

# Understanding the Earth Systems of Malawi: Ecological Sustainability, Culture, and Place-Based Education

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**ABSTRACT:** The purpose of this 2-year study was to investigate Malawian teacher educators' perspectives and dispositions toward teaching about ecological sustainability issues in Malawi, a developing country in sub-Saharan Africa. This study was embedded in a larger theoretical framework of investigating earth systems science through the understanding of nature–knowledge–culture systems from local, place-based perspectives. Specifically, we were interested in learning more about eco-justice issues that are related to environmental degradation in Malawi and the potential role of inquiry-oriented pedagogies in addressing these issues. In a science methods course, the African educators' views on deforestation

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and teaching about ecological sustainability were explored within the context of the local environment and culture. Teachers participated in inquiry pedagogies designed to promote the sharing of perspectives related to the connections between culture and ecological degradation. Strategies encouraging dialogue and reflection included role-playing, class discussions, curriculum development activities, teaching experiences with children, and field trips to a nature preserve. Data were analyzed from postcolonial and critical pedagogy of place theoretical perspectives to better understand the hybridization of viewpoints influenced by both Western and indigenous science and the political hegemonies that impact sustainable living in Malawi. Findings suggested that the colonial legacy of Malawi continues to impact the ecological sustainability issue of deforestation. Inquiry-oriented pedagogies and connections to indigenous science were embraced by the Malawian educators as a means to involve children in investigation, decision making, and ownership of critical environmental issues. © 2006 Wiley Periodicals, Inc. *Sci Ed* 1–21, 2006

## INTRODUCTION

Across south central Africa, Malawi, and her people, are known as the “Warm Heart” of Africa. Sadly, however, the gentleness of the Malawian people and the vast beauty of the Malawian countryside do little to hide the desperate environmental conditions of Malawi, as well as the impoverished living conditions of most of its inhabitants. As one of the world’s least developed countries, Malawi has a population of approximately 12 million and an average per capita income of U.S. \$160. Frequent food crises, the result of droughts, and claims of government mismanagement have produced widespread famine in rural areas (Bearak, 2003; Hammer, 2005; Wines, 2005). As reported by the Malawian Ministry of Natural Resources and Environmental Affairs (2002), the food shortage is compounded by significant health problems that include widespread malaria (380 cases per 1000 people) and HIV/AIDS (50,000 deaths among 15–49 year olds in the year 2000). As only 17.1% of the urban population and 0.6% of the rural population have access to treated water, about 50% of illnesses in Malawi are due to waterborne diseases such as cholera, typhoid, and dysentery. The average life expectancy in Malawi in the year 2000 was 35 years.

The purpose of this research was to explore the many challenges of teaching children to live in a sustainable society within the context of the primary education system in Malawi. By recognizing that “sustainability is about the relationship between human beings and the world” (Smith & Williams, 1999, p. 1), we investigated the important role of indigenous culture and the colonial European legacy in teaching about ecological sustainability. In contrast to *technological sustainability* which assumes “that every problem has either a technological answer or market solution” (Orr, 1992, p. 90), *ecological sustainability* requires “a patient and systematic effort to restore and preserve traditional knowledge of the land and its functions. . . this is, knowledge of specific places and their peculiar traits of soils, microclimate, wildlife, and vegetation, as well as the history and the cultural practices that work in each particular setting” (Orr, 1992, p. 32). Understanding the connections among ecological sustainability, culture, and education is particularly important when posed within the context of developing nations that are struggling to both modernize and improve the educational experiences of their citizens in the midst of widespread challenges such as poverty, hunger, lack of infrastructure, and environmental degradation. Although the goal of education in Malawi is the reduction of poverty, the challenges are immense due to lack of books and resources, a severe shortage of qualified teachers, and average class sizes of over 80 pupils in primary schools (Ministry of Natural Resources & Environmental Affairs, 2002).

## NATURE–KNOWLEDGE–CULTURE SYSTEMS

This research is framed using an earth systems science approach to understanding how humans interact with the physical and biological environment. According to Mayer (1995), an earth systems science curricula requires that natural cycles and biogeochemical processes be studied in the context of environmental problems that affect students' everyday lives. Mayer (1997) later suggested that earth systems approach may provide a unifying framework for achieving global science literacy by encouraging "dialogue among peoples of different languages and different cultures" and a "sustainable lifestyle for all the world's citizens" (Mayer, 1997, p. 104). Investigating the role of humans in the earth systems requires an analysis of how people from different cultures understand and relate to nature.

Research has suggested that the view of humans as part of the interconnected earth and living in harmony with the natural world is the worldview of many indigenous people (Dzama & Osborne, 1999; Kawagley, Norris-Tull, Norris-Tull, 1998; Snively & Corsiglia 2001). At first glance, establishing a link between earth systems science and indigenous cultures may seem to be an obvious way to promote global scientific literacy; however, science educators know very little about "science for all students" as advocated in the U.S. National Science Education Standards (Lee, 1997). Teaching science to all students requires understanding the scientific worldviews and epistemologies of diverse cultures as well as the conflicts and problems that students may experience when science is taught in schools (Aikenhead, 1997, 2001; Cobern & Loving, 2001; Lewis & Aikenhead, 2001; Snively & Corsiglia, 2001; Stanley & Brickhouse, 2001). Further, because scientific literacy is defined exclusively in the Western scientific tradition in school curriculum and national standards, students from non-Western or underrepresented cultures (e.g., Native American, African-American, African, Latin American) may have problems crossing cultural borders to learn Eurocentric science (Aikenhead, 1997; Aikenhead & Jegede 1999; Eisenhart, Finkel, & Marion, 1996; Lee, 1997; Rodriguez, 1997). A better understanding of indigenous science, and how nature–knowledge systems of peoples from different cultures interact and potentially be in conflict, is essential to addressing the educational issues related to teaching about ecological sustainability in developing countries.

### Western Science vs. Traditional Ecological Knowledge

Researchers in science education have compared the culture-laden nature–knowledge systems of Western modern science (WMS) with traditional ecological knowledge (TEK) of indigenous societies (Lewis & Aikenhead, 2001; Snively & Corsiglia, 2001). From the Western modern science perspective, scientists have historically maintained a dualistic relationship with nature in which detached observers gather empirical evidence to support theories about the natural world. Western science is typically empirical, reductionistic, and in the positivist tradition, is considered nonbiased, objective, and disconnected with human or spiritual values. The focus on reductionistic, experimental approaches in science education, however, inadequately represents the nature of science and understanding the complexity of the earth systems (Mayer, 1995).

Bowers (1997, 2001) explains how Western science, emerging from the enlightenment, is considered high-status knowledge and maintains a human-centered perspective of nature in which the individual, rather than the community, is the basic social unit. As a rational process for understanding nature, Western science is closely linked to the globalization of the corporate marketplace that promotes consumerism and the development of standardized technologies that can be used anywhere (Bowers, 2001). Consequently, Western scientists often eschew indigenous cultural traditions that inhibit progress and instead embrace change

as being inherently progressive in nature. Bowers (2001) asserts, however, that economic development without consideration of ecological sustainability has had a devastating effect on the environment. Further, the globalization of the dualistic Cartesian form of Western consciousness is contributing to the disassociation between humans and the environment. The cultural implications of this stance include the fact that Western peoples are typically more detached from food sources, energy production, and other resources that nature provides.

In contrast to Western modern science, traditional ecological knowledge (TEK) embraces a more holistic framework as humans are viewed as intricately and spiritually interconnected with nature. TEK represents descriptive and explanatory knowledge about nature acquired across generations of people from indigenous cultures with strong oral traditions. Rooted in local culture, Orr (1992, p. 32) explains how traditional knowledge “is a source of community cohesion, a framework that explains the origins of things (cosmology), and provides the basis for preserving fertility, controlling pests, and conserving biological diversity and genetic variability.” As indigenous people are directly dependent on the resources that nature provides for survival through sustenance living, they subsequently have knowledge of, and a relationship with the natural world that stands in marked contrast to peoples from Western cultures who typically do not share such an intimate connection with nature. For many people from traditional cultures in developing countries, living in poverty and on the brink of survival in environmentally degraded conditions is the norm. Therefore, understanding indigenous science and technology or how scientific knowledge is understood and applied in everyday life contexts may have important implications for curriculum reform in primary science and environmental education in developing African countries.

### **Influence of Traditional Beliefs on Science Learning in Malawi**

In an empirical study about the interaction of Western science and traditional African cultures, Dzama and Osborne (1999) questioned whether the poor performance of Malawian students in science is the result of monistic worldviews about nature. In contrast to Cartesian dualism, in which mind and matter are fundamentally separated, the monistic view emphasizes the connectedness of physical and spiritual events. Accordingly, the notion of causality, for example, in African cultures is often interpreted in anthropomorphic terms, through which people have given human characteristics to their ancestors, animals, or supernatural events throughout history. Dzama and Osborne (1999, p. 390), however, challenged the notion that anthropomorphism is particular to indigenous cultures and argue that the structure of the human mind is essentially the same everywhere, and has “mystical and pre-logical characteristics as well as logical characteristics.” In Western cultures, as well as African cultures, a belief in a supernatural God, for example, is considered a monistic worldview. Further, because monism and anthropomorphism are basic characteristics of humans, students of all cultures may experience conflict with monistic beliefs when learning Western modern science. For Malawian students, however, Dzama and Osborne (1999) found that traditional beliefs are actually not a major factor in accounting for variance in students’ understanding of science topics.

### **Postcolonial Theory**

Postcolonial theory (Carter, 2004) may provide insight into Dzama and Osborne’s (1999) concern about assuming that Malawian students’ ability to learn science is necessarily clouded by monistic worldviews. According to Carter (2004), science learners in developing countries may develop a hybridization of perspectives and multiple identities that include

interactive knowledge and epistemologies from both Western science and traditional ecological knowledge. Carter (2004, p. 283) used a postcolonial analysis to reveal problems with binary approaches that contrast the “bounded and homogenous nature” of indigenous science with Eurocentric Western science. By taking into account the “emergent mixed, hybrid, and diverse identities consequent to intensified globalization and diaspora,” postcolonial theory challenges the notion of codified cultural pluralism and distinct boundaries of nature–knowledge systems (Carter, 2004, p. 823).

According to Carter (2004), postcolonial theory also provides a framework for exploring the hegemonies and power relationships between dominant and emerging worldviews and cultures. Similar to “cultural interface zones” in urban settings (Norman, Ault, Bentz, & Meskimen, 2001), the interactions and reactions of students in developing countries when exposed to Western science curriculum may provide a fruitful and dynamic cultural phenomenon for investigation where “consequences of economic-political and cultural globalization play out” (Carter, 2004, p. 823). Although Carter’s (2004) views on hybridization and nondistinct cultural boundaries have been challenged by other scholars of culture studies in science education (McKinley & Aikenhead, 2005; Snively & Corsiglia, 2005), the concepts of emerging cultural identities and border epistemologies (as distinct from border crossings) may provide a useful framework for deconstructing dominant colonial influences (Carter, 2005). For example, one of the negative aspects of colonialism in sub-Saharan Africa was the commercialization of land by the Europeans, which has contributed to the widespread poverty of indigenous people (Boahen, 1987). Chirwa (2005) suggested that land redistribution, along with access to extension services and the education of villagers in modern farming techniques, should be primary strategies for poverty reduction in Malawi. This research attempts to better understand how Malawians are coping with a colonial legacy that has disrupted indigenous lifestyles while at the same time are being exposed to a Western science curriculum that may be disconnected from everyday life.

## PLACE-BASED EDUCATION AND ECO-JUSTICE ISSUES

Environmental educators have embraced the importance of helping children connect with their local environment to develop a sense of “place” to better understand the relationships between humans and nature (Orr, 1992, 1994; Sobel, 1993, 1996; Thomashow, 1996; Smith & Williams, 1999). Place-based education is concerned with the education of citizens that “might have some direct bearing on the well-being of the social and ecological places people actually inhabit” (Gruenewald, 2003, p. 3). According to Orr, sustainable living “will not come primarily from homogenized top-down approaches but from the careful adaptation of people to particular places” (Orr, 1992, p. 32).

As a theoretical framework, *critical pedagogy of place* synthesizes two education traditions, “critical pedagogy” and “place-based education” and has been proposed as a suitable perspective from which to investigate the connections among ecosystems, culture, and education (Gruenewald, 2003). Critical pedagogy challenges the “assumptions that education should mainly support individualistic and nationalistic competition in the global economy and that educational competition of winners and losers is in the best interest of public life in a diverse society” (Gruenewald, 2003, p. 3). According to Bowers (2001, p. 11), critical pedagogy of place is concerned with eco-justice and addresses “the causes of poverty and the creation of wealth at the community level, which requires an understanding of how to regenerate the sense of local responsibility and mutual support that has been undermined by national and international market forces.” Rather than teaching and assessing student understanding of an abstract, decontextualized science, an eco-justice curriculum “encompasses an explicit understanding of relationships and processes, an embodied knowledge

of community relationships and the ecology of place, an awareness of the layered nature of the interdependencies of life-sustaining processes” (Bowers, 2001, p. 152).

Very little research has explored the connections among ecological sustainability, culture, and place-based education as an approach to both investigating and teaching about the earth systems in developing African countries. This paper elaborates our attempts to do so from a postcolonial and critical pedagogy of place perspective in the Malawian educational context. With the help of our Malawian colleagues, we were interested in identifying and deconstructing the influences of traditional ecological knowledge and colonialism on the deforestation of the country. From a place-based education perspective, we explored the challenges of teaching children about sustainability issues through an inquiry approach. In an effort to guide our understanding of ecological sustainability issues in Malawi, we were guided by three research questions:

1. What are the Malawian educators views on the influence of traditional ecological knowledge and the colonial legacy on deforestation?
2. How did the Malawian educators respond to their participation in a science methods class that explored an inquiry approach to teaching about place-based ecological sustainability issues in the primary schools?
3. What influence did the methods class have a year later on the Malawian teacher educators’ views and practices on teaching about place-based ecological sustainability issues in the primary schools?

The research questions emerged based on the discussions among the four authors in identifying critical issues relevant to understanding and teaching about ecological sustainability in Malawi. Careful attention was given to report the perspectives of the Malawian teacher educators in answering these questions.

## METHODOLOGY

This study was a 2-year project in which two of the coauthors from the United States were actively involved as teacher researchers in “systematic and intentional inquiry” (Cochran-Smith & Lytle, 1993) as part of their role as science and mathematics methods instructors in a graduate teacher education program for primary school educators in Malawi. Two of the other coauthors were Malawian teacher educators in science and social studies who were graduate students in the primary teacher education program, and also traveled to the United States to study in a post-masters program and collaborate with the U.S. authors to assist in the analysis of data. The sharing of data and interpretations between the Western and Malawian educators was essential for developing an authentic understanding of ecological sustainability issues in sub-Saharan Africa, and the connections that these issues have to the education and culture of Malawi. A visit to Malawi by one of the U.S. researchers the following year provided a second opportunity to gather data regarding implementation of ideas and teaching practices by the Malawian educators that had been developed in the graduate program.

### Data Collection

**Year One: The Methods Course.** The researchers and the 24 Malawian primary teacher educators participated in a 3-week, 6-hour-per-day intensive science and mathematics methods course. This research focused on topics relating to ecological sustainability, culture, and

place-based education that were taught as part of the science education curriculum. The class participants were representative of five ethnic groups in Malawi, including the Chewa, Yao, Lomwe, Mang'anja, and Tumbuka. They all spoke a dialect of Chichewa and were fluent speakers and readers of English as a second language. In addition, these teacher educators all had bachelors degrees from the University in Malawi in fields that included science, social studies, mathematics, literacy, agriculture, and home economics. Previously, these participants were teachers in primary or secondary schools in Malawi and were currently employed as teacher educators in Teacher Training Colleges throughout the country.

Class activities, the products of which were added to the data record, involved the teacher educators directly as they studied various earth systems topics such as deforestation, climate change, energy sources, recycling, erosion, and landscape changes. The pedagogy employed in the methods course was designed to model recommendations from the *National Science Education Standards* (National Research Council, 1996) for teaching science as inquiry from a personal and social perspective. For example, in class the teachers constructed electric circuits and discussed issues surrounding the disruption of the hydroelectric power grid in Malawi due to excessive erosion and the overgrowth of green plants in the watershed. Teachers were also engaged in frequent dialogue as they shared ideas and discussed sustainability and environmental issues affecting Malawi. The inquiry approach employed in the methods class deviated from the traditional didactic approach to primary education in Malawi, in which students listen attentively to teachers and responding to questions in a recitation-type manner.

After participating in inquiry-oriented science activities, the Malawian teachers designed science lesson plans to teach with primary school children, ages 10–15, in standards 4–8 in the local government school. (Primary school in Malawi includes standards one through eight—the equivalent of grades one through eight in the United States.) Using the 5E learning cycle model (Bybee, 1997), the teachers planned lessons following an instructional sequence which promotes accessing students' prior knowledge and experiences through active exploration (e.g., engage, explore, explain, elaborate, evaluate). These lessons included topics such as the food web, the water cycle, weather, heat and energy, and electricity. Rather than utilizing large whole class instruction, students were divided into smaller groups of four to five to participate in hands-on science investigations. The lessons were all taught in English, although the teachers frequently translated the instructions in Chichewa. Time was then spent reflecting in the methods class on the viability and potential of this inquiry, learner-centered approach for teaching about science and ecological sustainability in the Malawian primary schools.

Other class activities included the involvement of teachers in role-playing scenarios in which teachers were organized into political groups representing constituencies that included rural subsistence farmers, tea plantation owners, charcoal merchants, ecologists, teachers, and the government. The role-playing generated class discussion on the influence of indigenous practices and the colonial legacy for the degradation of the environment. Teacher participants were also involved in issue-oriented activities on sustainability and ecology that were adapted from the *Project Wild* curriculum (Council for Environmental Education, 2002). For example, in an activity on sustainability, the Malawian educators identified the “needs” and “wants” of their society and compared African communities of 100 years ago with the present time, as well as projections of 50 years into the future. As student's abilities to develop earth systems thinking has been found to be enhanced through inquiry-based learning in the context of outdoor learning environments (Assaraf & Orion, 2005), the class participated in a field trip to a national park. This trip stimulated class discussions of conservation issues, the role of wildlife in Africa, and the role of traditional ecological knowledge.

***Year Two: Assessing the Impact and Challenges Ahead.*** In the second year of the study, one of the U.S. researchers returned to Malawi to continue working with a subset of four Malawian teacher educators who had participated in the methods course experience 1 year earlier. These teacher educators were specialists in science or social studies education. Additional data were collected to learn about the Malawian educators' perspectives on their participation in the science methods course a year earlier and the challenges for teaching children about ecological sustainability in the schools.

During the second year, the two Malawians coauthors also participated in a Primary Curriculum Area Reform (PCAR) project. This project was part of a consortium of sub-Saharan African countries including Malawi, South Africa, Botswana, and Zambia. A focus of this reform was on ecological sustainability issues and exploring the inclusion of indigenous science and technology in the curriculum. Information from interviews pertaining to this project provided data to address science curriculum reform efforts related to teaching about ecological sustainability in Malawi.

### **Data Sources**

Documents related to class assignments and activities were gathered as data sources to detail the written perspectives of the Malawian educators. These documents included: (1) position papers on ecological sustainability and education in Malawi, (2) inquiry-oriented lesson plans on science and environmental education, (3) original children's story books about sustainability and the environment in Malawi, and (4) participants' reflections on teaching about ecological sustainability with Malawian children. We also videotaped class discussions and activities in the methods class directly related to environmental education issues (e.g., role-playing activities). To learn more about the Malawian educational system, we observed and videotaped several classes in local primary schools and in teacher education classes in which science was being taught. We conducted audio-recorded interviews with Malawian educators to learn more about their perspective of how to teach about ecological sustainability issues in primary schools. As teacher researchers, we wrote in reflective journals and composed field notes, and systematically collected the artifacts generated by the class.

### **Data Analysis**

From a postcolonial perspective (Carter, 2004), we were particularly interested in understanding the cross-hybridization of ideas and identities of Malawian educators as they explored sustainability issues within the context of a Western earth systems science curriculum. A postcolonial perspective provided a framework for understanding the influences of Western science, indigenous culture, and colonialism on the viewpoints of Malawian educators. From a critical pedagogy of place perspective, we were interested in exploring the eco-justice issues related to environmental degradation in Malawi and the potential role of inquiry-oriented pedagogies in addressing these issues.

In the tradition of qualitative research, iterative processes of data analysis were conducted to generate themes reflective of the data, to capture the complexities of the research context, and illuminate the questions that guided this research (Ely, Ansul, Friedman, Garner, & Steinmetz, 1991). Videotaped and audio recorded class discussions, lesson observations, and interviews were carefully transcribed, coded, and categorized to identify themes related Malawian teacher educators' perspectives (see Table 1 for examples of categories and descriptive data codes). Reflective journal writings and field notes of the teacher researchers, along with examples of position papers on sustainability, curriculum

**TABLE 1**  
**Descriptive Data Codes**

Categories	Codes
Impact of deforestation	Erosion and soil depletion; connection to famine; lack of alternative energy sources; eutrophication
Influence of colonialism	Land acquisition and ownership; deforestation for energy and cash crops; Western science taught in schools
Use of indigenous science	Indigenous trees and fruits for medicines; fish poisons affecting environment; spiritual beliefs connected to saving trees; slash-and-burn no longer practiced
Challenges in primary education	Didactic, recitation-style pedagogies; lack of books and resources; large class sizes; shortage of qualified teachers
Malawian educator's perspectives on inquiry teaching	Ownership and student exploration of ideas important; learner-centered instruction connects with village life; inquiry confronts students' misconceptions
Connections between pedagogy and teaching about sustainability	Indigenous science provides context for teaching Western scientific concepts; community involvement and ownership; inquiry provides opportunity for questioning and decision making

plan assignments, and children's storybooks written by the Malawian educators, were similarly coded and categorized to compare different perspectives to identify emerging themes. As an illustrative example, one theme that emerged repeatedly in the data was the notion that colonialism had greatly influenced the sustainability of indigenous ethnic groups and environmental degradation. As the teachers participants referred to colonialism both in writing, class discussions, and individual interviews, codes were used to triangulate the data and distinguish how teachers used the notion of colonialism as it pertained to various cultural issues that had the potential to impact sustainability. This process helped the researchers develop a more comprehensive understanding of the impact of Western culture on the earth systems of Malawi.

Finally, frequent conversations, the sharing of interpretations of the data, and shared readings of earlier drafts of this manuscript between the U.S. researchers and the Malawian researchers were invaluable and necessary components in the process of identifying confirming and disconfirming evidence related to interpretation of the data (Erickson, 1986). This was particularly important for comparing Western and non-Western viewpoints on sustainability. For example, in one excerpt of the field notes of one U.S. researcher, Malawian children carrying firewood were referred to as "poor." One Malawian author challenged this statement by asserting that these children were not considered "poor;" rather they were considered as an integral part of the family and community economic structure.

The findings presented in this article are the product of our unique participation as a research team in the Malawian educational context over a 2-year time frame. Through the dual role of teacher/facilitator and researcher, the U.S. investigators took advantage of every opportunity to learn from the "inside" about an educational system in south-central Africa to gather data pertinent to our questions of interests. Simultaneously, we viewed our participation and collaboration with the Malawians educators as a unique opportunity to confront our own biases concerning "what's best for Malawians" and to learn from the Malawian educators about non-Western cultural perspectives of education and sustainability issues.

## RESULTS

### The Impact of Deforestation in Malawi

*Research Question #1:* What are the Malawian educators views on the influence of traditional ecological knowledge and the colonial legacy on deforestation?

Deforestation is a major human activity affecting the sustainability of the Malawian earth systems. Indigenous and exotic (nonnative) trees are cut down to create land for growing crops, and also are used as firewood or charcoal for cooking and heating. Many indigenous trees such as ebony and mahogany are also cut down as a source of income to produce wood carvings for tourists. As trees are cut down, soil is eroded into the watershed, resulting in water pollution from agricultural run-off and silted fish spawning grounds. Anderson, a geography teacher educator, describes erosion and deforestation problem in Malawi:

Go to any part of Malawi, you find evidence of soil erosion. Gullies are everywhere. Topsoil is hard because the loose particles have been washed away by either water or wind. You plant your crops in ridges today and tomorrow all the ridges are washed away in heavy downpours. Roads in the rural areas are almost impassable in the rainy season. This is all because trees have been cut “mercilessly.” Forested areas and bushes are being cleared in order to open up farmland to support the ever-growing population. (Position paper on sustainability and education)

As hydroelectric power is the country’s only source for electricity, the erosion of soil and the overgrowth of plants in the watershed due to excessive fertilization frequently clogs the turbines, resulting in daily power outages. Erosion, soil depletion, and flooding caused by deforestation prevent crops from growing during the rainy season, hence contributing to widespread food shortages.

***Influence of Traditional Ecological Knowledge.*** Traditional ecological knowledge of Malawian villagers still plays a role in the sustainability of the forest. For example, Gift, a social studies educator, wrote about how spirituality is connected to the preservation of trees:

In some quarters, it was an abomination to cut down trees at night or in the graveyard. For instance, among the *Chewa* of central Malawi, the graveyard used to be a place where the masks of their traditional dance were kept under the guise of ancestral spirits. This meant that trees had to be preserved in any way if the secret of the dance was to be maintained by only those who were initiated into the tradition. There was some secret environmental education going on in the communities although not properly pronounced. (Position paper on sustainability and education)

Cutting down trees is a problem for traditional healers who no longer have access to medicines. In an interview, Absalom, a science educator, explained that “because people have cut down such trees, they are finding it very difficult to cure certain diseases, which were cured easily when trees were in abundance.” Even today, traditional healers extract quinine, the bark of the “fever” tree to treat malaria. Absalom, however, also explained how traditional medicines and poisons that are extracted from indigenous forests may negatively impact the environment by contaminating the water and making it inhabitable for fish and other aquatic life. Other indigenous practices such as slash-and-burn agriculture as a means to fertilize the soil and grow crops are no longer commonly practices because of increased population and loss of forested land.

A class field trip to a wildlife preserve helped class participants learn about natural resources and connections to ecological sustainability and traditional Malawian culture. Wildlife guides shared many examples of traditional ecological knowledge with class participants, including medicinal uses of plants, the use of baobab trees for baskets and as storage places for meat, and the potential uses of plants to develop poisons to help harvest fish. Despite spending their whole lives in Malawi, most of the teacher educators had never visited a wildlife park in their own country. This opportunity was powerful for many of the participants, and thus helped the teacher educators learn more about the traditional interplay of humans and the Malawian earth systems. From our interviews and class discussions, it is clear that the Malawian teacher educators were aware of the potential health benefits of traditional medicines from indigenous forests as well as traditional practices such as slash-and-burn agriculture that are destructive in modern society. However, the acquisition and application of traditional ecological knowledge was marginalized due to the severe impact of deforestation and economic pressures for survival. For most Malawians, nature is resource for survival, and survival is not taken for granted.

***Equity Issues and the Influence of Colonialism.*** As wood is the principle source of energy in the country, air pollution from burning wood or charcoal is a major problem in the country. However, because most Malawians cannot afford electricity, the charcoal merchant is a central player in the economic and societal fabric of Malawi. Esther, a social studies educator representing the role of a charcoal merchant, explained the equity issues involved with accessibility to electricity:

Not all homes have access to electricity. And many parts of Malawi up to this very moment have not had a line of electricity to that area. Now, how are they surviving? It's us, the charcoal merchants who provide the fuel for them to sustain their lives. . . . Even in this room on this campus, they have had their electricity cut off in their houses, they're in darkness, they are using charcoal. They depend on us and look at us, guys, we have not been to school, you have the white collar jobs, that's our industry, that's our employment, cut us off from burning charcoal, we are doomed, now we are trying to get this money from charcoal to educate our children to be like you guys, to have white collar jobs. (Role-playing discussion)

According to the Malawians, white-collar jobs were brought by the Europeans and were the only jobs that paid enough for people to afford electricity. Frequently, during our time in Malawi, electricity was cut off, and was often available only a few hours a day. Recognizing the negative impact of charcoal burning of the environment, the government frequently sets up roadblocks throughout the country to impound the charcoal. However, the Malawians have little choice for alternative means of energy.

During the role-playing activity, the conversations about the practice of tea farming initiated intense discussion of eco-justice and land use issues by the class participants. Tea farming contributed to deforestation as indigenous trees were not only cut down for the plantations, but tea curing is fueled by the burning of wood. Even though tea is a cash crop for Malawi, villagers work in the tea fields for extremely low wages and child labor is common. Further, the British colonists acquired vast tracks of fertile land for growing tea from the Lomwe and Mang'anja ethnic groups. Alois, a social studies educator, explained:

The missionaries came and asked the chiefs if they could have a piece of land. Later the missions were growing, they claimed bigger land, and the owners were dispersed. In fact there were chiefs who benefited from the missionaries who were given blankets and so on,

and when the villagers came to realize that the best land was taken from them, they wanted to get the land . . . so it is becoming an issue. (Role-playing discussion)

According to Alois, the government is now negotiating with the British tea plantation owners to return some of the land to the villagers. However, most Malawians do not have money to buy the land. Another class participant shared that her father was once in prison because he was fighting the plantation owners for the family land of his ancestors. Further discussion revealed that large tracks of land in Malawi have recently been leased to European people coming from Zimbabwe to open up farms. However, even with widespread famine, much of this land and previous land bought by Europeans remains idle for growing crops. One of the class participants asked how people acquired farms in the United States. In response, the U.S. teacher researchers shared how land was taken from indigenous people who were forced to relocate to less desirable land. This sharing of the eco-justice issue of Native Americans being displaced from their ancestral land was remarkably similar to the diaspora of villagers in Malawi.

The elite top down approach from experts or the government for solving ecological degradation problems did not seem to resonate with the class. Symon, a geography educator, exclaimed, “the policy should not originate from government, it should come from the people; if policy is imposed, then people are going to defy that policy, there must be ownership.” Stella, a literacy educator, agreed:

People don’t understand deforestation and what its impact is, they really don’t. Unless we Malawians come to agree, come to form hands to make sure that at least much of the population of Malawians become literate, they will begin to read some of these messages better and they will have more of an understanding of some kind. (Role-playing discussion)

This theme of participation and ownership became more prevalent as the discussion continued. Frequent appeals were made for the “government” to do something such as provide alternatives and incentives for alternative energy, including solar and biomass. These solutions were questioned, however, because only people of means could afford them. The simple solution identified by the Malawians was “cut down one tree, plant ten.” However, exotic (nonindigenous) trees that were planted were often fast growing conifers (e.g., pines) or eucalyptus (blue gum), resulting in a loss of indigenous species with many fruits, potential medicines, and animal habitat. Frequently, seedlings were not available for reforestation. As satellite images of deforestation in many parts of the world were shown in class as a supplement to the role-playing activity, the Malawian educators understood the connections between cutting down trees, erosion, and subsequent flooding, but offered few ideas toward a solution.

Alois later wrote about the connection between the colonial system and ecological degradation:

A profit motive of the colonial system stole respect of nature from the culture of Africans. Animals were hunted and killed with no thought for the future, bushes cleared for tea plantations and a new system of agriculture based on monoculture. Arable cropping was introduced which later ensured ecological degradation. (Position paper on sustainability and education)

Indigenous animals have been hunted to near extinction and are now confined to a few national parks in Malawi, once home to thousands of elephants. This colonial legacy has manifested itself in a country whose land is devastated by deforestation and whose earth systems are out of balance.

### **Inquiry Learning and Ecological Sustainability**

*Research Question #2:* What are the challenges for implementing inquiry-oriented instruction as an approach to teaching about place-based ecological sustainability issues in the primary schools?

The second question of interest for this study had to do with the challenges of teaching children about the ecological sustainability issue of deforestation in the primary schools. From the Malawian teachers' perspectives, an important purpose of instruction in Malawi is to prepare students for national exams that determine whether primary students can advance to secondary school. However, as the national goal for education in Malawi is the reduction of poverty, it was our belief as Western science educators that inquiry-oriented pedagogies were essential for empowering students to learn about and discuss issues related to ecological sustainability that affect their everyday lives. Yet, implementing such pedagogical strategies in countries like Malawi is no easy task. With extremely large class sizes and lack of books and other materials, it is very difficult for Malawian educators to implement inquiry and learner-centered approaches. Students attend school from 7:30 am–1:30 pm and most arrive without anything to eat, except during the harvest season. In standards one through four, students sit on the floor of buildings without electricity or any modern teaching materials, computers, or audio-visuais. In standards five through eight, students sit 5–6 to a desk in crowded, dark rooms. Frequently, a chalkboard is the only teaching resource available. The Ministry of Education encourages teachers to use locally available materials (Teaching and Learning Using Locally Available Resources—TALULAR) such as collectable objects found in the villages that are part of everyday life (e.g., buttons, yarn, sticks, etc.), yet our experiences suggested that the use of such materials was not often realized. Environmental education was reportedly taught across the curriculum but more specifically in the geography part of the social studies curriculum. Rather than focusing on the role of humans in the environment, the science curriculum focused exclusively on the scientific explanations for ecological degradation.

To learn more about how science was taught in Malawi, we observed several science classes in which teacher-centered pedagogies were prevalent. For example, an observed videotaped lesson on human diseases taught by John, a dedicated and experienced science teacher, demonstrates the teacher-center approach. John was an elegant lecturer who clearly articulated and transmitted information to a classroom full of approximately 80 students in standard 7. John began his lecture prompting students to identify diseases they knew. Each disease was listed on the board and repeated by John (e.g., typhoid, dysentery, cholera, AIDS). John then asked the students what were the “explanations” or causes of these diseases. John listed three: scientific explanations, religious explanations, and cultural explanations. Under scientific explanations, John emphasized that “germs cause disease” and he wrote this on the board. Cultural explanations were playfully ridiculed, and John emphasized that people would not necessarily be cured if they went to traditional healers. After the “lecture,” students were asked: “how many explanations for diseases do we have?” One student replied, “two,” which prompted the teacher to ask the question again until a student responded with “three.” The emphasis was on repeating the right answer, not necessarily understanding the connections between disease and cultural practices in society. From our observations, the children were seemingly attentive, yet passively involved in the lecture, and were not emotionally or intellectually involved despite the ways in which these diseases are so prevalent in the lives and daily experiences of all Malawians. Little or no effort was made to connect the role of traditional ecological knowledge in Malawian culture as pertaining to the diseases under discussion despite the fact that many Malawians living in villages, if sick, are most likely to visit a traditional healer.

**Introducing Inquiry-Oriented Pedagogies.** The challenges of transitioning to an inquiry approach in which students examine ecological sustainability issues within the context of the Malawian culture were daunting, if not difficult to imagine. Even though the class was aware of the importance of inquiry and learner-centered instruction, it was not regularly practiced in the school or teacher education programs in the country. Therefore, in the science methods course, we made a conscious attempt to model a learner-centered approach in which students were actively engaged in inquiry and collaborative group work.

As part of their class assignments, the Malawian teacher educators were asked to design an inquiry-oriented lesson on environmental education. These lessons were completed after the class visited the national park and introduced to *Project Wild* activities. All the lessons that were submitted involved children in studying the local habitat outside the school. For example, in several lessons, children were asked to identify local animals and plants and complete a food web drawing of the habitat. Students also studied erosion of soil and discussed reasons why the erosion occurred. The lessons were designed to promote the development of scientific ideas as students were asked to discuss and share their knowledge in groups. In one lesson, students were asked to respond to a “letter” from wild animals complaining about the encroachment of humans on their habitat. The children were given a chance to draft a reply to the animal’s letter. As many Malawians look at animals exclusively as a source of food to eat, these lessons challenged children to think of the role that animals play in the Malawian ecosystems. Several lessons advocated the creation of wildlife clubs in the schools.

The Malawian teacher educators also wrote children’s stories with embedded messages on sustainability and the environment. The stories included examples of traditional ecological knowledge. For example, one story was about a pride of hungry lions that decided to burn the forest to kill animals so food could easily be obtained. (This story was analogous to traditional slash-and-burn agricultural methods.) Even though some of the animals escaped to another forest, after a while the lions were starving and had nothing to eat. In the end, the lions sent a messenger bat to ask the other animals to return to the forest to live interdependently. This story exemplifies the interdisciplinary nature of the earth systems in the forest and provides an example of children’s literature that would appeal to the imagination of Malawian students. Other stories included lessons about visits of children to the national parks to learn about indigenous plants such as the “yellow fever tree, sausage tree, baobab tree, impala lily, and the python vine” and animals such as the “marshall eagle, jesus bird, impalas, hippos, and elephants.” Unfortunately, there is virtually no children’s literature accessible to Malawian children in the primary schools.

**Reflections on Teaching Science as Inquiry.** Admittedly, teaching inquiry-oriented science lessons was somewhat contrived as the Malawian children were divided into smaller groups of 30 students and arranged around in tables of 4–5 students. Nevertheless, the U.S. researchers were interested in how the Malawian teachers and children would react to participating in inquiry science lessons. The following scenario describes the Malawian teacher educators’ response to teaching children using an inquiry approach.

Just before teaching an inquiry-based lesson in a nearby school classroom, Esther, the social studies educator, reflected on her plans during an interview:

We want them to be able to explain and give evidence of the process that they have used, to justify it, to own it, and to feel they have participated, and they have learned something from their experiments. So they are going to work in groups so the diversity is in the groups to assist them to learn from each other. We don’t want to stand in front and be the authority, no, but we want to situate learning in the students’ own experiences and to validate them as knowers. (Interview, 7/03)

As the Malawian children were more accustomed to teacher lecture and recitation, collaborating in groups and hands-on instruction was a new experience. The children were actively participating in the hands-on activities and discussing their observations on a variety of topics including electricity, cloud formation, heat transfer, and the food web. These activities were characterized by children taking risks to manipulate objects, discuss observations, and verbalize their understandings with the teachers. For the most part, the children were very enthusiastic when given the opportunity to participate in inquiry instruction but were somewhat reticent to verbalize their observations in English.

In written reflections on this teaching experience with children, the Malawian educators embraced the inquiry approach as a means to engage students in exploring ideas on their own. Absalom, a science educator, explained:

Another very outstanding observation was that pupils seemed to have had little hands-on experiences and that they were not used to exploring their own ideas— although they were quite eager to do the hands-on activities when they realized that the teacher wanted them to feel free in trying out their own ideas. (Written reflections on teaching inquiry lessons)

This approach was also viewed by the teachers as important for integrating the science lessons with other subjects and the pupil's lives. Ndalapa, a social studies educator, discussed how a lesson using a discrepant event to demonstrate cloud formation connects with students' life experiences:

Using such experiments in science, the pupils could use their own experiences from the empirical evidence to explain these natural occurrences. . . . In fact, in the villages where most of the pupils live, there are lot of songs, poems, and stories about natural occurrences like rain and clouds. But most of such compositions have a lot of misconceptions. These experiments can assist in correcting those misconceptions by asking the pupils to compose songs, poems or write a story based on empirical evidence. (Written reflections on teaching inquiry lessons)

Ndalapa noted that the cloud experiment helped the children change their original misconception that clouds are all made up of smoke from fires.

Ibrahim, another science educator, spoke of the importance of connecting a lesson on food webs to children's lives and particular place where they are living:

Almost all organisms that students study in this lesson are those that students meet in everyday life. They keep some in their homes (e.g. maize, chicken, cats, and dogs while others are those that they see on their way to school (e.g. grasshoppers, crows, hawks, etc.) The lesson could therefore help students relate to the importance of conservation of the environment—a topic which is today's global concern. (Written reflections on teaching inquiry lessons)

Although these lessons taught with Malawian children were not all linked explicitly to local ecological sustainability issues, they were effective in generating discussion about the importance of actively engaging children in learning and exploring their own ideas within the Malawian context.

In conclusion, the Malawian teacher educators seemed to enjoy participating in inquiry-oriented activities and were enthusiastic about the responses of children to active learning. As Western educators, it seemed clear to us that when given the chance and resources, all children benefited from the inquiry lessons and these approaches were useful in designing activities on teaching about local ecological sustainability issues. However, in reflecting on

these experiences, the Malawian teacher educators identified important issues and concerns with this approach including the size of class, adequacy of materials, and the ability of children to express themselves in English. Research in the second year of the project provided more data on the Malawian educators' views on the relationship between inquiry-oriented instruction and teaching about ecological sustainability.

### **Year Two: Assessing the Impact and Challenges Ahead**

*Research Question #3:* What influence did the methods class have a year later on the Malawian teacher educators' views and practices on teaching about place-based ecological sustainability issues in the primary schools?

During year two of the project, one of the U.S. researchers traveled to Malawi as a follow-up to interview and observe former class participants who were responsible for teacher preparation in science and environmental education. We were interested in the impact that the inquiry approach adopted in the methods course might have had on the perceptions and teaching practices, particularly in relation of teaching about place-based sustainability issues. All of the Malawian educators spoke of the positive impact the science methods class had on their thinking about education, particularly the importance of learner-centered and inquiry instruction. For example, Ibrahim spoke of the importance of play and active participation in the class activities:

I remember the games that we used to do [in *Project Wild*]. Those, I found them to be very nice and they were a very powerful way to teach, especially when we look at primary schools, because, primary school students or pupils, they like to play. And that method was like, they are playing, and they have to be learning with what they are comfortable doing, playing. (Interview, 7/04)

Ibrahim continued to reflect on the importance of being actively involved in the lesson:

I like the innovations that were incorporated in the methods of science. We were not just seated listening to you speaking, but we saw things happening, we got involved in the activities, and as things were happening, we were part of the action. (Interview, 7/04)

Participants also spoke about the importance of modeling the inquiry approach and the exposure to lots of books and resources.

The inquiry-oriented strategies also were being implemented in the science methods classes at the Teacher Training Colleges. Ibrahim explains how his instruction has changed from lecture to more learner-centered approach:

Usually our students are talking. We lecturers or professors are just like facilitating . . . . Sometimes we have to prepare in advance, we have to tell the groups we would like you to read this and then they have to find their own ways of finding the information on the particular topic and then if we want them to present, they present. (Interview, 7/04)

This approach was explicitly observed in two primary teacher education classes that were visited by the researcher. For example, Maxwell's class was studying the process of planning a lesson on air pressure. Listed on the board were steps involved with lesson planning (e.g., what the teacher should do, what the students should do, what the students and teachers should do together). The preservice teachers worked in groups of five or six to interpret the steps involved in the context of completing a hands-on activity on air pressure. Students reported their findings related to their experiment back to the class. According to Maxwell,

beginning teachers have problems with planning and teaching activity-oriented science lessons. For Maxwell, the inquiry approach that he learned in the masters program has “given me a lot of ideas” to teach in a more active manner. Ebiudi, the deputy principal of the Teacher Training College where Maxwell teaches, spoke of importance of getting prospective teachers to “speak as much as possible.” From other interviews and observations, it was clear that the participants had developed more confidence in their ability to implement inquiry-oriented instruction. Hopefully, this approach, according to Esther, the social studies educator, will translate to the classroom, as students begin to discover things on their own, and if it does not work, “tomorrow we can work it out together.”

In interviews, we found that the Malawians thought that an inquiry approach was appropriate for teaching about local ecological sustainability issues. Absalom, the science educator, explains how usually children are just told a few things like “let’s just conserve the environment.” However, Absalom explains the importance of the active involvement of children in the local environment:

They have not talked about tangible things that are going on in the environment, like a visit to the lake, getting to see such kind of things brings awareness to children about what are the problems. If children would write about things, they could have pictures of things, what would be the future as well as what is going on here, they would see more in what is going on than just telling them, so probably we have not drawn on so much of what is there. (Interview, 7/04)

In a group interview, four of the Malawian educators were asked to identify strategies or techniques that would connect inquiry-oriented instruction to content issues related to ecological sustainability. The following strategies were prevalent in the discussion: (1) involve children in asking questions and investigating local environmental issues; (2) engage children in problem solving and decision making; (3) promote citizenship through participation and collaboration; (4) increase awareness about wildlife conservation through field trips to watersheds and local environments; (5) enhance science learning by investigating indigenous science and technology. Specific suggestions for addressing deforestation included researching the growth cycle and importance of indigenous trees, exploring alternative energy sources, and investigating farming practices to improve crop yield. Although we only collected data from the Malawian educators involved in primary education project, we hope to collaborate with the other Malawians in future research to assess whether these strategies are being implemented by teachers in the primary classroom to teach about ecological sustainability and environmental issues.

In the second year of the project, the two Malawian coauthors were directly involved as collaborators on the Primary Curriculum and Assessment Reform (PCAR) project sponsored by the Malawian Ministry of Education. In their deliberations, the reformers adopted a learner-centered approach and organized the curriculum around the following core elements: basic science, technology, investigations for applications, managing change, knowledge for development, and marketing. These core elements all target economic development in villages because most of the children drop out after primary school. According to Absalom, the science educator working on the team, managing change is an essential component to teaching about sustainability:

We are living in a world of change and many times we have problems when change arrives. We are trying to inculcate in children how they would cope with the change using scientific understandings. And we have AIDS today, it’s a change in our lives, how do we manage that? We are having change in terms of numbers of people population-wise, and food supply,

and nutrition. How do we cope with these changes? The environment has changed but we are using scientific explanation or scientific skills and knowledge to help with managing these changes. (Interview, 7/04)

Absalom explained how this curriculum is designed to “provide the skills which will help children survive and acquire ideas or things they could do to contribute to the market economy of the country.” Learning about indigenous science and technology was also emphasized. For example, Absalom explained how students would learn about “grinding facilities for corn, maybe nuts, some of these grinding things were used for the sake of turning out powder but in some cases they had equipment that could be used for squeezing oil out of nuts.” Connecting indigenous science and technology from the past with modern Western science was seen as the key to making the reformed curriculum relevant to the learners. According to Ndalapa, in the new vision of the social studies curriculum, sustainability issues are addressed as part of “critical contemporary issues,” which include studies of the environment, AIDS, and gender issues. More emphasis in the reformed curriculum was placed on the role of government, citizenship, and human rights. Although our science methods class was exploring these issues the year before, it is clear that these topics were clearly on the agenda for large scale primary school curriculum reform efforts in Africa.

## Discussion

In support of Carter (2004), the perspectives of Malawian educators were more characteristically dynamic and hybrid in nature as we explored together place-based contexts for teaching Western science. The Malawians in this study clearly did not need to be led across cultural borders from indigenous to Western science. Instead, there was a dynamic discourse throughout the project among the Malawian educators and U.S. researchers that led to a sharing of ideas related to the viability of teaching Western science in the context of Malawian culture and traditional ecological knowledge. These rich class discussions revealed that contemporary African educators were very aware of traditional beliefs and practices; however, this knowledge was expressed in relation to understanding how indigenous knowledge might provide a context for the learning of Western scientific concepts. For example, learning that smoke does not produce clouds, and is hence unrelated to rains, demonstrates the importance of teaching children explanations from Western science. However, the Western science knowledge becomes more meaningful when it is not compartmentalized and taught as a subject separate from the place-based culture and environment of Malawi.

Our research also reveals the importance of understanding the influence of colonialism on the ecological sustainability of developing countries. Certainly, Malawian citizens live in a deforested and ecologically degraded ecosystem that is at least in part the result of economic exploitation of Europeans. The Malawian educators in this study were very aware of this connection between ecological sustainability and colonial domination in their history and culture; however, they were given little opportunities to explore these connections as learners within their own educational system. In this study, the issues related to the colonialism, such as the lack of access of Malawians to arable land, were revealed in role-playing discussions in the methods class. However, from a critical pedagogy of place perspective, understanding these eco-justice issues in developing countries remains a significant political challenge. For example, land redistribution in Malawi would require the government to make decisions that weigh the benefits to the national economy of exporting cash crops with more community-based strategies that promote economic development and sustenance farming by the villagers. Nevertheless, by understanding the dominant Western worldviews and hegemonies that have contributed to colonization and ecological degradation, Malawians may begin to

work together to restore the ecosystems in which they live and begin to develop an integrated science and social studies curriculum that will help children understand these issues.

### **Implications for Teaching About Ecological Sustainability in Malawi**

The culture and environment of Malawi offered a rich context to explore the connections between education and ecological sustainability on the African continent. This was evidenced by the rich, place-based context in the design of Malawian educators' lesson plans and storybooks, their insightful reflections on teaching inquiry lessons with children, and the excitement they demonstrated as learners while participating in group discussions, and field trips to their national park. From our work as a team in Malawi, we became even more aware of the potential benefits of connecting inquiry-oriented pedagogies to the culture and places familiar to students in the community. Rather than teaching Western science (sometimes referred to as "white man's science") exclusively for the purpose of passing an exam, the Malawian educators in this project were immersed in writing and teaching lessons designed to engage children in learning Western science concepts within authentic contexts that connected to everyday life in the villages. From our research, we learned that a commitment to inquiry pedagogies within the framework of place-based education has the potential to promote community involvement, authentic learning, and ownership of the educational process.

Future research is needed to document the impact that inquiry pedagogical approaches might have on children in developing countries that lack the resources and cultural capital for education. Clearly, this is a problem in countries such as Malawi with average class sizes of 80 pupils and a significant lack of resources and trained teachers. Starting in the Teacher Training Colleges and continuing through in-service educational opportunities, we recommend that inquiry be modeled during instruction so that future teachers have the opportunity to dialogue and collaborate as they learn about the many connections that exist between science, culture, and the daily lives of human beings. In so doing, it is our contention that Malawian teachers will develop the confidence and pedagogical awareness to take risks in changing how they approach teaching and learning. For example, by dividing large classes into smaller subgroups, teachers can encourage active participation of learners that is essential when discussing ecological sustainability issues that are vital to the survival of the citizens. The transformation of the pedagogical approaches for teaching science in Malawi, however, will require more resources for teacher development, school infrastructure improvements, smaller class sizes, books, and other teaching materials. One can only hope that a commitment and support for place-based education will help Malawians decide how to allocate the resources they do have to support learning that is both culturally authentic and relevant.

### **Implications for Western Science Educators**

From a Western perspective, we offered few solutions for Malawian educators: we only shared our guilt as representatives of a larger consuming Western society that is interconnected with the earth systems of the rest of the underdeveloped world. We were humbled when Malawians identified basic needs that we take for granted, such as a refrigerator or stable supply of electricity. Other Western consumptive commodities such as automobiles were only "wants" for Malawians, with the hope that one day in the future all Malawians will not be forced to "walk everywhere." It was interesting that in our class many students said they would prefer to live a 100 years ago when Malawians had more ownership in their environment and lived in a more sustainable world.

To Western observers, the problem of ecological sustainability in Malawi is microcosm of developed societies. From our perspective, we should consider examining our own nature–knowledge–culture worldviews and how we are interacting in the earth systems. Certainly, as the world’s largest consumers of oil and natural resources, our automobile culture is symbolic of our imbalance and our dualistic relationship with the earth systems. The corporate culture of automobile racing, for example, is a powerful symbol for the conspicuous consumption of oil for the purpose of entertainment. However, the burning of fossil fuels and subsequent release of carbon dioxide is clearly linked to the earth systems issues of global warming, and is looked at with amazement by human beings in developing countries who, likewise, impact earth systems, but do so simply in a quest for survival. We wonder about the responsibility of Western countries to assist less developed countries in preventing waterborne diseases, famine, and ecological degradation, even as we are guilty of even more egregious acts of irresponsibility concerning the sustainability of the earth. How can we help ourselves, as world citizens, live in harmony with nature, thus creating a more sustainable world?

Addressing sustainability issues from a critical pedagogy of place perspective remains a challenge for science educators worldwide. As we focus on accountability and standards-based instruction in Western countries, we should not lose sight of our responsibility as science educators to address issues of ecological sustainability that remain so vitally important on a global scale. Although understanding the interdependence of earth systems is essential for crossing ecological borders, it may be more difficult to empower earth citizens to negotiate *cultural* boundaries as we both explore and endeavor to understand reasons for ecological degradation.

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