



Globalization and Science Education: The Implications for Indigenous Knowledge Systems

Cassie Quigley

Curriculum and Instruction, Indiana University

201 North Rose Avenue

Bloomington, Indiana 47405 United States of American

Tel: 317-652-5197 E-mail: cquigs@indiana.edu

Abstract

Much of the current diversity literature in science education does not address the complexity of the issues of indigenous learners in their postcolonial environments and calls for a “one size fits all” instructional approach (Lee, 2001). Indigenous knowledge needs to be promoted and supported. There is currently a global initiative of maintaining worldviews, languages, and environments of which science education can be a part (McKinley, 2007). This paper is organized around five main topics that further guide the theoretical framework for this important area: a) describing postcolonialism and indigeneity related to science education, b) defining the terms indigenous knowledge, traditional ecological knowledge, c) western modern science and the effects of globalization on these terms d) examining the research on learning implications of IK and/or TEK in classrooms with a focus on the research into student learning in indigenous language, e) connecting place-based education to curricular implications for indigenous knowledge systems.

Keywords: Indigenous knowledge, Postcolonialism, Science education, Globalization, Indigenous language

1. Introduction

Science education research has become increasingly concerned with the diversity of students in the classroom as demonstrated by the increase in articles on issues of equity in the last 10 years. However, much of this diversity literature does not address the complexity of the issues of indigenous learners in their postcolonial environments and calls for a “one size fits all” instructional approach (Lee, 2001). Now more than ever, indigenous knowledge needs to be promoted and supported. As globalization continues to increase, it allows for contact between once geographically isolated groups, and traditional knowledge systems are being assimilated and in some cases disappearing all together. For many indigenous peoples, this type of culture is one of colonizing, although due to increased globalization, the means of colonizing is changing. In a time of globalization in terms of technology and increased worldwide travel where populations migrate, indigenous knowledge is often dismissed as irrelevant and the Internet makes location an intangible concept. However, increasing local achievement in science and science education is advocated by a number of researchers in order to provide opportunities for people globally (McKinley, 2005). This issue of making local knowledge part of the global brings with it the challenges of politics, history, language, economics and ethics. Throughout this paper, I will address these challenges and discuss ways to overcome these difficulties by focusing on place based science education that supports indigenous knowledge.

As educators become more immersed in exploring traditional belief systems and finding a place for them in the Western world, the youth of many indigenous groups are becoming disinterested in their own native culture. Among the youth, a negative view of their culture has been championed by the lack of value the Western world has traditionally placed on these knowledge systems. However, in the last few decades, voices of educators and indigenous peoples themselves have led an awareness of the importance of IK. Encouragingly, some indigenous societies are keeping their cultural autonomy intact and demand for local curricula despite the modern domination of the Western world. An acknowledgement of this domination has been spreading, even in industrialized societies. Educators are beginning to recognize that Western-based formal knowledge remains just one knowledge system of many. Though traditional knowledge has long been, and often continues to be, assigned a lower status in both development and scientific circles than Western-based science and technology, the value of IK in science has been receiving increasing attention. Previously, the literature treated all minorities and indigenous peoples as requiring similar solutions to under achievement and this created exclusions for many people as individual voices and struggles were ignored. The research

on culturally and linguistically diverse students in science education challenges traditional notions of WMS content, learning, teaching, and assessment (Lee, 1999). No longer is it acceptable to treat diverse groups as a homogenous whole with the same needs and experiences. Instead, indigenous study is requiring the world to take note of its rightful and unique place in multicultural research. David Clark (2004) argued that indigenous studies are about, “restoring well-being to our nations” (p. 230). Well-being for indigenous students comes from an approach that involves social, economic, and cultural development and a “strong sense of identity as indigenous” (McKinley, 2007, p. 221). However, in order for indigenous knowledge systems to continue, we need people with the ability to embrace indigenous ways and science. To accomplish this we need to not only create the space where that can happen but learn through their experiences how this can be done. The reality of the current situation is that most indigenous students are in cross-cultural classrooms where the teacher is from a different cultural group and often does not speak the same language, and has different knowledge systems than the students (McKinley, 2007). Little research has been done with respect to student learning in indigenous language however, there are some programs that are attempting to use indigenous language instruction with indigenous teachers using place-based instruction that position themselves to control their own academic destiny by promoting indigenous peoples as the norm. The purpose of these programs is to empower students and communities (Bishop & Glyn, 1999). This goal is ideal and its path brings complex issues. However, the development and successes of indigenous science education programs are vital in order to provide the foundation for successes in cross-cultural classrooms. This paper focuses on indigenous students’ interests from international contexts and acknowledges the need to create way to support and promote achievement and equity in science education for these students. In my view, achievement and equity can only occur if there is careful consideration of students’ language, cultural knowledge and experiences as well as an analysis of the current role of science education. Equitable instruction and assessment practices for diverse students involve consideration of their cultural and linguistic experiences, which should enable them to connect to science and maintain their identities (Lee, 2001). There is currently a global initiative of maintaining worldviews, languages, and environments of which science education can be a part (McKinley, 2007). As well, science education needs to consider the indigenous communities themselves and pay attention to the needs of the people. Because of the complex relationships that are reflected in the literature on indigenous students, which highlight the historical and current effects of colonization, including changes to their language and culture, indigenous studies are grounded in political and moral bases. Therefore, history, science education necessarily involves philosophy, sociology, history, psychology, and anthropology (Young, 1974). This paper is organized around five main topics that further guide the theoretical framework for this important area. These topics include: a) describing postcolonialism and indigeneity as they relate to science education, b) defining the terms indigenous knowledge, traditional ecological knowledge, c) western modern science and the effects of globalization on these terms d) examining the research on learning implications of IK and/or TEK in classrooms with a focus on the growing research into student learning in indigenous language, e) connecting place-based education to curricular implications for indigenous knowledge systems. Finally, I conclude with the gaps in the research that still remain and need to be addressed through future research.

2. Postcolonialism and Indigeneity in Science Education

A single, definite postcolonial theory is controversial among many researchers (Ashcroft, Griffiths, Tiffin, 1995; Mohanram, 1999). Postcolonialism generally deals with the cultural identity in colonized societies including the issues after the colonial rule. However, the term “after” indicates finality in the rule and definite point of time. Homi Bhabha (1994) argued that a more realistic term is “beyond” to signify the blurring of borders of a linear progression. In *Post-Colonial Drama: theory, practice, politics*, Helen Gilbert and Joanne Tompkins (1996) write:

The term postcolonialism — according to a too-rigid etymology — is frequently misunderstood as a temporal concept, meaning the time after colonialism has ceased, or the time following the politically determined Independence Day on which a country breaks away from its governance by another state, Not a naïve teleological sequence which supersedes colonialism, postcolonialism is, rather, an engagement with and contestation of colonialism's discourses, power structures, and social hierarchies ... A theory of postcolonialism must, then, respond to more than the merely chronological construction of post-independence, and to more than just the discursive experience of imperialism. p.

Here, Gilbert and Tompkins describe the long-term effects of colonialism that have often changed societies and cultures and do not return to pre-colonial days as soon as the colonizers leave. By viewing postcolonialism as not only blurred point in history but also an integration of ancestry, cultural history, and language, helps to step away from the “them and us” position that is often present in this type of discourse (McKinley, 2007). To disconnect from this binary view, we need to understand that colonial rule was very different for different cultures and people, for some people there was wealth and success with the rule while others were forced to change languages and religions. For example, in India was seen as “the jewel of the British Empire” (McKinley, p. 201). In contrast, Australia was colonized with the purpose of a military base (Pagden, 1998). Therefore, the experiences of colonial rule were very different not only because of the indigenous cultures but also because of the intentions of the colonizers. However, one commonality between indigenous groups is the colonizing experience will always be ongoing in their country. Therefore,

throughout this review, I will use postcolonialism not to mean a point of time after colonization occurred, but to describe a complexity and hybridity of culture, language, history, politics, and education due to colonization, which are also relevant to the process of globalization. Therefore, this blurring of lines will be used to describe the challenges and complexity that globalization has added to postcolonialism and indigenous knowledge.

The link between postcolonialism and science education is strengthened due to globalization. One result globalization that ultimately affects science education and threatens indigenous knowledge is the changing of environments. For example, invasive species have profound affects on indigenous people as they are often a serious threat to the biodiversity, which is often central to the knowledge and way of life of these people whose language, belief systems, and survival are often embedded in the environment. For example, French settlers in Cambodia brought Arugula lettuce seeds with them with the intention of creating a cash crop for the indigenous people in the regions of Mondulkerri, however they underestimated the travel time to the markets to be sold and now Arugula is an expensive, way for the farmers to feed their pigs. In many cases, the environments of the indigenous people have changed due to colonization. Other introductions were accidental such as, the predatory brown tree snake, introduced in cargo from the Admiralty Islands, which has eliminated ten of the eleven native bird species from the forests of Guam (Simberloff, 2008). As well, other invasive species were intentional such as the introduction of the red fox to Australia. The fox was introduced from British for recreational hunting. Now the fox has a threat level of “extreme” and is considered an elusive prolific predator of native animals and livestock (NBII & ISSG, 2005). These disruptions to the environments put a huge financial burden to the indigenous people who are left with the disruptions caused by others and depend on agriculture for survival.

Another effect of postcolonialism on science education is through curriculum development, which is highly influenced by Western countries. As explorers and settlers attempted to “modernize, develop, instruct, and civilize the natives they found” (McKinley, 2007, p.202), colonizers brought with them books, curricula, and wildlife with the intentions of “helping” the indigenous people and to make their new home more comfortable (Crosby, 2004). Countries who want to “succeed” in a global world are forced to learn Western modern science that follows a curriculum based out of the European or North American countries. Phnom Penh, Cambodia sits in the heart of the Kirirom Rainforest however the majority of Year 11 Biology focused on deciduous and desert biomes, neither of which is present anywhere in the country (MoYES website).

Indigeneity is an extremely complex concept, particularly in the contexts where colonizers were not numerically dominant such as Africa, South America, Southeast Asia, and India. Here, these countries had settlers that never were a majority but highly influenced through educational institutions, culture and language (Maddock, 1981). Defining an indigenous group can be equally difficult. Although the term is meant to include cultural groups (and their continuity or association with a given region, or parts of a region, and who formerly or currently inhabit the region either, based on the groups history this can be challenging and therefore consideration of the history of the place is equally important. A central part of this definition is including the linguistic, cultural, and social characteristics that make it different from the colonizers of the place. However, the term is not meant to assume that all the people are the same, but form “a collective of people who share some similarities in their aspirations and circumstances” (McKinley, 2007, p. 203). Even if all the criteria are met, some people may not consider themselves as indigenous even when governments, organizations and scholars do. This again touches on the complexity of indigeneity. At the same time, it is also important to note that the people does typically not use this term and often they have their own ideas of outsiders. For example, in Cambodia, Cambodian call themselves *lok nung lok srey* (men and women) whereas they called all foreigners regardless of the color of their skin, *barrang*, (white). This is important to keep in context; this term was developed for purposes of academia but is not used locally.

For indigenous groups, what is often important in regard to “others” is they are respected and live without threat to their language, culture, and resources but this gets even more complicated when involving education. They see education as important for preparing their children both locally and globally because of the dual environments they will live in and therefore the challenges arise. Currently, their world is combination of both local and global spaces and they recognize both spaces as a concurrent part in their everyday lives. Research, however, has tended to focus on the problems indigenous students have in integrating in the global world. In an analysis of the beliefs and practices of indigenous people from around the world, Knudtson and Suzuki (1992) identified the following characteristics as distinguishing their worldviews from the predominant beliefs and practices in western society. Nisbett succinctly describes how these completely different worldviews have maintained themselves for thousands of years:

These approaches [to the world] include profoundly different social relations, views about the nature of the world, and characteristic thought processes. Each of these orientations is self-reinforcing and homeostatic. The social practices promote the worldviews; the worldviews dictate the appropriate thought processes; and the thought processes both justify the worldviews and support social practices. (p. xx)

The compartmentalization, hierarchical and linear thinking that are inherent features of western world are often in direct conflict with social structures and practices in indigenous societies, which tend toward collective decision-making, a relationship with and a respect for nature, and a slower pace of life. Western people often have a remarkable sense of “personal agency”, which is the sense that are in charge of their own lives and free to act as they chose, (Nisbett, 2003). One definition of happiness described by the Greeks was “being able to exercise their powers in pursuit of excellence in a life free from constraints” (Nisbett, p. 3). In contrast, indigenous peoples counterpart to personal agency, is “collective agency” or harmony. It is often described as “the totality of roles I live in relation to specific others...taken collectively, they weave for each of us, a unique pattern of personal identity such that if some of my roles change, the others will necessarily change also, literally making me a different person” (Rosemont, 1997, p.65). The ideal of happiness for indigenous people is often described a life shared within a harmonious social network. It is little wonder then that formal education structures, which often support Western worldviews, have not addressed the educational needs of indigenous societies. However, Dzama and Osborne (1999) challenged this idea that opposing worldviews were main issue by arguing that the problems that plague indigenous people often plague Western societies as well. They stated, “It is often forgotten that the emergence of the scientific way of thinking was a radical change in worldview that occurred between 1500 and 1700 a.d. Attempts to permeate national life with the scientific worldview initially were unsuccessful” (p. 401). They concluded poor performance in science in developing countries is not due to the worldviews of students in these countries but to the absence of supportive environment for serious science learning and a lack of scientists as role models for the youth. Here Dzama and Osborne urge researchers to step away from the worldview model and focus on the real life problems that are preventing success in indigenous peoples.

However, even though the indigenous youth are able to function adequately in their fragmented world, science educators need to tap into the important resource of indigenous people and realize the vast knowledge base of science they use in their daily life. Castellano (2000) also argued that the challenge for science educators of indigenous peoples is to include all types of knowledge valued by these people including traditional knowledge and empirical knowledge. Traditional knowledge is passed down from generations, which keeps records of genealogies and creations of species. It also passes along values and beliefs and well as some forms of technologies. It is passed on through the elders who are highly respected. This often leads to a conservative attitude toward change and therefore is linked to the slow pace of the environment. Empirical knowledge is gained only through careful observation of entire ecosystems and extends over many persons and much time. It is often described, as a loop in which is refined only when new information is gained and needs to replace other information. Therefore, Castellano argues that the challenge is “to open up space for Aboriginal initiative in schools and colleges, work sites, and organizations so that indigenous ways of knowing can flourish and intercultural sharing can be practiced in a spirit of coexistence and mutual respect” (p. 23). It is with this type of inclusive space that science education can contribute to the overarching aspirations of indigenous peoples including preparing their youth for involvement in their own indigenous societies, which are both local and global.

3. Defining terms: Indigenous knowledge (IK) and Traditional Ecological Knowledge (TEK)

School science traditionally has had the goal of preparing students for future science courses by focusing on intellectual knowledge acquisition specifically guided by Western modern science (WMS), however, alternatives to this science curriculum have existed since its inception. The most enveloping alternative describes science as a human endeavor, which includes culture, language, society, technology, experiences, and community views. This is the focus of indigenous knowledge. Indigenous cultures are found worldwide: for example, Native Americans; First Nations of Canada, Indian nations of South America; the Maori of New Zealand. These cultures possess knowledge systems of nature that serve their people. The goal of this science is to contribute to practical ends of the community.

The concept of indigenous knowledge (IK) refers to acquisition of and practices that are developed by groups with long histories of intimate relationships with their natural environment. This base of knowledge is part of a cultural system that encompasses native languages, naming and classification systems, utilization of resources, rituals, spirituality, and worldviews. This is often described as a frame of knowledge and a subset of that is Traditional Ecological Knowledge (Cajete, 1999). Indigenous science relates to the science knowledge of long-resident, usually oral culture peoples, as well as the science knowledge of all peoples who as participants in culture are affected by the worldview and relativist interests of their home communities. A well-documented branch of indigenous science, known to biologists and ecologists as traditional ecological knowledge (TEK), focuses on the science that is highly localized and socialized. TEK, though difficult to disconnect from the larger IK system, is a way to understand the complexity of social relationships between a particular groups of indigenous people in their community. Therefore, the knowledge is accumulative and ongoing. In the literature, it is generally used to denote the worldviews of indigenous peoples. Therefore, I will follow this demarcation created by the literature and I will use IK to mean the knowledge and worldviews of indigenous communities and TEK to focus on localized knowledge. Although it is important to note that from indigenous point of view the two objects, TEK and IK are the same.

Disputes regarding the universality of the standard scientific account are of critical importance for science educators because the definition of science is a *de facto* “gate keeping” device for determining what can be included in a school science curriculum and what cannot. When Western modern science (WMS) is defined as universal it does displace revelation-based knowledge (i.e., creation science); however, it also displaces pragmatic local indigenous knowledge that does not conform to formal aspects of the “standard account.” Thus, in most science classrooms around the globe, Western modern science has been taught at the expense of indigenous knowledge. However, because WMS has been implicated in many of the world’s ecological disasters, and because the traditional wisdom component of TEK is particularly rich in time-tested approaches that foster sustainability and environmental integrity, it is possible that the Universalist “gatekeeper” can be seen as increasingly problematic and even counterproductive (Snively & Corsiglia, 2001). Because of the Western Modern Science (WMS) stronghold on the American public schooling system since colonization, IK and TEK have often times been reduced to primitive or technical knowledge for survival. WMS emphasizes the importance of data and empirical evidence on which to build theories. The reverence for WMS is seen in its ties to governmental, political, and social spheres of influence. Many attribute WMS as being predominately influenced by white, male, Western meanings (McKinley, 2007).

4. Western Modern Science (WMS) and the Current Challenges of Globalization for Indigenous Knowledge

There is a large amount of international literature that explores the relationship between indigenous and WMS. The nature of these types of knowledge underlies much of the debate. This debate began with Kuhn’s (1970) “scientism” attitude, which challenged an objective science and legitimized challenging positivism thought inherent in WMS. Current discussions in science education, center on the undeniable roots of WMS in non-Western thinking. One question raised by some researchers is whether WMS is a threat to IK. However, Sandra Harding (1991) argues that modern science owes its roots to African, Asian, and other Third World indigenous peoples. Harding outlines these contributions that tend to get de-emphasized, or often completely ignored, when people conceive of modern science. In effect, her claims provide an opportunity for expanding our historical perspectives on science and illuminate the Eurocentric assumptions that narrowed our understanding of the humanity in science, complete with its forces of power and domination. Certainly, most funding in the sciences is from Westerners to research diseases and technologies that would seemingly benefit mainly Westerners. The effects of this de-development of the Third World are seen readily in modern day, with the mass genocides and disease pandemics that plague Africa and other Third World countries. This continues to be exacerbated as globalization continues.

A recent phase in globalization, which simply put means the extension of Western capitalism and modernist institutions and practices to the whole world in the development of a global capitalist system (Segesvary, 1998). These institutions and practices “include the OPEC oil crisis and saturated markets of the 1970s; abandonment of international exchange controls; the competitive penetration of Western markets by newly industrialized countries; the development of new information, communications and transport technologies; and more recently, the fall of the Berlin wall and disintegration of the communist bloc” (Carter, 2008, p. 620) Globalization not only refers to a series of economic changes but technological changes that have changed the way the world works and transfers information (Penn, 2005, p. 4). These changes include: changes in the financial markets, changes in international trade, changes in investment patterns, even changes in the way crimes are carried out. Brown and Lauder (1996) extended this definition of globalization to include “a change in the rules of eligibility, engagement, and wealth creation” (p. 2). The rules of eligibility have changed to either include or exclude certain groups. The included are wealthy, highly mobile, and typically Western with certain skills (Freidman, 2000) while the excluded are incorporated into the global world by the dominance of the global markets. Therefore, the new terms of eligibility due to globalization are creating a new binary view from have/have-not into eligible/ineligible (Carter, 2008). Those that are eligible participate in new modes of wealth creation, changing from industrial work to the ever-changing knowledge that design, produce and market products and services. Specifically, this is having a profound effect on scientific knowledge moving away from fundamental inquiry towards discovery of new products and services (Carter, 2008).

Leading these changes is the USA, which is the richest country in the world in terms of amount of money it earns. Furthermore, USA is also contributing greatly to globalization through language, as English is the prominent language; English has been the dominant language of trade, commerce, law and science (Penn, 2005). Today, globalization continues to accelerate at an extreme rate through development of technologies of communication however people living in poor countries access is very difficult because of the energy and financial demands that technology requires. In the Western world, one can connect to the Internet wirelessly and often for free. However, in most developing countries, the opposite is true. For example, the connection of Cambodian people to the global ocean of knowledge is a very small stream that is both slow and expensive to navigate. Cambodia has one of the lowest rates of Internet connectivity with one of the highest pricing structures to access such connectivity (<http://www.unescap.org>).

This shifting of information is one type of globalization that indigenous communities face. Another is the shifting of people and goods. Air travel has increased at a phenomenal rate and one can now fall asleep in Johannesburg and

wake up in London 8 hours later. Goods are now travelling huge distances to arrive at our stores. Apples picked in Peru travel to China to be concentrated and bottled and then ship to California to be distributed to the Midwest. Even with all of the travelling of people and goods, indigenous people are unlikely to travel great distances. Those travelling around the world mostly hold European or North American passports, and the cost of flights is astronomical in compared with their wages (Penn, 2005). Therefore, in terms of science education it is necessary to understand that it is the “Others” rather than indigenous peoples choosing to be introduced to other cultures bring the majority of the globalization indigenous people face into their world.

One consequence of globalization for science and science education is it creates even more complex societies and challenges for indigenous communities. Similarly to colonization globalization changes indigenous knowledge systems, even if that is not the goal. “Globalization has meant that at the local level, the world’s peoples rub more closely together ensuring that diversity, plurality, hybridity, dislocation, and discontinuity have become the leitmotifs of the global age” (Carter, 2004, p. 820) Therefore, indigenous communities are forced to encounter the Western world more rapidly and frequently. “Science has seen considerable change in recent decades with the emergence of a new economic and sociopolitical contract between science, the nation, state, and private commercial interests. Generally regarded as having been precipitated by globalization, these changes in the sciences are beginning to be documented by a range of commentators” (Carter, 2008, p. 617). Science's changing forms hold profound implications for the development of science education. There is little science education scholarship exploring the implications sciences' altering forms. Detailing this relationship is important because it can help formulate new questions, and methods for their investigation, relevant to the work of science education in the newly global world (Carter, 2008).

Because of the USA being the powerhouse of globalization, English has become the language of globalization. Because of the power it holds in trade, diplomacy, aid, technology, and academia, all other languages are disadvantaged. As well, there are repercussions for those who communications must always be through a second or third language, particularly in a learning environment. Access to scientific literature in developing countries is marginal at best. While scientists and college students can use the resources of fairly good technical libraries, young students are less fortunate. While many scientists in developing countries typically read and understand English, most scientific journals are not within easy reach. University libraries in these countries are often strapped for funds and can barely afford to subscribe to even a few journals in each specialty field. The rest are generally unavailable to scientists and students. Without access to current literature, the preparation and publication of works directed to the more general public is delayed or impaired. Simultaneously, and perhaps more damaging in the long run, is the difficulty that many scientists in developing countries have in trying to publish their research results in American, European or global-scope journals. The conventions and regulations with respect to language use, reference citations, and the necessity of supporting research results with up-to-date bibliographic information, makes the publication of their articles an ordeal. (de la Rosa, 2008). Therefore, learning English and following the “rules” of WMS becomes a necessity for scientists in indigenous communities. This is only one of the many effects of globalization on science education for indigenous communities.

As science education research continues to pay more attention to cultural diversity, indigenous knowledge systems, and globalization, the long-held notions of WMS are being challenged, and questions such as how to have a science education that truly is for “all” and in what ways other ways of knowing can be incorporated into our public education system are being explored like never before.

5. Research on Culture and Learning for Indigenous Students in Science Education

One complexity of indigenous students learning science is culture. This section examines studies that relate culture and learning to indigenous students in science education classrooms. Until the very recent past, there has been little debate about a likely connection between culture and science education. The scenario is now changing as more and more attention is being paid to the science exposure of indigenous students who live in communities in which traditional practices and beliefs guide daily actions. The interest has been fuelled, in part, by the global thrust towards school science programs that are intended, not for a select few, but for all students. The “science for all” movement is intended to equip all students to use their knowledge of science in their daily lives. “Science for all” and “science for daily living” take on new meaning when indigenous communities’ needs are considered in cultural context.

Currently, there are three approaches dominating the IK field that are all derived from anthropology. These are worldviews (Cobern, 1991), collateral learning (Jegade, 1995), and border crossing (Costa, 1995; Aikenhead, 1996). Cultural anthropology (Maddock, 1981) and postcolonial scholarship (McKinley, 1996) both influenced the direction of indigenous science education research toward humanistic school science. In 1981, Maddock focused on theory building through a review of literature in science education and anthropology. He argued against the deficit model that focused on bring Western modern science into developing nations. His viewpoint was that science and science education are cultural enterprises, which form part of the cultural matrix of society, and that educational considerations concerning science must be made in light of that wider perspective. He considered the science curriculum projects of many nations,

and emphasizes that they were greatly influenced by Western scientists. Many of the science curricula developed by Western scientists was simply transplanted from one culture to another, often for little regard to resources or place. Typically, it had been assumed that 'primitive' cultures had no science, yet there had been little research in these cultures to confirm that assumption. Finally, Maddock concludes with the argument that to continue to progress, science education, both in its practice and research, needs to adopt an anthropological point of view.

Empirical research incorporated Maddock's viewpoint of including an anthropological approach to science education research. These studies were localized and used this humanistic framework (Ogunniyi, 1982; Henry, 1987; Ogunniyi, 1987). The purposes of these studies were to study specific curricula in a specific location. These new curricula were attempting to focus on science learning that was relevant to everyday life. They used quantitative techniques to determine how students or teachers were negotiating their opposing viewpoints (WMS and indigenous knowledge) often through Likert-scale or surveys. Most of the findings described that the curriculum needs to be relevant to the specific culture and not force the learners or teachers to abandon their traditions; however a distinction still remains between indigenous knowledge and WMS. It was with this use of anthropological definition of culture that a framework for worldview was brought into science education (Cobern, 1991).

Within this framework, George (1987) sought to explore the role of practical and culturally relevant curricula in a Caribbean context, which added a new dimension to the argument for indigenous knowledge in school science. She argued that, "Children in developing countries therefore need to learn that technological innovation does not always have to originate in the developed world but that they too have the ability to create" (p. 818). She proposed that in addressing this idea through science curriculum, students would have pride of their heritage and would drive to continue to innovate.

There have been many studies that explore how culture affects the students' learning abilities and desires. Deloria's (1992) ethnography claimed that American Indians made careful observations based on the principle that all things are related, an idea that is investigated in the modern theory of physics. Employing a multi-cultural theoretical perspective, Deloria asserted that American Indian students could radically transform scientific knowledge by grounding themselves in traditional knowledge about the world and working this understanding into the Western scientific format. However, Cajete (1999) cautions how using these cultural differences can cause isolation. He claimed there is a mismatch between cultural perspectives that results in many young Native Americans and other indigenous students becoming alienated from science. Kawagley (1999) attempted to resolve this issue and sought ways to maintain culture despite strong opposition and set up Alaska native camps in an attempt to assert more control over the changes. This worldview perspective outlines suggestions for seasonal camps in which elders would teach Native language, culture, environmental knowledge, and subsistence skills, as well as the means of bridging Native and Eurocentric science and worldviews. In this model, natives had autonomy to focus on the context and language imperative to the study of IK. Garrouette (1999) echoed calls for culturally relevant programming that recognized the legitimacy of American Indian models of inquiry into the natural world Davidson & Miller (1998) described a course for teachers of American-Indian students that focused on the development of culturally relevant activities as part of the science and mathematics curricula. Programs were embedded in a holistic approach to the curriculum and linked the informal science and mathematics of the culture with traditional school science and mathematics. Rowland and Adkins (1995) wrote about the Science and Mathematics for Indian Learners and Educators (SMILE) Project at Northern Arizona University, which provided science in-service training to K-8 teachers from Bureau of Indian Affairs schools on the Navajo reservation. The training aimed to increase and improve science instruction for Indian children and to connect science education to Native science. McKinley (1996) discussed the development of a Maori curriculum in New Zealand. An important emphasis was the participation of the Maori people throughout the curriculum development. The ideas were many, however, remained unevaluated in research.

Some proposed programs, however, were evaluated for success. The U.S. Global Change Research Program was established in 1990 to develop scientific projections of anticipated impacts of the changing biosphere on humans and social systems. As part of this program, the National Science Foundation created the Arctic System Science Program (ARCSS) to consider how humans interact with physical and biological environmental change in the Arctic. Over a 5-year period (1995-2000), initiatives systematically documented the indigenous knowledge systems of Alaska Native people and developed educational policies and practices that effectively integrate indigenous and Western knowledge. Program emphasis was on renewing Native pathways to education so that traditional knowledge systems, ways of knowing, and worldviews may be used as a foundation for learning all subject matter. Elders' councils and the Alaska Native/Rural Education Consortium provided overall guidance. Resources were assembled in each of Alaska's five cultural regions (Yup'ik, Inupiaq, Athabasca, Aleut/Alvtiiq, and Southeast regions) and entered into a curriculum resource collection maintained through the Alaska Native Knowledge Network and listed on the World Wide Web. During the first 3 years of implementation, these schools showed a net gain relative to control schools in mathematics achievement scores and dropout rates. Entering its third year, effects have shown a decrease in the dropout rate and

increases in student achievement scores; the number of rural students attending college; and the number of Native students pursuing studies in fields of science, math, and engineering (Barnhardt & Kawagley, 1998).

Historically, little research has been done to address student learning and indigenous languages. Because of the paucity of research in this area, there is no consistency among researchers about how or if indigenous language should be included in science instruction and the majority of research is in debate of how much indigenous language to use in the science classroom. Rutherford and Nkopodi (1990) carried out a study of English language learners in South Africa and found that the use of vernacular hindered student learning in a science classroom. They argued that there should be more English language usage to avoid confusion. However, this study did not examine the questions they asked the students from a linguistic viewpoint, which has demonstrated helping to eliminate misconceptions in the testing (Clerk & Rutherford, 2000). McKinley (2005) argued that one of the main ways in which indigenous knowledge systems will survive and thrive is through the establishment of programs taught through indigenous languages so that a dialectal relationship between language and science knowledge is established that continues to act as the wellspring. However, the critical issue is not only what happens in the science classrooms but also what happens in the teacher education institutes. Indigenous languages in science education face many barriers with a possibility of extinction of the languages and this area of research is in urgent need. Therefore, the focus needs to move away from what makes teaching and learning effect for indigenous peoples to understand, what makes an effective indigenous language learner and teacher of science? (McKinley, 2007)

6. Incorporating Indigenous Language through Placed-Based Curriculum

The multicultural debates are linked to other debates in science education aimed at inclusion, such as the constructivism approach, 'science for all', and SSI initiatives, which can improve the learning and achievement in science of a wider range of students. "However, the failure of science education research during these times was in not taking culture, language, 'race' or colonization as major factors in any of the projects" (McKinley, 2005, p. 230). This is despite that fact that a number of indigenous writers have argued the importance of connecting school science education to the students' cultural background (Cajete 1995, Kawagley 1995, Kawagley and Barnhardt 1999, McKinley, 1997). Making the connection to the cultural background can be done in two different ways, both of which are the foundations for place-based curriculum: 1) making science 'relevant' to the student, which usually involves teaching in culturally relevant contexts or everyday science, 2) using culturally responsive teaching or culturally based pedagogy (see Bishop and Glynn 1994, Ladson-Billings 1995).

A multidisciplinary analysis of place reveals the many ways that places are profoundly pedagogical. That is, as centers of experience, places *teach* us about how the world works and how our lives fit into the spaces we occupy. Further, places *make* us: As occupants of particular places with particular attributes, our identity and our possibilities are shaped. Snyder's (1990) assertion "The world is places" (p. 25) can be expanded: People make places and that places make people. The kind of teaching and shaping that places accomplish, of course, depends on what kinds of attention we give to them and on how we respond to them. Although culture and place are deeply intertwined (Feld & Basso, 1996), our relationship with places has been obscured by an educational system that currently neglects them. That is, schooling often distracts our attention from, and distorts our response to, the actual contexts of our own places.

To appreciate "place" as a productive educational construct, one must first explore its meanings. Place has recently become a focus for inquiry across a variety of disciplines, from architecture, ecology, geography, and anthropology, to philosophy, sociology, literary theory, psychology, and cultural studies. No single, obvious theory of place exists that might inform educational studies, although most scholars who study place would agree that an understanding of it is key to understanding the nature of our relationships with each other and the world (Grunewald, 2003).

Place-conscious education recognizes that places are what people make of them, which also include human culture. This suggests a more active role for schools in the study, care, and creation of places. If human beings are responsible for making the place, then we must become conscious of ourselves as place makers and participants in the sociopolitical process of place making. Educationally, this means developing the connections with places that allow us to invest them with particular kinds of meaning. The perceptions of students and teachers must be extended to include reflection on how a diversity of places became what they are today. In addition, from the perspective of democratic education, schools must provide opportunities for students to participate meaningfully in the process of place making to include the process of shaping what our places will become. As Grunewald suggests:

Systems of education that do not take on this work can be said to reproduce the unconscious assumption that material cultural formations-places-are natural and inevitable parts of our social and geographical landscape. Such an assumption is dangerous because (a) it obscures the connections between education, culture, and place; (b) it releases people from their responsibility as place makers; and (c) it legitimizes the ideology that is embedded in the places we take for granted. Educational disregard for places, therefore, limits the possibilities for democracy (and for places) because it diverts the attention of citizens, educators, and students from the social, cultural, and political patterns involved in place making. (p. 628)

Place-based theory and indigenous knowledge systems often use feminist pedagogical strategies. Feminist pedagogy is democratic, cooperative, and concerned with the connected and relational approaches to learning (Maher & Tetreault, 1994). Feminist perspectives include an inclusion of both place and experience (Nielsen, 1990, 24). A relational approach to learning, which centers on connecting students to teachers and subject matter, is central to the teaching process (Bingham & Sidorkin, 2004; Clandinin, 1985; Cochran-Smith, 2001; Greeno, 1997; Noddings, 1986, 2004). Relational knowing does not suggest that knowledge and knowing are not important; rather they are entrenched together with relation (Stengel, 2004). In relational knowing, the classroom is community and content knowledge “whose paths through life have fallen together” (Rorty, 1979). Thus, this relates to the importance of place in indigenous communities by viewing education from a holistic standpoint, which is the nature of indigenous people, and one that includes all views, cultures and backgrounds as central to the classroom.

Schroder (2006) explored the ways to bring together local and global knowledge systems in the context of education using place-based education. She discussed the concepts of native science and intercultural education in Ecuadorian indigenous education today and explored the views of Ecuadorian indigenous educators and leaders around issues of education and science. The primary need voiced by these individuals is that of defending their communities against various kinds of encroachment, economic and well as cultural, and the enterprise of education is viewed within this reality. The paper discussed the paradigm of place-conscious education, which Schroder argued is a unifying conceptual framework that speaks to the concerns voiced by the educators in Ecuador and elsewhere.

Grunewald (2003) agreed with this need for place and he pointed out that students and their teachers are too often isolated from the places outside the classroom, leading to a limiting of the experiences and perceptions of the students, a stunting of development and a lack of connection to and appreciation of the place in which they are located. This isolation from the place outside the school walls is exacerbated in many countries by the standardized curriculum, testing, emphasis on high scores at the conclusion of schooling, and a reliance on textbooks produced to serve a wide range of students.

Although the research in indigenous knowledge and place-based education is extremely limited, in 2007, Chinn (2007) provided a clear framework of how this can be successfully implemented. She explored how would teachers evaluate traditional/indigenous knowledge, would there be evidence of transformative learning defined as interest in developing place-based curriculum relevant to environmental issues, and finally would place, culture, and prior experience figure in their lessons and evaluations. The context for her study was a 10-day Summer Teacher Institute in Honolulu titled “Thinking in Math and Science: Making Connections” and was described as a “global learning opportunity for middle and high school teachers of math and science.” Nineteen experienced secondary teachers participated in the institute and the study. Chinn reported her results through teachers’ written responses as part of the collaborative action research, analysis of lesson videotapes, written evaluations, interviews and e-mails. Chinn concluded that teachers recognized the overlaps between indigenous and Western science knowledge, the value of including indigenous science in the curricula, and in final writings, an explicitly ethical stance that pure positivism and scientism are no longer relevant to science education. Chinn also concluded that the professional development institute provided a model for developing place and problem-based science curricula responsive to students’ lives and incorporating indigenous perspectives. Furthermore, Chinn argued that teacher’s desires to address culture and place-based environmental literacy should be considered in the debate on national education policies. She concluded that most participants connected topics to familiar contexts and places towards the larger project of developing place-based lessons oriented to active environmental literacy. Thus, these results implied that science teacher education incorporate active learning active learning situated in contexts and issues that recognize personal, socio-cultural, and ethical contexts of science.

7. Gaps in the Literature

The research in indigenous knowledge is dominated by cultural approaches that focus on worldviews, collateral learning, and border crossing. While this research helped us to step away from a deficit-model approach, it still has issues of power and economic privilege. In effect, underachieving of indigenous students continues to be a problem. This is most likely due to cultural conflict between home and classroom, low teacher efficacy and expectation, low student self-expectation, inadequate teacher subject, cultural and pedagogic knowledge, and a rigid curriculum framework with little space for culturally based pedagogy. Perhaps due to economic and technological strains, the Euro-American domination of science education is powerful and resistant to alternate worldviews. There is continued debate on worldviews and their place in the science curricula. Because researchers can have problems getting articles on local communities published in international journals, it can be difficult to access a broad view of the work that is being done in this area of study. There is a lack of empirical studies on indigenous languages, assessments of indigenous learning, and science education in terms of a dynamic exchange with indigenous cultures. Grouping together all other forms of knowledge uncritically as ‘indigenous knowledge’ and separating them from their context makes it nearly impossible to avoid generalization and oversimplification. Such generalization fails to recognize the potentially unique and important contribution that local knowledge can make to development. More research needs to be done on IK systems, and methods need to be developed for dealing with it. This research must be done together with the people

who possess the IK and with the local communities involved. This growing interest in IK is reflected in statements made by governments and non-governmental organizations in many countries are now acknowledging the contribution that local knowledge can make to sustainable development. An awareness of the value of indigenous knowledge is growing at the same time when such knowledge is under great threat to being lost and forgotten. It is in danger of disappearing not only under influence of global processes of rapid change, but also because the lack of resources needed to document, protect, and share such knowledge. Besides the need for facilities, research, and financial resources, there is also a need for a shift in moral and political support, as local knowledge continues to be denoted a lower status in both development and scientific circles than Western-based science and technology.

Overall, we need to avoid reducing the purpose of education to producing workers that can compete in the global economy (Apple, 2001). Globalization survives on uneven development, which includes economic, social, and political conditions and is necessary for the acquisition of wealth and power. And therefore, adding a new dimension to “science for all” as it is creating even greater disparity among populations. Globalization impact is felt in a range of domains including science education. Clearly, science’s changing forms from globalization hold profound implications for science. However, few studies situate science with the impact of globalization (Carter, 2008). Therefore, to move beyond the science as identified as important in the West, we need to be paying attention to the non-Western science within postcolonial thinking with concern for culture, rights, language, and place of indigenous peoples.

There continues to be a call for a sincere attempt to get indigenous students participating and achieving in science, as well as to find a place in the curriculum for IK that recognizes and protects its value and contribution to our society. If the focus was shifted towards what makes an effective indigenous language learner and teacher of science, the primary issues indigenous learners face would be illuminated by preventing language loss and protecting indigenous information. The use of indigenous languages as a means of science instruction is essential to develop the culture and language (McKinley, 2005). By creating a place in science curricula and classrooms for indigenous knowledge, this will add to scientific knowledge and methods by learning from indigenous people. Not only would these indigenous students be empowered by this could serve as a model for cross-cultural classrooms that are forced to face similar issues due to globalization. This approach also has implications for Western science classrooms as these students learn another valid approach to thinking about the world and can serve as a way to examine internally their own beliefs and habits of mind.

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