associated with knowledge, known as "coming-to-knowing" (Sutherland, 1999). Native children are often told that when the time is right they will understand the lessons of their teachings. By openly discussing this idea that students will "come-to-know", educators can help all students realize that ideas are interconnected and that people can understand and learn about them at different levels at different times. Eventually, all of the knowledge will come together and the student will 'know'. This aspect of how TEK is learned can add a dimension of relevance to many subjects.

While culture affects the students learning style, educators must avoid over-generalizing about students. Some Native students will be visual learners who learn by observing, some will need to feel confident before they will do an activity, some will learn best cooperatively and others learn best from practical and personal stories (Cleary & Peacock, 1997). Some Native students are holistic, creative learners (p. 1). The relationship between the teacher and the student, and the student's home life and culture, will help the teacher determine each child's learning style. Learning about the represented cultural groups in a school can help a teacher to better understand their students. Getting out into the community and experiencing the local cultures will help a teacher achieve amore complete understanding of where the students come from and what sort of interactions and learning styles they are most familiar with. It is all part of building respectful relationships.

Inquiry learning can work well for indigenous populations, if it is done correctly. As noted in Ignas, Garrison (1999) stated: "the inquiry based approach is useful for Indigenous students because it acknowledges and respects the fact that culturally different students have a different knowledge base compared to mainstream students" (p. 51). Within the inquiry experience there are many ways of reasoning. Deductive and inductive reasoning are just two examples. In a multicultural classroom it is important for the teacher to remember that different methods of reasoning are prevalent in different students. Some students may have very evaluative thinking skills, others may be more imaginative. Teachers can encourage students to cross borders between their cultural background and school science by allowing and encouraging these different types of reasoning (Brown & Abell, 2007).

Statistics show that Native American students graduate from high school at a rate of 66% (Babco, 2001). In 1998 it was found that while 16% of Native American student graduates took physics, and 47% took chemistry, less than one percent took AP or Honors courses in chemistry or physics. In the 1990's Native American students experienced the greatest increase in college preparatory work (Babco, 2001). While the numbers prepared for college have increased, the numbers attending college have also increased. Of Native American college graduates, about a third receive degrees in STEM fields (Babco, 2001). It is not that our Native students can not or do not want to participate in science in general. Washington State science testing scores for Native American students are not at the same level as other minority groups. According to the OSPI website, 22% of Native Students passed the tenth grade science WASL in 2007-2008. That same year, 45% of white students passed the same test. Similar passing rates occurred in math, reading and writing, with Native American students passing at a rate twenty percent or more below the white students. If teachers are to meet the NRC's call for 'science for all' something needs to change (NRC, 2000).

MULTICULTURAL SECONDARY SCIENCE EDUCATION FOR CENTRAL WASHINGTON

How does an educator take this vast mountain of knowledge and incorporate it into the classroom? How can a teacher make it relevant to rural and diverse students in Mattawa, Moses Lake, Wapato, Cle Elum, or Othello, Washington? The cultures that are most highly represented in our schools are Hispanics and Native American, with small groups of Ukrainian, Filipino, and others. In Yakima county, 41% of the population is Hispanic, 32% of the population speaks a language other than English at home (Census, 2000). Benton, Franklin and Grant counties also home large Hispanic populations. Science education must be tailored to fit our students.

In searching for the perfect multicultural science curriculum for Central Washington, the author read many books. One that proved to be helpful was *Uncomfortable Neighbors: Cultural Collisions between Mexicans and Americans,* by J.V. Tiffany of Wenatchee (2003). This text helped in understanding the social structures, learning styles and behavior patterns of first and second generation Hispanic students. Using the information it contained greatly improved the relationships with Hispanic students and their families. For a teacher working with students from traditional Mexican homes this is an essential reading. It is relevant being that it is current and geographically reflective. Originally published as a set of newspaper articles in Spanish and English, more for farm owners than for teachers, the author answers questions relevant to formation of multicultural interactions. Why a student won't look at a teacher, why students get emotionally upset if praised individually, or why they don't like to question are all addressed in this work..

With that bit of help regarding relationships with Hispanic students, the author went searching for help concerning effective relations with Native American students. *Widening the circle: Culturally relevant pedagogy for American Indian children,* by B.J. Klug and P.T. Whitfield (2003), and Gary Cajete's books: *Igniting the sparkle: An indigenous science education model* (1999) and *Motivating American Indian students in science and math* (1988) were helpful in understanding Native American students in general, but not specific to Central Washington. To find specific resources for Central Washington the author had to search deeper.

The invisible culture: communication in classroom and community on the Warm Springs Indian Reservation by S.U. Philips (1983) provided insight into some of the behavior patterns seen in Wapato High school classrooms. The book revolves around the Confederated Tribes of Warm Springs. The Warm Springs tribes live in Central Oregon and the tribes throughout the Columbia Basin are mostly related to this group, including sharing the language of Sahaptin and the fishing grounds at Celilo Falls. However, the book's age cautions an educator in its direct application to pedagogy. The work is worth reading though, especially if an educator is not familiar with the behavior and communication styles of the Columbia Plateau tribes.

While relationships are one piece of the puzzle, information is still needed on rigorous and relevant curriculum materials to complete the picture. K.M. Porterfield and E.D. Keoke *American Indian contributions to the world: 15,000 years of inventions and innovations* (2003) and the *Keepers* series by M.J. Caduto and J. Bruchac are great places to start. Caduto and Bruchac have books on many biological and ecological subjects available including animals, life, night and the Earth. Porterfield and Keoke's book is an excellent reference manual. It makes it easy to find a relevant story or piece of TEK to tie into any subject students may be studying in science. The only downfall to these materials (which really isn't a downfall per se), is that they are not Central Washington specific, but they do include some examples from Washington State.

Continuing the search for Central Washington specific materials, the author looked to books of legends of the Pacific Northwest which acknowledged the stories as the intellectual property that they are. There are many books out there on the topic, they can be easily found in any local bookstore. E.E. Clark's *Indian legends of the Pacific Northwest* (1953), because it is older, is more in the original form than some of the modern texts. The oral tradition is emphasized in the opening section of the book. It is a good resource to have as an educator teaching science in Washington. It is of particular use in Earth Science units when talking about the Cascades formation and the Missoula Floods.

With all these good intentions, how does a teacher achieve a multicultural science classroom and curriculum? "Science education reformers need to be aware that it will take a lot more than good intentions to help teachers work with a growing and ethically diverse pupil population . . . They (teachers) need concrete examples of how to meet the demands of an increasingly diverse student population with diverse needs" (Rodriguez, 1998, pp. 592-593). This is what the author wanted to find as a first year teacher, concrete examples. Not many were found. The searching took literally dozens of hours, even with the help of the internet. It became apparent, in this search for materials specifically relevant to Central Washington secondary science students that culturally relevant lessons were few and far between.

As the author began her second year of teaching, a collection was started of these relevant lessons, books, articles into a handbook. The author felt propelled to fill in the hole in knowledge and practice, because of the obvious students' need for more. The traditional materials the school provided were not working for more than 90% of students. Disconnected from the students, from their lives, and even from science itself, the author felt as lost as the students must have felt. Science had become a foreign country and no one was speaking the language. Something had to change. Using the ideas of constructivism, differentiated instruction, inquiry, critical thinking, rigor, relationships, local relevance and pluralism the authors teaching has improved each year, and students have benefited. Every time the author gathers a lesson, a website, a reference or a strategy it is added to the handbook. It has become the author's time ball. The Yakama have a tradition surrounding the creation of time balls, described here by Bonnie Fountain:

> New brides used hemp twine to record their life history starting with courtship. They tied different knots into the twine for days and weeks and added special beads for significant events. They then rolled the twine into a ball known as the "ititamat," which means "counting the days" or "counting calendar." The ball of twine grew in size as time passed and as events occurred. The women would sometimes divide the twine into 25-year lengths to make it more manageable. When the women were very old, they could use the knots and beads of their time balls to recall not only what happened in their lives but when the events occurred. They could easily recount when their children were born, when they moved away, and other major experiences. When a woman died, her "ititamat" or time ball was buried with her. (Fountain)

Now, I want to share my science teaching ititamat with you.

CHAPTER III

METHODOLOGY

This project was put together through research spanning a period of six years, from 2003-2009. Research was primarily conducted through the use of on-line databases including ERIC, Ebsco, and FirstSearch. The library system of Central Washington University was the primary source for literature.

Originally research was done from the standpoint of a student, searching for information on multicultural education. This initial research was an analysis of documents and materials primarily in the form of historical research. Some of this research was set aside for a period to help establish credibility through referential adequacy. By setting aside a portion of the reference materials, producing initial drafts of my project and then going back to the set aside literature, I was able to confirm that what I had done was predominantly in accordance with the established literature. The suggestions of Lincoln and Guba (1985) were followed to establish internal validity throughout the study.

To establish credibility within the study many sources were read and analyzed, attempting to triangulate the information. Sources from different timeframes from the late 1960's through the present were analyzed. Materials were purposefully selected from multiple perspectives and from different educational theories. Negative cases were sought though few were found. These were analyzed and put into the triangulation as well.

Throughout the study the author became more and more a postmodern critical ethnographer, meaning that she started to care more about what could be done about culture and science and not just about them. This shift to a more transformative approach came in 2005. In 2005, the author began working in her first full time teaching position at Wapato High school. The reality of teaching in a multicultural setting located on a reservation changed the research standpoint to one of necessity and reality. Anecdotal evidence was collected to establish greater project credibility. Informal data gained from classroom observations proved a need for a project within the context of multicultural science education. Previous to full time employment, the author's reality of multicultural education was formed by professors, textbooks and reading research studies. Now, the reality of the project is more socially constructed. Existing WASL data and Pass/Fail rate data from Wapato High school also contributed to the need for this project. This data will be discussed in the results section of this paper.

To establish a level of transferability a thick description of multicultural science education is provided. Multiple levels of social and cultural interactions have been addressed, taking time to compare the needs of multiple stakeholders and discuss many aspects of multicultural science education. Context for the research and the project itself are clearly addressed in the results section. Further measures that will add to the transferability of the project are addressed in the conclusion of this paper.

Opening the project up to peer debriefing established a few areas that needed polishing. Three peers provided suggestions that have been integrated into the project. In order to confirm objectivity, reflexivity was consciously attended to throughout the process. From 2003 through 2005, when the initial historical research was completed, a bias was present in the work. Through reflexivity in 2005 the project was opened up to a thicker description of multicultural science. Analyzing approximately thirty more journal articles helped establish the credibility that the author's multicultural science beliefs and the project are in accordance with the original project purpose and the prevailing professional standpoint.

CHAPTER IV

RESULTS

Beginning in 2005, and continuing through the present, the teaching methods that integrate multicultural capital into science education have been implemented in the author's classroom. Although no direct data was collected, classroom observations indicate that students are more able to critically think about scientific information. Students this year are better able to analyze and decipher scientific literature and connect the new knowledge to their conceptual framework. Students who would not speak in class now discuss ideas with other students and with the instructor. Students appear to feel safe enough to stand up in front of the group and present information and opinion for public discussion. Creating a classroom environment where everyone's participation is valued and applauded is thought to contribute to these changes.

Student responses on reflective writing prompts throughout the four years have provided greater depth and insight into the students' thought processes. At the beginning of 2005, common reflective responses were generally brief, with a typical response being 'I picked the first answer because it sounds right'. Now, a typical reflective response covers half a page, where the student addresses the claim and evidence, as well as their reasoning; conflicting evidence is also addressed. The number of long response questions left blank on assignments has decreased by approximately fifty percent.

Students appear to be more willing to write comparative answers and draw diagrams to visually represent their responses.

In addition to classroom observation and informal evaluation of student work, existing student data was mined to provide additional context for students' benefit from including cultural capital in science classrooms. Using existing data from OSPI and Wapato High School, WASL data and Pass/Fail rates for science were examined to determine the potential influence of integrating cultural capital in the classroom. This data was also used to inform the science department goals of reducing the fail rate by ten percent and to increase the WASL passing rate every year. Although, Wapato's science department only consists of four teachers, and there are many influences that may explain the trend, an overall improvement in student achievement and a reduction in failure rate has occurred. Two members of the department, including the author, have been in the building for four years. One teacher has been in the district for eight years, but in the building for only two of those years. The final teacher is a first year teacher. A common curriculum has been adopted and in place for the last eight years. Individual teaching styles and supplementation of the existing curriculum vary considerably from classroom to classroom.

Figure 1 shows a slight decrease in Science WASL scores in 2006-2007. This dip may be an unintended result of initial cultural capital implementation. These students were freshman in 2005-2006, the first year of teaching for both of the freshman science teachers. Data shown in Table 2 indicates that Hispanic, Asian, and White students from

Wapato High School closed the achievement gap in 2008. The gap between Wapato's overall student passing rate and the state passing rate has also decreased. Greater gains are expected for 2009. One of the factors besides cultural capital that may have contributed to the students' gains is the increased rigor resulting from the introduction of a Science Academy begun in Wapato High school in 2007-2008. The academy focuses on promoting math and science in populations currently underrepresented in math, science and engineering fields. This study is unable to separate out the effects of implementing the use of cultural capital and those of the academy. Regardless, continued gains in WASL scores and decreased failure rate are expected for this year.

Native American students at Wapato High do not seem to benefit at the same rate as the other student populations. The percentage of Native American students passing the WASL exam in 2008 increased from 10% to 15.6%, when calculated based on the number of students that actually took the exam. The number of Native Students who passed the Science WASL has been in single digits from 2005 to 2007, seven, two and five students respectively. Because of the small number of students taking the WASL it is likely that fluctuations in the data are more due to the small sample size than from other factors. It is also possible that more Yakama cultural capital needs to be incorporated in the author's classroom. This will be addressed with further research as detailed in the conclusion. Clearly, more needs to be done to promote achievement for all students at Wapato High, including Native American students.

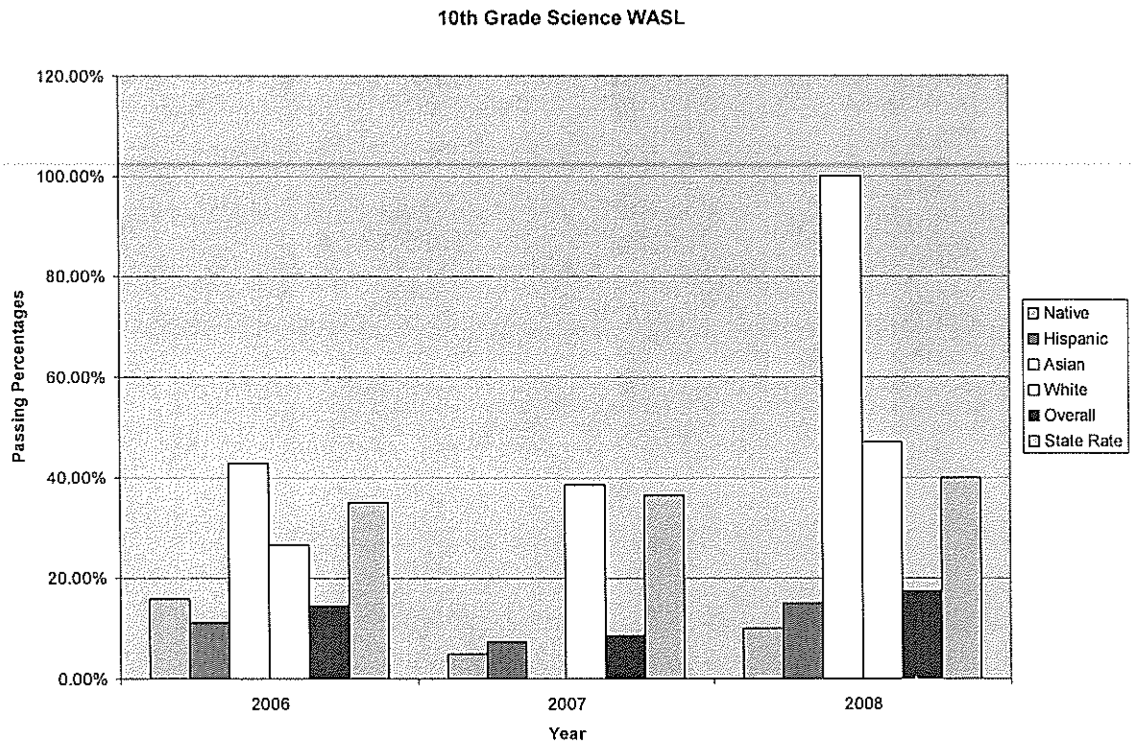

Figure 1: 10th Grade Science WASL Pass Rate for Wapato High School from 2006-2008. Information gathered from the Washington State Office of Superintendent of Public Instruction.

Table 2
10th Grade Science WASL Passing Rates for Wapato High School & Washington State

Year	Ethnicity					
	Native	Hispanic	Asian	White	Overall	State
2006	15.9%	11.2%	43%	26.7%	14.4%	35%
2007	5.0%	7.3%	N/A	38.5%	8.6%	36.5%
2008	10.0%	15.0%	100%	47.1%	17.4%	40.0%

Figure 1 and Table 2 indicate the number of students who pass and fail science classes at Wapato High has fluctuated considerably over the last four years. Wapato High School's greatest failure rate occurs in its freshman classes, as is common with most high schools in the area. The science failure rate for freshman was 29% in 2005-2006 and 20% in 2006-2007. Data for the 2007-2008 was unavailable. A comparison of the author's classroom and an adjacent classroom shows a marked difference in freshman failure rate. The freshman failure rate in the author's classroom was down to 17.9% among in 2008-2009 as compared to the historical rate of 20%. An adjacent classroom showed a freshman failure rate of 37%, for a difference of 19.1%. This performance difference may be due to the rote teaching style with little adjustment for the student cultural background or response to the students needs. In contrast, it is possible that the implementation of the use of cultural capital employed by the author may have influenced the students' gains and reduction in failure rate. Making science accessible to all students and providing them with an inclusive instruction environment and appropriate tools needed to make sense of science is likely to have contributed to their gains. However, this interpretation is speculative and further formal research is needed to establish a cause and effect relationship.

The following collection represents the most useful materials gathered during the author's research of multicultural science education. The websites, books, articles and lessons described are those that were found most suitable for Central Washington.

SUGGESTED BOOKS

Banks, J.A. (1999). *An Introduction to Multicultural Education* (2nd ed.). Boston: Allyn and Bacon.

Caduto, M.J. & Bruchac, J. (1995). *Keepers of life: Teacher's guide: Discovering plants through Native American stories and earth activities for children.* Golden, Colorado: Fulcrum Publishing.

Caduto, M.J. & Bruchac, J. (1997). *Keepers of the animals: Native American stories and wildlife activities for children.* Golden, Colorado: Fulcrum Publishing.

Cajete, G.A. (1999). *Igniting the sparkle: An indigenous science education model.* Kivaki Press: Skyand, NC.

Clark, E.E. (1953). *Indian legends of the Pacific Northwest.* Los Angeles: University of California Press.

Howard, G.R. (1999). *We can't teach what we don't know: White teachers, multiracial schools.* New York: Teachers College Press.

Klug, B.J. & Whitfield, P.T. (2003). *Widening the circle: Culturally relevant pedagogy for American Indian children.* New York: Routledge Falmer.

National Research Council. (NRC). (1999). *How people learn: Bridging research and practice*. (Donovan, M.S., Bransford, J.D., & Pellegrino, J.W. Eds.). Washington, D.C.: National Academies Press.

National Research Council (NRC). (2000). *Inquiry and the national science education standards: A guide for teaching and learning.* Washington, D.C.: National Academies Press.

National Research Council (NRC). (2005). *How students learn: Science in the classroom.* (Donovan, M.S., & Bransford, J.D. Eds.). Washington, D.C.: National Academies Press.

Noel, J. (2000a). *Developing multicultural educators.* New York: Longman.

Noel, J. (Ed.). (2000b). *Notable selections in multicultural education.* Guilford, Connecticut: Dushkin/McGraw-Hill.

Philips, S.U. (1983). *The invisible culture: communication in classroom and community on the Warm Springs Indian Reservation.* Prospect Heights, Illinois: Waveland Press, Inc.

Porterfield, K.M. & Keoke, E.D. (2003). *American Indian contributions to the world: 15,000 years of inventions and innovations.* New York: Checkmark Books.

Reyes, P., Scribner, J.D., & Scribner, A.P. (1999). *Lessons from high-performing Hispanic schools: Creating learning communities.* New York: Teachers College Press.

Tiffany, J.V. (2003). *Uncomfortable neighbors: Cultural collisions between Mexicans and Americans.* Gorham Printing: Rochester, WA.

WEBSITES

General links

http://www.econedlink.org/lessons/index.cfm?lesson=EM127

Moonflowers – web quest assignment / lesson plan

http://www.as.wvu.edu/~equity/hispanic.html

Science Education For Hispanic Students – helpful hints & tips.

http://jeffcoweb.jeffco.k12.co.us/passport/lessonplan/lessonindex.htm

A set of multicultural lesson plans for America – not many are specifically science, set to Colorado standards

http://www.nytimes.com/learning/teachers/lessons/19991109tuesday.html?searchpv=learning_lessons

New York Times lesson on the First people in America – covers migration, archaeology, etc.

http://edsitement.neh.gov/view_lesson_plan.asp?id=324

Native Americans – not Indians – not a lesson to use in science but the reference materials are great.

http://www.nationalgeographic.com/xpeditions/lessons/04/g68/cultureshock.html

Not a science lesson – great links on Cultures & customs

http://www.nationalgeographic.com/xpeditions/lessons/04/g912/twocitiesinca.html

Again – not a science lesson but great info on the Maya and the Aztecs

http://www.ankn.uaf.edu/publications/handbook/index.html

Handbook for culture – Alaskan native

http://www.edchange.org/multicultural/

Many resources – including songs, poems, quizzes, lessons, handouts

Multicultural Lessons

http://www.sciencenetlinks.com/sci_update.cfm?DocID=14

Lesson - The Anasazi

http://www.nationalgeographic.com/xpeditions/activities/08/climates.html

Lesson - Climate in the world

http://www.nationalgeographic.com/xpeditions/lessons/08/g912/globalclimate.html

Lesson - Weather and agriculture US

http://www.nationalgeographic.com/xpeditions/lessons/08/g912/dogsevolution.html

Lesson - Humans and dog evolution

http://www.nationalgeographic.com/xpeditions/lessons/08/g68/venn.html

Lesson - Comparing Washington Rain forests to South American

http://www.sciencenetlinks.com/sci_update.cfm?DocID=53

Lesson - Earthworm invaders – invasive species

http://edsitement.neh.gov/view_lesson_plan.asp?id=268

Lessons - Kennewick Man

http://www.sciencenetlinks.com/Lessons.cfm?DocID=150

Lesson - Polymers and people – science comes from curiosity & technology

http://www.sciencenetlinks.com/lessons.cfm?Grade=9-12&BenchmarkID=1&DocID=457

Lesson - Exploring human history

http://www.sciencenetlinks.com/lessons.cfm?Grade=9-12&BenchmarkID=5&DocID=459

Lesson - Human skin color

http://www.sciencenetlinks.com/lessons.cfm?Grade=9-12&BenchmarkID=7&DocID=0

Lesson - Immigration

http://illuminations.nctm.org/LessonDetail.aspx?ID=L381

Lesson - Smokey the Bear takes Algebra

http://www.nationalgeographic.com/xpeditions/lessons/06/g68/molson.html

Lesson - Preservation of species, human interactions, history

http://www.nationalgeographic.com/xpeditions/lessons/09/g68/index.html

Lesson - Human migration

http://www.nationalgeographic.com/xpeditions/lessons/14/g68/tgrivers.html

Lesson - Rivers and demolishing a dam

http://www.sciencenetlinks.com/Lessons.cfm?DocID=118

Lessons, A little juvenile – but good on the wide variety of scientists http://www.nationalgeographic.com/xpeditions/lessons/07/g68/hawaii.html

Lesson - Ancient explanations for seasons – good additive lesson

http://www.sciencenetlinks.com/lessons.cfm?BenchmarkID=8&DocID=18

Lesson -The chemistry pH of hair care products

http://solar-center.stanford.edu/folklore/folklore.html

Lesson -Solar folklore

http://www.newhorizons.org/strategies/multicultural/freed.htm

Lesson - Moon Phases

http://retanet.unm.edu/article.pl?sid=03/05/18/2106111

Lesson -Latin American Medicinal Plants

http://retanet.unm.edu/article.pl?sid=03/05/18/1912211

Lesson -Why is there Pollution in Mexico City?

Plant Reference Sites

http://www.nps.gov/archive/grsa/resources/curriculum/elem/lesson24.htm

Native Dyes – some for Washington

http://www.cwnp.org/ethnobot2.html

Ethnobotany of the Middle Columbia River Native Americans

Peace Corp Lessons

http://www.peacecorps.gov/wws/educators/lessonplans/lesson.cfm?lpid=163&sid=3

The True cost of Coffee – Honduras, but easily relates to our agriculture system and other things Hispanic students may be familiar with if they are immigrant.

http://www.peacecorps.gov/wws/educators/lessonplans/lesson.cfm?lpid=299&sid=4

Lesson plan – Nature of Science - Differentiating Fact & Opinion – with a multicultural flair

http://www.peacecorps.gov/wws/educators/lessonplans/lesson.cfm?lpid=295&sid=4

Lesson – Nature of Science - Perceptions and misunderstandings

Native American pages

http://www.cradleboard.org/main.html

More than just cradle boards. Tons of free lessons and helps http://www.nationalgeographic.com/xpeditions/lessons/15/g68/contributions.html

Lewis & Clark – Native American Contributions

http://www.ecoknow.ca/documents/tekUnit2.pdf

Forests for the Future. Unit 2: Traditional Plant Knowledge of the Tsimshian

http://www.ecoknow.ca/documents/tekUnit3.pdf

Forests for the Future. Unit 3: First Nations Resource Use on the Northwest Coast: Investigations into Geography, Ecology, Knowledge and Resource Management

http://www.ankn.uaf.edu/

The Alaska Native Knowledge Network

http://www.critfc.org/

Columbia River Inter-Tribal Fish Commission – it would be very easy to put together a web quest for any age based solely on this one website

http://www.nisbase.org/nisbase/index.jsp

NISBase is a distributed database providing information concerning nonindigenous species. Through his site, users can access information on taxonomy, life history, native and introduced ranges, photos, maps, and impacts of aquatic species introduced around the world.

http://www.suquamish.nsn.us/

Chief Seattle's tribe

http://www.education-world.com/a_lesson/lesson038.shtml

Great extensive Native Americans general lessons

http://content.lib.washington.edu/aipnw/

American Indians of the Pacific Northwest Collection at University of Washington – includes thousands of images

http://www.mrdonn.org/nativeamericans.html

Good resources

http://www.wwu.edu/depts/skywise/legends.html

Star stories – many from Washington

http://www.kstrom.net/isk/stories/NWmyths.html

A collection of stories – make sure to site the tribe and storyteller – these are cultural property.

http://www.spokanetribe.com/

The Spokane Tribe of Indians has an extensive Department of Natural Resources, including a large fisheries program.

http://www.ilhawaii.net/~stony/loreindx.html

150 different stories – this site is linked to by Discovery

http://www.coghlanart.com/stories.htm

Coghlan Art Story Archive

Many masks, stories and dances are owned by native family groups and individuals. This cultural property is passed on through the potlatch system. Ownership of these properties is important, reflecting the status of family in the complex society of the Northwest Coast. The stories shown here are meant only to give insight to those that have an interest in the meaning of this great art form.

http://www.umatilla.nsn.us/

Confederated Tribes of the Umatilla Indian Reservation – website includes information on horses, food, life cycles and other topics.

http://www.colvilletribes.com/

Confederated Tribes of the Colville Reservation – website similar to the Umatilla with information on myths and other aspects of traditional Colville life.

www.grandronde.org

The Confederated Tribes of the Grand Ronde – another tribal website with cultural information.

http://spokanelanguage.com/

The Spokane Tribe of Indians Language Program. This website includes local stories, most revolving around wildlife and the natural world.

http://www.atnitribes.org/

Affiliated Tribes of Northwest Indians. This group has many subcommittees including a natural resources / land committee which maintains a list of local native natural resource links.

http://www.hanksville.org/NAresources/indices/NAknowledge.html

An index of sites that have Indigenous knowledge base. Lots of good resources.

http://www.rpi.edu/~eglash/csdt.html

Virtual bead looms

http://www.nwrel.org/indianed/indianreading/

Twelve Northwest Indian reservations actively participated in the program from its beginning. For the next 11 years, the NWREL Indian Reading & Language Development Program produced 140 culturally relevant stories written by local Indian authors and illustrated by Indian artists.

http://www.nwifc.org/

Northwest Indian fisheries commission

LESSONS

The next two hundred and fifty one pages are a collection of multicultural lesson plans. Each lesson plan includes the title of the lesson, the original website URL (if taken from a website) and a brief description of the lesson at the top. When possible, all items needed to teach the lesson are included. In order to honor those who created the lessons they are presented in as close to their original form and format as possible, some are slightly modified to fit this media. Complete references are supplied at the end of this project.

Please note:

These pages have been redacted due to copyright restriction.

Chapter 4, pages 66 - 317: Lessons have been redacted due to copyright concerns or restrictions.

CHAPTER V

CONCLUSION

Multicultural education is a complex entity. There are many layers to multicultural education and many aspects not often thought of. This project has highlighted just some of the aspects of a multicultural secondary science program. Multicultural science education includes being culturally competent, integrating how students learn though prior knowledge, content frameworks and metacognition, and building relationships with students. This project has integrated many different opinions, research studies and schools of thought in multicultural education, including Banks transformation approach and Cross et al.'s work on cultural proficiency levels (Banks, 1979; Cross, et al. 1989). It has also integrated the work of Brooks and Brooks (1993) on constructivism and also addressed the literature on globalism, universalism and relativism. By combining these different schools of thought, it has been the goal of this project to create a working document that will meet the needs of local students and teachers.

According to Bryant (1996), "Multicultural education embraces cooperative learning, constructivism, questioning techniques, strategies of inquiry, creative and critical thinking, and authentic assessment of student performance" (p. 30). In accounting for all of these on a local level this resource guide can begin a teacher on their path to a more multicultural science education experience in their classroom, department, school and even district. It is important to remember that even monoethnic classrooms need to be multiculturalized (Atwater, 1995). In our ever changing world students need to be able to function in multicultural settings. They need to have the level of cultural competency to go about their lives in a socially responsible way. Students need to be able to function in a scientifically literate world. They need to understand how science is done, yet remain grounded in their own culture at the same time. With the help of this resource guide a teacher can help their students to achieve this goal.

LIMITATIONS AND CONTRIBUTIONS

The ultimate goal of this project was never to be a transferable document. This resource guide is intended for use by teachers in Central Washington. It is limited in it's applications to elementary grades and also to use outside of the state of Washington. Its form however could be duplicated for other areas. This resource guide is not intended to be used as curriculum, but as resources for supplementation. It may be used as supplementary units.

This project does something that has not been done yet for Central Washington. It combines many scattered thoughts, ideas, and resources and compiles them all into one place. It gives teachers a starting point on their travels in multicultural secondary science education. It helps to eliminate many hours of tedious research for a teacher just starting in the integration of multicultural lessons. It also condenses much of the primary literature on multicultural education and multicultural science education over the last forty years down into a more readable document. For a classroom teacher who is very short on time, this will be extremely useful.

SUGGESTIONS FOR FURTHER WORK

In order to further establish the credibility of this project, it will go through a member check process. By member checking with both local educators and students, more external validity for the project can be established. External validity is often socially relative, and since this project is socially relative as a whole, member checking should reveal any missing pieces. By member checking, more comprehensive and critical information can be collected and used in a manner similar to the information received from peer debriefing. This will improve the project's credibility and transferability.

If a suitable study group can be formed among local secondary school teachers, Participatory Action Research (PAR) will be performed. As described by Wadsworth in 1998, PAR involves multiple stakeholders in the research process (p. 1). PAR tries to solve problems by conducting research, not just for the researcher, but also for those the research is being done for. In this case the research would involve myself, other teachers, students and also leaders of the cultural groups involved (Yakama and Hispanic).

With member checking and PAR in place, further establishment of credibility through prolonged engagement in the implementation of the project and observation of the project will be documented. More formal classroom observations using data collection tools will provide quantitative data to further enhance gathered qualitative data. WASL data, or data from the replacement assessment, will be analyzed over the coming years. Pass/Fail data for Wapato High Science will also be scrutinized. Data collection will be used to establish an identifiable cause and effect relationship between the use of teaching methods that value cultural capital and cultural needs and student gains in science. With PAR, the resource guide will hopefully further develop into more locally based lessons and even units for use with Native and Hispanic students in Central Washington. Member checking will hopefully lead to more culturally accurate and detailed lessons involving Yakama TEK.

True transferability is not the goal of this project. The project was designed to be specific to South Central Washington. According to Cronbach (1975), "when we give proper weight to local conditions, any generalization is a working hypothesis, not a conclusion" (p. 125). This project is a working hypothesis, and will always be in progress. The goal is to use what the children have, their culture and their prior knowledge, in combination with other best teaching practices to increase student success in science. The ititamat continues to grow.

REFERENCES

Abdi, S.W. (1997). Multicultural teaching tips. *The Science Teacher, 64 (2).* 34-37.

Aikenhead, G.S. (1996). Science Education: Border Crossing into the Subculture of Science. *Studies in Science Education, 27.* 1-52.

Aikenhead, G.S. & Jegede, O.J. (1999). Cross-cultural science education: a cognitive explanation of a cultural phenomenon. *Journal of Research in Science Teaching, 36 (3).* 269-287.

Aikenhead, G.S. (2001 March). *Cross-cultural science teaching: Praxis.* Paper presented at the annual meeting of the National Association for Research in Science Teaching, St. Louis, MO.

Ambrosio, A.L., Seguin, C.A., Hogan, E.L., & Miller, M. (2001). Assessing performance-based outcomes of multicultural lesson plans: a component within a comprehensive teacher education assessment design. *Multicultural Perspectives, 3 (1).* 15-22.

American Association for the Advancement of Science (AAAS). (2001). *The chemistry of hair care.* A lesson plan in Science Net links. Retrieved April 2, 2007 from http://www.sciencenetlinks.com/lessons.cfm?BenchmarkID=8&DocID=18

American Association for the Advancement of Science (AAAS). (2001). *Images of science.* A lesson plan in Science Net links. Retrieved April 2, 2007 from http://www.sciencenetlinks.com/Lessons.cfm?DocID=118

American Association for the Advancement of Science (AAAS). (2001). *Polymers and people.* A lesson plan in Science Net links. Retrieved April 2, 2007 from http://www.sciencenetlinks.com/Lessons.cfm?DocID=150

American Association for the Advancement of Science (AAAS). (2006). *Computerized civilization.* A lesson plan in Science Net links. Retrieved April 3, 2007 from http://www.sciencenetlinks.com/sci_update.cfm?DocID=14

American Association for the Advancement of Science (AAAS). (2006). *Earthworm invaders.* A lesson plan in Science Net links. Retrieved April 3, 2007 from http://www.sciencenetlinks.com/sci_update.cfm?DocID=53

American Association for the Advancement of Science (AAAS). (2006, August). *Exploring human history.* A lesson plan in Science Net links. Retrieved April 2, 2007 from http://www.sciencenetlinks.com/lessons.cfm?Grade=9-12&BenchmarkID=1&DocID=457

American Association for the Advancement of Science (AAAS). (2006, December). *Immigration.* A lesson plan in Science Net links. Retrieved April 2, 2007 from http://www.sciencenetlinks.com/lessons.cfm?Grade=9-12&BenchmarkID=7&DocID=0

American Association for the Advancement of Science (AAAS). (2006). *Variation in human skin color.* A lesson plan in Science Net links. Retrieved April 2, 2007 from http://www.sciencenetlinks.com/lessons.cfm?Grade=9-12&BenchmarkID=5&DocID=459

Arsenault, A. & Forsyth, D. (1996). *Why is there pollution in Mexico City?* A lesson plan retrieved January 28, 2004 from http://retanet.unm.edu/article.pl?sid=03/05/18/1912211

Atwater, M.M. (1995). The multicultural science classroom part II: Assisting all students with science acquisition. *The Science Teacher, 62 (4).* 42-45.

Atwater, M.M. (2000). Multicultural Science Education. *The Science Teacher, 67 (1).* 48-49.

Babco, E. (2001). *The Status of Native Americans in science and engineering.* Retrieved March 18, 2005 from http://ehrweb.aaas.org/mge/Reports/Report1/Babco-StatusOfNativeAmericansInSandE.pdf

Babco, E. (2000). *Limited progress: The status of Hispanic Americans in science and engineering.* Retrieved April 2, 2007 from http://ehrweb.aaas.org/mge/Reports/Report2/Report2.html

Bagley, C. (1984). Education, ethnicity and racism: a European-Canadian perspective. *Currents.* 8-12.

Banks, J. (1979). Shaping the future of multicultural education. *The Journal of Negro Education, 48.* 237-252.

Banks, J. (1988). Ethnicity, class, cognitive, and motivational styles: Research and teaching implications. *Journal of Negro Education, 57.* 452-466.

Banks, J. (1995). Multicultural education and curriculum transformation. *The Journal of Negro Education, 64 (4).* 390-400.

Banks, J.A. (1999). *An Introduction to Multicultural Education* (2nd ed.). Boston: Allyn and Bacon.

Barton, A.C. (2006). Learning to teach science and mathematics across diversity. *Studies in Science Education, 42.* 185-193.

Bettac, T., Huckabee, C., Musser, L., Patton, P., & Yates, J. (1997). Advanced science for kids: Multicultural assessment and programming. *Science Scope, 21 (3).* 33-35.

Bhargava, A., Hawley, L.D., Scott, C.L., Stein, M., & Phelps, A. (2004). An investigation of students' perceptions of multicultural education experiences in a school of education. *Multicultural Education, 11 (4).* 18-23.

Brooks, G., & Brooks, M. (1993). *In search for understanding: The case for Constructivist classrooms.* Alexandra, VA: Association for Supervision and Curriculum Development.

Brown, P.L. & Abell, S.K. (2007, Summer). Cultural diversity in the science classroom. *Science and Children, 44 (9).* 60-61.

Bryant Jr., N.A. (1996). Make the curriculum multicultural. *The Science Teacher, 63(2).* 28-31.

Caduto, M.J. & Bruchac, J. (1995). *Keepers of life: Teacher's guide: Discovering plants through Native American stories and earth activities for children.* Golden, Colorado: Fulcrum Publishing.

Caduto, M.J. & Bruchac, J. (1997). *Keepers of the animals: Native American stories and wildlife activities for children.* Golden, Colorado: Fulcrum Publishing.

Cajete, G.A. (1999). *Igniting the sparkle: An indigenous science education model.* Kivaki Press: Skyand, NC.

Cajete, G.A. (1988). *Motivating American Indian students in science and math.* Washington D.C.: Office of Educational Research and Improvement. (ERIC Document Reproduction Service No. ED296812)

Chacon, H.A. (1996). *Finding out about herbs in Latin America.* Retrieved April 1, 2007 from http://retanet.unm.edu/article.pl?sid=03/05/18/2106111

Clark, E.E. (1953). *Indian legends of the Pacific Northwest.* Los Angeles: University of California Press.

Cleary, L. & Peacock, T. (1997). *Collected wisdom: American Indian education,* 172. Retrieved March 18, 2005 from www.noao.edu/education/native/teaching-science.php

Cobern, W.W. & Loving, C.C. (2001). Defining 'science' in a multicultural world: Implications for science education. *Science Education, 85.* 50-67.

Cooper, J. & Matthews, C. (2005). A decade of concern: a review of multicultural science education issues in The Science Teacher. *The Science Teacher, 72 (3).* 49-52.

Corsiglia, J. & Snively, G. (2001). Rejoinder: Infusing indigenous science into western modern science for a sustainable future. *Science Education, 85 (1).* 82-86.

Cronbach, L. J. (1975). Beyond the two disciplines of scientific psychology. *American Psychologist, 30*(2), 116-127.

Cross, T., Bazron, B., Dennis, K., & Isaacs, M. (1989). *Towards a culturally competent system of care: Volume 1.* Washington, DC: CASSP Technical Assistance Center.

Davis, K. (1997). *Exploring the intersection between cultural competency and managed behavioral health care policy: Implications for state and county mental health agencies.* Alexandria, VA: National Technical Assistance Center for State Mental Health Planning.

DiCerbo, P.A. (2000). Common practices for uncommon learners: Addressing linguistic and cultural diversity. *Framing Effective Practice: Topics and Issues in Education English Language Learners.* In NCBE. Retrieved April 2, 2007 from http://www.ncela.gwu.edu/pubs/tasynthesis/framing/1commonpractices.htm

Emtech. (2000). *Alternative/Performance-Based Assessment*. Retrieved April 22, 2009 from http://www.emtech.net/Alternative_Assessment.html

Franks, S. & Kean, E. (2000). Minority students learning science well: a classroom case study. *Journal of African American Men, 4 (4).* 89-107.

Fountain, B.M. (?). *Never lose sight of freedom: Using the Yakima Native American time ball oral history tradition to tell the story of the 1965 Selma-to-Montgomery voting rights march.* National Park Service. Retrieved April 22, 2009 from http://www.nps.gov/archive/semo/freedom/Edukit/civil-activities/3L/yakimatimeball.pdf

Freed, A.B. (1999). *Multicultural science education: Myths, legends and moon phases.* Retrieved April 4,2007 from http://www.newhorizons.org/strategies/multicultural/freed.htm

Gallard, A. (2007). *Creating a multicultural learning environment in science classrooms.* In NARST Research Matters - to the Science Teacher. Retrieved May 29, 2004 from http://www.narst.org/publications/research/multicultural.htm

Gay, G. (1994). *A synthesis of scholarship in multicultural education.* Retrieved March 29, 2009 from http://education.washington.edu/areas/ci/profiles/documents/gay_synth_schol_multicultural.pdf

Gilbert, A. & Yerrick, R. (2001). *Same school, separate worlds: a sociocultural study of identity, resistance, and negotiation in a rural, lower track science classroom.* Journal of Research in Science Teaching, 38 (5). 574-598.

Gorski, P.C. (2006a). *7 Key characteristics of a multicultural education curriculum.* In Edchange Multicultural Pavilion. Retrieved May 29, 2004 from http://www.edchange.org/multicultural/resources/ct_characteristics.html

Gorski, P.C. (2006b). *Circles of my multicultural self.* Retrieved April 2, 2007 from http://www.edchange.org/multicultural/activities/circlesofself.html

Grant, C.A. (1977). *Multicultural education: Commitments, issues, and applications.* Washington D.C.: Association for Supervision and Curriculum Development.

Hadi-Tabassum, S. (1999). Assessing students' attitudes & achievements in a multicultural & multilingual science classroom. *Multicultural Education, 7 (2).* 15-20.

Hankes, J.E. & Fast, G.R. (Eds.). (2002). *Changing the faces of mathematics: Perspectives on indigenous people of North America.* Reston, Virginia: National Council of Teachers of Mathematics.

Hernandez-Sheets, R. (2001). Whiteness and white identity in multicultural education. *Multicultural Education, 8 (3).* 38-41.

Hopkins, G. (1997). Exploring Native Americans across the curriculum. *Education World (online).* Retrieved April 2, 2007 from http://www.education-world.com/a_lesson/lesson038.shtml

Howard, G.R. (1999). *We can't teach what we don't know: White teachers, multiracial schools.* New York: Teachers College Press.

Ignas, V. (2004). Opening doors to the future: Applying local knowledge in curriculum development. *Canadian Journal of Native Education, 28 (1/2).* 49-60.

Indian Education/Title I/Community Outreach Office. (2000). *Proposed standards for culturally-responsive schools: Indian education plan for Washington state.* Washington: Office of Superintendent of Public Instruction.

Kimmerer, R.W. (2002). Weaving traditional ecological knowledge into biological education: A call to action. *Bioscience, 52 (5).* 432-438.

King, M.A., Sims, A., & Osher, D. (1999). *How is cultural competence integrated in education?* Retrieved October 7, 2004 from http://cecp.air.org/cultural/Q_integrated.htm

Klug, B.J. & Whitfield, P.T. (2003). *Widening the circle: Culturally relevant pedagogy for American Indian children.* New York: Routledge Falmer.

Krugly-Smolska, E. (2004). Let's stop talking about western science. *Canadian Journal of Science, Mathematics and Technology Education, 4 (3).* 419-422.

Lee, O. (2003). Equity for linguistically and culturally diverse students in science education: a research agenda. *Teachers College Record, 105 (3).* 465-489.

Lee, O. (2004). Teacher change in beliefs and practices in science and literacy instruction with English language learners. *Journal of Research in Science Teaching, 41 (1).* 65-93.

Lee, O., et al. (2005). An instructional interventions impact on the science and literacy achievement of culturally and linguistically diverse elementary students. *Journal of Research in Science Teaching, 42 (8).* 857-887.

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry.* Beverly Hills, CA: Sage Publications, Inc.

Luft, J. (1999). The border crossing of a multicultural science education enthusiast. *School Science and Mathematics, 99 (7).* 380-389.

Luykx, A., Lee, O., Mahotiere, M., Lester, B., et al. (2007). Culture and home language influences on children's responses to science assessments. *Teachers College Record, 109 (4)*. 897-926.

McElroy, K. (1999). Cultural factors in science instruction: A review of science in the multicultural classroom. *Multicultural Education, 7 (2)*. 38-39.

Madrazo Jr, G.M. (1999). So, how does a multicultural classroom look? Sound? *Science and Children, 36 (5)*. 6-7.

Mathison, C. & Young, R. (1995). Constructivism & multicultural education: a mighty pedagogical merger. *Multicultural education, 2 (4)*. 7-10.

Matthews, M. R. (1994). *Science teaching: The role of history and philosophy of science.* New York: Routledge.

Medina-Jerez, W. (2005). Students' worldviews and school science: a David and Goliath confrontation? *Journal of Science Education, 6 (2)*. 90-93.

Menkart, D. (1993). Multicultural education: Strategies for linguistically diverse schools and classrooms. *NCBE Program Information Guide Series, 16.* Retrieved April 2, 2007 from http://www.ncela.gwu.edu/pubs/pigs/pig16.htm

Montgomery, W. (2001). Creating culturally responsive, inclusive classrooms. *Teaching exceptional children, 33 (4)*. 4-9.

Muller, P.A., Stage, F.K., & Kinzie, J. (2001, Winter). Science achievement growth trajectories: Understanding factors related to gender and racial-ethnic differences in precollege science achievement. *American Educational Research Journal, 38 (4).* 981-1012.

National Academy of Sciences. (1998). *Teaching about evolution and the nature of science.* Washington, D.C.: National Academies Press.

National Center for Educational Statistics (NCES). (2008). *Trends in international mathematics and science study (TIMSS).* Washington, D.C. Retrieved April 12, 2009 from http://nces.ed.gov/timss/

National Council on Economic Education. (2000). *Save the moonflowers.* Retrieved April 2, 2007 from http://www.econedlink.org/lessons/index.cfm?lesson=EM127

National Endowment for the Humanities. (2002). *Kennewick man: Science and sacred rights.* In EdSitement website retrieved April 3, 2007 from http://edsitement.neh.gov/view_lesson_plan.asp?id=268

National Geographic Society. (2001). *Creative climates.* A lesson plan retrieved April 2, 2007 from http://www.nationalgeographic.com/xpeditions/activities/08/climates.html

National Geographic Society. (2004). *Human migration: The story of the cultural landscape.* A lesson plan retrieved April 2, 2007 from http://www.nationalgeographic.com/xpeditions/lessons/09/g68/index.html

National Geographic Society. (2006). *The human role in dog evolution.* A lesson plan retrieved April 2, 2007 from http://www.nationalgeographic.com/xpeditions/lessons/08/g912/dogsevolution.html

National Geographic Society. (2006). *Lewis and Clark: Native American contributions.* A lesson plan retrieved April 2, 2007 from http://www.nationalgeographic.com/xpeditions/lessons/15/g68/contributions.html

National Geographic Society. (2006). *Preservation issues: Competing interests.* A lesson plan retrieved April 2, 2007 from http://www.nationalgeographic.com/xpeditions/lessons/06/g68/molson.html

National Geographic Society. (2006). *Recording the changing seasons in ancient times.* A lesson plan retrieved April 2, 2007 from http://www.nationalgeographic.com/xpeditions/lessons/07/g68/hawaii.html

National Geographic Society. (2006). *Rivers: Lifelines of the land.* A lesson plan retrieved April 2, 2007 from http://www.nationalgeographic.com/xpeditions/lessons/14/g68/tgrivers.html

National Geographic Society. (2006). *Using Venn diagrams to compare two ecosystems.* A lesson plan retrieved April 2, 2007 from http://www.nationalgeographic.com/xpeditions/lessons/08/g68/venn.html

National Geographic Society. (2006). *Weather and agriculture.* A lesson plan retrieved April 2, 2007 from http://www.nationalgeographic.com/xpeditions/lessons/08/g912/globalclimate.html

National Park Service. (2006). *Natural Dyes.* Retrieved April 5, 2007 from http://www.nps.gov/archive/grsa/resources/curriculum/elem/lesson24.htm

National Research Council. (NRC). (1999). *How people learn: Bridging research and practice*. (Donovan, M.S., Bransford, J.D., & Pellegrino, J.W. Eds.). Washington, D.C.: National Academies Press.

National Research Council (NRC). (2000). *Inquiry and the national science education standards: A guide for teaching and learning*. Washington, D.C.: National Academies Press.

National Research Council (NRC). (2005). *How students learn: Science in the classroom.* (Donovan, M.S., & Bransford, J.D. Eds.). Washington, D.C.: National Academies Press.

National Science Teachers Association (NSTA). (2000). *NSTA position statement: Multicultural science education.* Retrieved May 29, 2004 from www.nsta.org

Noel, J. (2000a). *Developing multicultural educators.* New York: Longman.

Noel, J. (Ed.). (2000b). *Notable selections in multicultural education.* Guilford, Connecticut: Dushkin/McGraw-Hill.

Peace Corps. (2006). *Is that a fact?* A lesson plan retrieved April 3, 2007 from http://www.peacecorps.gov/wws/educators/lessonplans/lesson.cfm?lpid=299&sid=4

Peace Corps. (2006). *The blind men and the elephant.* A lesson plan retrieved April 3, 2007 from http://www.peacecorps.gov/wws/educators/lessonplans/lesson.cfm?lpid=295&sid=4##

Peace Corps. (2006). *The true cost of coffee.* A lesson plan retrieved April 3, 2007 from http://www.peacecorps.gov/wws/educators/lessonplans/lesson.cfm?lpid=163&sid=3#

Philips, S.U. (1983). *The invisible culture: communication in classroom and community on the Warm Springs Indian Reservation.* Prospect Heights, Illinois: Waveland Press, Inc.

Porterfield, K.M. (2002). Ten lies about indigenous science –How to talk back. In *American Indian contributions to the world.* Retrieved March 18, 2005, from www.kporterfield.com/aicttw/articles/lies.html

Porterfield, K.M. & Keoke, E.D. (2003). *American Indian contributions to the world: 15,000 years of inventions and innovations.* New York: Checkmark Books.

Reyes, P., Scribner, J.D., & Scribner, A.P. (1999). *Lessons from high-performing Hispanic schools: Creating learning communities.* New York: Teachers College Press.

Rodriguez, A.J. (1998). Strategies for counterresistance: Toward sociotransformative constructivism and learning to teach science for diversity and for understanding. *Journal of Research in Science Teaching, 35 (6).* 589-622.

Sandefur, S., White-Watson, S., & Johnston, L.B. (2007). Literacy development, science curriculum, and the adolescent English language learner: Modifying instruction for the English-only classroom. *Multicultural Education, 14 (3)* . 41-50.

Sanfeliz, M. & Stalzer, M. (2003). Science motivation in the multicultural classroom. *The Science Teacher, 70 (3).* 64-66.

Shaw, J. (2002). *Linguistically responsive science teaching.* Electronic Magazine of Multicultural Education [online], 4 (1), 24 paragraphs retrieved from: http://www.eastern.edu/publications/emme/2002spring/shaw.html

Siegel, H. (2002). Multiculturalism, universalism, and science education: in search of common ground. *Science Education, 86 (6).* 803-820.

Siegel, M.A., Wissehr, C., & Halverson, K. (2008). Sounds like success: a framework for equitable assessment. *The Science Teacher, 75 (3).* 43-46.

Slay, J. (2001). Research perspectives on culturally sensitive science education. *Intercultural Education, 12 (2).* 173-184.

Sleeter, C.E. & Grant, C.A. (1988). *Making choices for multicultural education: Five approaches to race, class and gender.* Columbus: Merrill Publishing Company.

Snively, G. & Corsiglia, J. (2001). *Discovering indigenous science: Implications for science education.* Science Education, 85 (1), 6-34.

Stanford Solar Center. (2005). *Solar Folklore.* Retrieved April 1, 2007 from http://solar-center.stanford.edu/folklore/folklore.html

Stanley, W.B. & Brickhouse, N.W. (2001). Teaching sciences: the multicultural question revisited. *Science Education, 85 (1).* 35-49.

Stoddart, T., Pinal, A., Latzke, M. & Canaday, D. (2002). Integrating inquiry science and language development for English language learners. *Journal of Research in Science Teaching, 39 (8).* 664-687.

Sutherland, D. (1999). The treatment of knowledge. *The Science Teacher, 66 (3).* 40-43.

Swisher, K. & Deyhle, D. (1989). The styles of learning are different, but the teaching is just the same: Suggestions for teachers of American Indian youth. *Journal of American Indian Education (special edition August, 1989).*

Tabak, I. (2005). Creating multicultural classrooms: Are disciplinary distinctions pertinent to multicultural education? A view from science. *Multicultural perspectives, 7 (4).* 33-38.

Tan, G. (2002). The need for multiculturalism in the classroom as perceived by Mexican-American schoolchildren. *Multicultural Education, 9 (3).* 21-24.

Taylor, B.A.P., Poth, J.E. & Portman, D.J. (1994). *Teaching science with toys: Physics activities for grades K-9.* Middletown, Ohio: Terrific Science Press.

Tiffany, J.V. (2003). *Uncomfortable neighbors: Cultural collisions between Mexicans and Americans.* Gorham Printing: Rochester, WA.

Trent, S.A., Kea, C.D., & Oh, K. (2008). Preparing preservice educators for cultural diversity: How far have we come? *Exceptional Children, 74 (3).* 328-350.

Trumbull, E., Greenfield, P.M., & Quiroz, B. (1996). Cultural values in learning and education. In B. Williams (Ed.), *Closing the achievement gap: A vision for changing beliefs and practices.* Alexandria, VA: Association for Supervision and Curriculum Development.

Ukpokodu, N. (1999). Multiculturalism vs. globalism. *Social Education, 63 (5).* 298-300.

United States Census Bureau (Census). (2000). *United States Census: 2000.* Retrieved April 22, 2009 from www.census.gov

Wadsworth, Y. (1998). What is Participatory Action Research? *Action Research International, Paper 2.* Available on-line: http://www.scu.edu.au/schools/gcm/ar/ari/p-ywadsworth98.html

West Virginia University Department of Education (WVU). (2004). *Strategies for teaching science to Native Americans.* Retrieved March 18, 2005, from www.as.wvu.edu/~equity/native.html

West Virginia University Department of Education (WVU). (2005). *Strategies for teaching science to Hispanic Americans.* Retrieved April 2, 2007, from www.as.wvu.edu/~equity/hispanic.html

Zarry, L. (2002). A multicultural science curriculum: Fact or fantasy? *Educational Research Quarterly, 25 (4).* 3-10.

Zimbalist, A. (1999). *We, the first people: Understanding clues to the first peopling of America through archaeological finds.* In the New York Times, retrieved April 1, 2007 from

http://www.nytimes.com/learning/teachers/lessons/19991109tuesday.html?search
pv=learning_lessons

Zygmunt-Fillwalk, E. & Clark, P. (2007). Becoming multicultural: Raising awareness and supporting change in teacher education. *Childhood Education, 83(5).* 288-293.