

Exploring the Integration of Indigenous Science in the Primary School Science
Curriculum in Malawi

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(Abstract)

Moving out of theoretical academic constructs, the indigenous movement has attracted the attention of the Malawian education system to explore the value for contextualizing science by way of indigenous technologies. This is a milestone decision but the beginning is not smooth. However, indigenizing the curriculum has a promise of hope to invigorate science educators who are interested in the pursuit of science out of indigenous technologies, embedded in the “taken for granted” and “place-based” traditional knowledge systems. This is only the beginning of the journey in pursuit of local sciences that bear a promise for sustainability in development without relying exclusively on the outcomes of globalization systems of knowledge.

This study sought to unravel the issues that surrounded implementation of a ground breaking primary school science and technology curriculum that has integrated indigenous knowledge in the teaching of science. Commencing prior to the implementation of the new curriculum, this was a pilot study that was strategically conceptualized and timed to inform the curriculum developers and other stakeholders about issues to pay attention to as the curriculum implementation process unfolds.

The study revealed that teachers are likely to face multiple challenges stemming from the design of the curriculum, teachers background knowledge in academic science, pedagogical knowledge, and cultural foundations. The outcome of teaching was negatively affected by the design of the curriculum, inadequate teachers’ knowledge of science, and negative attitudes towards some indigenous knowledge.

Recommendations for improving the integration of indigenous knowledge and science in the curriculum include the need to better articulate the scientific principles involved in indigenous technologies and involving learners in meaningful “practical work” in science lessons, supported by further research.

Dedication

This work is a culmination of a period that denied my family the role of a husband, father, guardian, helper, and comforter. I therefore dedicate this work to my wife Susan for enduring these three years, taking care of my children, and also encouraging me to move on. This made it possible for me to work peacefully because she took the reigns of taking care of the family. My children did not miss me too badly because of her efforts to keep the family going.

I know the spirit of my father and mother always inspired me. Wherever they are, I report that I have finished the task that they sent me forth to accomplish when they sent me to school. This work is, therefore, partly a product of my father's love for education and my mother's persistence even when there were no means.

I owe this work to them. May their souls rest in peace.

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Chapter One: Introduction

Conceptual Framework

Integration of indigenous knowledge in school science curriculum, a movement that emerged in the late twentieth century (Brokensha, Warren, & Werner, 1980; Semali & Kincheloe, 1999; Michie, 2002), has invoked a huge debate in science education. At the outset, some scholars wonder why there is a dichotomy of nomenclature of bodies of knowledge, that is, *indigenous science* and *school science*, that are currently being united (Berkes, Coding & Folke, 2000). Others wonder what necessitates this union or what role will the integration of these knowledge systems play in human life that the well-established three-century old science could not independently achieve (Sithole, 2004).

To some postmodern scholars, the utterance pronounced in the latter statement provokes criticisms because it implies that western science is privileged knowledge, a notion that they would like to deconstruct (Carter, 2006; Dei, 2000). Other schools of thought contend that Western science is the only clear science that leads to universal reality and truth (Cobern and Loving, 2001). Yet others, who think about development among indigenous peoples, advocate the use of both local and western science since indigenous knowledge on its own is still far from propelling development to the extent of solving pressing problems (Brown-Acquaye, 2001). To those who think about pedagogy, inclusion of indigenous knowledge is viewed (beside other things) as a means for laying a foundation for celebrating cultural heritage among the minority cultural groups that may result into the motivation of indigenous learners (Klos, 2006) or reconciliation of traditional knowledge with science (Hooley, 2000).

It may be noted that this debate, among many other things, is charged with connotations that science is contested knowledge (Kalb, 2006; Schroder, 2006). This is why some scholars assert that there are many ways of knowing (Kawagley, 1998; Corsiglia & Snively, 2001), as they advance the notion that school science, which originated in Western culture, is not the only way of making sense of the world. This assertion conflicts with the well established view that Western science is universal. Defendants of the universalistic view herald this claim with reference to successes in the scientific movement that attained a clearest direction in the period of the enlightenment (during the eighteenth century). Since then, this trend has continued to grow to date and

this has resultantly made some people believe that nothing else counts as a way of knowing apart from science.

Obviously, to those who believe in the universality of science, the integration of the indigenous science movement and Western Modern Science is questioned (Cobern & Loving, 2001), despite the recognition of the value of some indigenous knowledge contributions to the pool of scientific knowledge. In their critical remarks against the integrations of indigenous knowledge in school science, Cobern and Loving (2001) argued that finding value in indigenous knowledge “is *not* the same thing as conferring the title *science* and admitting indigenous knowledge of nature to the standard account” (p. 54). Pondering on this debate, one would ask, “what prompts the need for integration of indigenous knowledge with science, which is already a well-established field of knowledge, after almost three centuries of its development?”

Answers to this question may vary depending on the stance taken by the respondents. There are varied understandings about the call for indigenous knowledge, just as there are varied understandings for reforming curriculums. Dei (2000) argues that each type of knowledge has a place in the academy. According to Dei (2000),

Exclusion of indigenous knowledges from the academy within the Euro-American context of knowledge production leaves space for the colonization of knowledges and cultures in local environments and contexts unchallenged (p. 113).

While Dei (2000) talks about power and knowledge representation, McKinley (2005) asserts that the inclusion of indigenous knowledge systems and languages in science education is an attempt to sustain indigenous knowledge and heritage. On the other hand, there are those who claim that science has borrowed its knowledge from indigenous knowledges; therefore inclusion of indigenous knowledges in the academy is a form of reconciliation and social justice (Shizha, 2006). The latter claim is also associated with self worth for the marginalized parties. Shizha (2006) further claims that balancing knowledge systems “empowers the peoples by providing voice to teachers, learners, and other community stakeholders interested in the education of their children.”

As it may have been noticed from the foregoing discussion, there are many reasons for demanding inclusion of indigenous knowledge in science. The reasons range from social justice, identity, politics and power and the list may go on.

Statement of The Problem

Recent years have witnessed several paradigm changes in the field of education. In science education, learner-centered approaches like Dewey's learning through inquiry are increasingly evolving. For example, Dewey's theory of inquiry has influenced reforms in many facets (Lemke, 2001). Some theorists have developed this theory further and come up with other brands of learner-centered approaches. Constructivism shares some elements of Dewey's theory apart from those of Piaget and Vygotsky. As Lemke (2001) affirms,

Piaget's view of the autonomous child-scientist constructing a Kantian epistemology from direct experience and Platonic logical schemas were revised along Vygotskian lines to take into account the social and cultural origins of learner's logical, linguistic, and semiotic resources and models – learned from more experienced social partners – and the actual role of social interaction in learning is and normal development.

All of the constructivist reforms aimed at improving learning and the focus tended to be the learner. This was a response to the growing challenges in a changing world. One of the most recent changes in science, although still in its primordial stage, is the integration of indigenous knowledge, whose objectives are mostly to improve performance of minority learners (Klos, 2006; Wanjia, 2000). This move arises from the fact that science and technology remain instrumental to every person's functionality in a technology laden world and hence, promotion of participation in science is taken as a human right (Banks & Banks, 2005).

Many developing countries (Malawi inclusive) are recently considering the inclusion of indigenous knowledge in the teaching of science, especially in Africa, Australia, North America and other places. In the recent curriculum reform for primary schools, Malawi caught up with this reform fever and many subject teams started working out curriculum units that would reflect indigenous knowledge in the curriculum. The new curriculum reform has resulted in a total revamp of the objectivist view of learning that emphasizes the conceptual transformation of learners in which a named objective must be realized within a short time frame (e.g. by the end of the lesson). In its place, outcome-based learning emphasizes the learners' achievements but not always at

the end of a specified learning time period. The latter view comes from a belief that learners may not always learn what has been prescribed by the end of each lesson. Rather, this view recognizes diversity of learners' performance and therefore strives to provide sufficient time and structures to enable all learners to develop, following varied achievements depending on their capability. Coming along this reform, Malawi introduced indigenous knowledge in the teaching of science.

However, there are many issues that come under play to effectively design and implement indigenous or culturally responsive curricula as pointed out by Herbert (2006). Herbert (2006) highlights many challenges, ranging from language, resources, beliefs (both for teachers and students) and theoretical frameworks that teachers have to use in the implementation of indigenous science curricula. Unfortunately, most teachers (in most parts of the World) were never trained on how to teach culturally appropriate curriculums. Hence, Herbert's (2006) concerns about languages and teacher's pedagogical knowledge and theoretical frameworks are likely to pose challenges to those who are just joining the process of indigenizing their curriculums like Malawian primary science teachers.

This study was, thus, designed to explore the pedagogical and socio-cultural issues that Malawi primary science teachers are likely face while implementing the newly reformed curriculum, Primary Curriculum and Assessment Reform (PCAR) (Appendix A). Curriculum developers proposed incorporation of indigenous technologies in science and technology in 2005. That curriculum had just been implemented in the preparatory class (P), followed by grades five and two in 2008. Thereafter grades six, three, and eight will be implemented in 2009 or beyond.

Justification of The Study

Since Malawi had just taken a bold step in reforming the curriculum by introducing indigenous science along side a major reform of the curriculum from objective driven curriculum to outcome based approach, and that science and technology would begin at grade one and go across the eight classes, I was interested to find out how standard five teachers would cope with the newly introduced topics, especially those with a slant to indigenous knowledge.

Standard five was previously the beginning of formal science education in the previous curriculum. This class also acts as a link between junior primary and senior primary school. Being a class of transition, learning is done in both vernacular and English, but focused more on English as time goes by. Formerly, the science curriculum begun in grade one but the 1990 curriculum reform shifted science to begin in grade five after a study revealed that children of lower ages could not process scientific facts, especially if English was a second language. Since literature indicates that inclusion of indigenous knowledge creates language challenges and also opportunities for creating a foundational base in the teaching of science (Herbert, 2006; Klos, 2006), I was interested to see how language, resources, and the theoretical knowledge of teachers will play in the learning process at this level in the primary school.

Results from this study have the potential to inform the curriculum developers, inspectorate in Malawi (responsible for quality control), and also teacher educators. Inspectors may use these results to decide issues to monitor or deal with during the rolling out of the implementation phase of the PCAR science curriculum. Such knowledge would therefore shape decision-making processes at classroom level up to educational management structures. Furthermore, findings from this study would inform other stakeholders (or countries) who aspire to embrace the integration of indigenous knowledge about issues that need attention in the design and implementation of such a curriculum.

The Primary Curriculum and Assessment Reform (PCAR) developers advance the need to contextualize learning in primary school education. This curriculum reform advocates a revolutionized approach to teaching known as outcome based education (OBE) and also encourages the use of indigenous knowledge in many learning areas, including the sciences. Again, instead of teaching traditional subjects as inherited from the British government (under which Malawi was a colony until 1964 when it attained independence), this program amalgamated subjects into six major learning areas in standards 5-8, namely: (1) Science and Technology, (2) Life Skills, (3) Literacy and Language (4) Social and Environmental Science, (5) Expressive Arts and (6) Numeracy and Mathematics (see Appendix B). Under this arrangement, science is integrated with related subjects, including agriculture and home economics. This amalgamation was done

in a bid to reduce content, which was viewed to be higher in the previous curriculum, mostly due to duplications of knowledge across subjects.

In Science and Technology area, technology has been highlighted because of development needs, which concurs with Brown-Acquaye's (2001) contention that Western technology and science are highly sought for by developing countries, but he also says the need to use traditional knowledge is still valid. It is not surprising, therefore, that the recent curriculum reform in Malawi encouraged inclusion of indigenous knowledge and technologies in Science and Technology learning area. Although suggestions to include indigenous knowledge in the Science and Technology area were made, I have not come across a local study that shows the possible content or pedagogical insights that would help teachers implement indigenous knowledge inclusion in science teaching in Malawi. In developing the rationale, the PCAR curriculum developers merely relied on what other countries are doing. However, even at international level, very few studies on integrating indigenous knowledge in the science curriculum have been conducted. Again, since science and technologies tend to be place-based, studies conducted elsewhere may only reflect problems and solutions that are specific to those areas. Furthermore, most literature that I have come across only shows theoretical justification for integration of indigenous knowledge and there are not as many primary studies on indigenous knowledge.

Literature lobbying for integration of indigenous knowledge came to the peak recently (between 2000 and 2006). For example, Boyne (2003), "Utilizing traditional knowledge in a scientific setting;" Cobern and Loving (2001), "Defining 'science' in a multicultural world: Implications for science education;" Brown-Acquaye (2000), "Each is necessary and none is redundant: The need for science in developing countries;" Corsiglia & Snively (2001), "Rejoinder: Infusing indigenous science into the western modern science for sustainable future;" Dei (2000), "Rethinking the role of indigenous knowledges in the academy;" Michie (2002), "Why indigenous science should be included in the school curriculum;" Ninnes (2000), "Representations of indigenous knowledge in secondary school science textbooks in Australia and Canada;" Klos (2006), "Using cultural identity to improve learning;" Semali and Kincheloe (1999), "What is indigenous knowledge: voices from the academy;" Snively and Corsiglia (2000),

“Discovering indigenous science: Implications for science education;” Stanley and Brickhouse (2001), “Teaching sciences: The multicultural question revisited;” Sundar (2002), “*Indigenize, nationalize and spiritualize*” - *an agenda for education?*;” Thomson (2003), “Science education researchers as orthographers: Documenting Keiyo (Kenya) knowledge, learning and narratives about snakes;” and Herbert (2006), “The challenges of designing and implementing a cross-cultural unit of work.”

My analysis of the above articles reveals a few prevalent issues that are analyzed and debated: (a) the validity of indigenous knowledge as a science or justification for including indigenous knowledge in science teaching, (b) pedagogical issues arising from inclusion of indigenous knowledge in science, (c) benefits for including indigenous knowledge in school science. Given the fact that some researchers have noticed teacher’s knowledge deficiency in planning cross-cultural studies (Herbert, 2006) and that many teachers have developed negative attitude towards some indigenous practices as a result of western influence (Shumba, 1999), it seems necessary to find out how teachers in Malawi would react to use of indigenous knowledge for the first time in their career or even for hearing it for the first time. The design of this study assumed that observing teachers planning and teaching of lessons that involve indigenous knowledge in science would reveal the nature of pedagogical challenges that science teachers might face, how they solve them, typical resources they are likely to use, and students’ responses to the revised science curriculum. This study was thus designed from such a background and assumptions.

Purpose of The Study

The purpose of this study was to develop an understanding of issues that will emerge during implementation of the newly reformed science curriculum for standard five that incorporated indigenous knowledge for the first time. Although the study was purposely done for my dissertation, its timing and setting were so timed as to provide feedback to Malawi Institute of Education and the Education system as a whole on the viability of the curriculum. Because the study was done almost a year before the new curriculum was to be implemented in 2008, ideas and research findings could be used during the orientation of teachers in order to enlighten the educators about issues to be monitored or addressed. At the outset, the study was envisioned to learn about the

following topics: (1) viability and adequacy of suggested indigenous knowledge content, (2) propriety of methodology suggested and actual implementation procedures in class, (3) compatibility and availability of teaching resources, (4) teacher's pedagogical readiness for handling indigenous knowledge in the context of conventional science and multicultural principles, and (5) pupils' responses to units that carry indigenous knowledge.

As stated earlier, knowledge gained was intended to inform participants, school administrators, and curriculum developers about (a) issues to work on during actual implementation, (b) refining of grade five content in the syllabus and teacher's guides, and (c) also issues to consider revisiting in the remaining work on production of teacher's guides for grades six and seven. The new PCAR curriculum implementation started with grade one (Class P) in 2007 and this will be followed by grades 2, 3, and 5 in 2008. The following year (2009) will roll out grades 4 and 7 and then finally grade 8 in 2010. This study, therefore, commenced at the right time to raise important issues that the education system in Malawi might need to respond to as the curriculum implementation rolls out.

Research Questions

This study was guided by three main research questions focused on the curriculum and teacher's experiences and conceptions as follows:

Question 1: How is indigenous knowledge featured in the standard five PCAR science and technology curriculum in Malawi?

Question 2: What issues did teachers face during the implementation of indigenous science topics in the Malawi primary science and technology curriculum?

Question 3: How do teachers conceptualize the role of indigenous knowledge in the newly reformed primary science and technology curriculum?

Question 1 is aimed at finding out how indigenous knowledge is represented in the curriculum and also the nature of content suggested under indigenous knowledge topics. This was done to show how such indigenous knowledge is articulated and how it was integrated with other forms of knowledge as compared with regular topics in science.

Question 2 mainly focused on classroom practices and the whole range of dynamics such as communication (between teachers and pupils), teacher's lesson

organization, development of scientific ideas, achievement of learning outcomes, and how they were assessed.

Question 3 was focused on (a) teachers' knowledge about indigenous knowledge and technology in relation to science, (b) teachers' attitude towards indigenous knowledge related to content, and (c) how they valued the new content on indigenous knowledge in relation to learners' benefits. Reporting of results has therefore been organized according to the three questions. After the second chapter (Literature Review) and the third chapter (Methodology), the next three chapters show analysis of data for questions 1 to 3, respectively. In chapter seven, the results will be discussed in relation to the prevalent literature on indigenous science and recommendations will be made for improving the reformed curriculum.

Chapter Two: Review of Literature

Introduction

To gain a better vision of the theoretical base that propels the indigenous knowledge integration agenda and the surrounding issues that spin along and around this momentum, we now turn to the key theoretical frameworks that all interested parties (teachers inclusive) need to know as they seek an understanding of the process or indeed participate in the implementation phase of this type of curriculum. In this paper we employ several frameworks, which act as lenses for processing the information that arises from both the field and the documents during the analysis of findings from this study.

Among theories that come to play during the integration of indigenous knowledge in science education are postcolonial, postmodernism, post-structuralism, multiculturalism, constructivism, worldviews, border crossing, collateral learning, situated cognition, and place-based education. A brief review of these theories provides a framework for the discussion of the integration of indigenous knowledge in science education. First, we are going to discuss postcolonial theory.

Postcolonial Theory

According to Carter (2006), postcolonial theory is a theoretical tool that opens up channels for revising philosophical frameworks, which do not function well in a world that is inter-civilized. As for science, this theory opens up vantage points for inquiring into describable transcultural processes leading to appraisal of dominances and subordinations. Carter (2006) further stated that post-colonialism has the capacity to permeate many of such processes and into the “deeper ravines like multiculturalism, boundaries, identity, representation, and pluralisms, underpinning theorization of diversity,” which “can open up spaces to generate different discussions about cultural work in science education” (p. 476) and “extend discourses in science” (p. 479). For example, Dei (2000) engages in the indigenous knowledge discourse with the intention to decolonize the dominant universal science discourse as he says, “my learning objective in indigenous knowledges is to develop a critical epistemology to account for the production and validation of critical knowledge for decolonization purposes.” Dei (2000) advocates hybridization of knowledge and balancing of knowledge bases, as he argues that both indigenous and western knowledge are contested in terms of boundaries and spaces

(p.113). Dei further states that postcolonial theory “interrogates the power configurations embedded in ideas, cultures, and histories of knowledge production and use.”

Postmodernism

Postmodernism entails dissatisfaction with the present state of affairs and in case of science, it would mean dissatisfaction with the way science is conducted, represented, or used. According to Hammersley and Atkinson (1995), postmodernism “attempts to celebrate the paradoxes of field research and social life” (p. 254). The essence of postmodernism is to abandon singular narrative viewpoints or the dominant voice of an authoritative ethnographer. Lyotard (1995), also sharing this viewpoint, “rose to challenge the conventional Western wisdom on the relationship between science and culture and the standard account itself.”

Multiculturalism

Multiculturalism in general is a view that diversity is normal and that each group ought to receive equal cultural or political value, as all groups deserve. In science education, this could be equated with recognition that different fields of knowledge exist and that all fields of knowledge deserve the same attention and opportunities like all groups. This claim arises under events where some members receive lower attention than others who tend to obtain higher attention (Cobern & Loving, 2001; Stanley & Brickhouse, 2001).

According to Stanley and Brickhouse (2001), such views have become visible as from the time multiculturalism in science education emerged in the late second half of the twentieth Century. Multiculturalists are renowned for challenging the universalistic and realist view of Western modern science (WSM), which in turn provokes counter arguments from those who hold on to the standard account as the superior and universal way of knowing. While multiculturalists challenge the reliance on the Western account of science as the only way of interpreting the world, they advance alternative ways of viewing the world. They claim that the alternative worldview of indigenous people avails opportunities for comprehending science to non-western learners or indeed open up new solutions (e.g. in medicine) that may not be forthcoming from the western science at the moment or in the near future (Stanley & Brickhouse, 2001).

Constructivism

Alongside the challenge from multiculturalists, emerging strategies for teaching science, such as constructivism, emerged in the 1980s in the process of reforming science education. Constructivism questions the realism that characterizes the Western account of science. Constructivist paradigms advance relativist views of scientific knowledge as they suggest that individuals construct worthwhile knowledge either individually or socially. Hence, constructivism, although accepted by western science scholars, it advocates relativist construction of knowledge that relates to social interaction and by implication align with multicultural science educators' notions of how scientific knowledge emerges from the community of a people (Stanley & Brickhouse, 2001). Therefore, engaging the constructivist approach to learning, implicitly or explicitly creates a link to local people's knowledge that comes under play in a child's process of learning science as purported under the constructivist learning paradigm (Stanley & Brickhouse, 2001).

Border Crossing

A border is a physical barrier but it can also be an ideological barrier suffused with power to bar someone from passing across a physical or perceptual barrier. Jegede and Aikenhead (1999) conceptualize the transition between a students' life-world and school science as a cultural border crossing. Border crossings are perceived to take place between cultures or between micro cultures. Jegede and Aikenhead (1999) further stated that transcending borders is a result of negotiation that all learners have to do but much more among minority learners.

Worldviews

The worldview discourse implies the way people understand what they perceive in their life worlds (e.g. beliefs, future, death). People from different cultures tend to differ in their perceptions of how the world functions but each group attempts to come up with an explanation of some sort. However, the scientific worldview (AAAS, 1990) differs from the worldviews of indigenous people (Kawagley, 1995). Kawagley (1995) states that "the concept of worldview is very closely related to the definitions of culture and cognitive map...a worldview consist of the principles we acquire to make sense of the world around us." Kawagley (1995) further states,

Among the indigenous cultures the worldview includes values, traditions, customs, myths, legends, stories, family, community, and examples set by the community leaders...a summation of coping devices that have worked in the past and may or may not be as effective in the present. (p. 9-8)

Different communities of people among indigenous cultures tend to have their own worldview, unlike the conventional scientific worldview, which tries to unify all worldviews. The scientific worldview, as it will be observed ahead, does not include values like those held among indigenous people. To gain better understanding of indigenous worldviews, let us turn to indigenous knowledge and learn its characteristics.

Indigenous Knowledge

General Introduction

Understanding aspects of indigenous knowledge (IK), with respect to its characteristics, production, maintenance, adaptation, transmission and its use, is crucial for one to make coherent relationships between IK and science and indeed in making a sound analysis of all propositions about the need for science teaching to embrace indigenous knowledge (Maurial, 1999; Mwadime, 1999). Efforts to understand indigenous knowledge are thwarted by several reasons ranging from ambiguity of terms, obscure forces that act on conception of ideas and processes surrounding indigenous peoples, socio-cultural lives (power, politics, and socio-economic factors), and lack of background knowledge (among teachers) to identify relevant or irrelevant bodies of knowledge in the process of planning and teaching science that embraces indigenous knowledge.

For teachers, who largely depend on knowledge that they learned from college, dealing with indigenous knowledge may look like far out of reach. In other words, ordinary minds do not usually worry about processes that shift the position of things in a society. Therefore, I consider it necessary to clarify some meanings that surround the terms “indigenous” and “knowledge,” and their associated characteristics, sub-branches and also theoretical perspectives that are associated with such conceptions.

The term “indigenous” is loaded with meanings (traditional, local, natural, primitive), just like the term *knowledge* connotes different things to different people. A combination of the two words (*indigenous knowledge*) obviously presents a huge task in

constructing a single concept. Hence, some people say, “the meaning of indigenous knowledge is difficult to pin down” (ICSU, 2002, Maurial, 1999). Since we are going to use these terms frequently, it is necessary to discuss aspects of indigenous knowledge, in general, through which the linkages with science can be discerned. Prior to analysis of “indigenous knowledge” as a unitary concept, let us put the terms *indigenous* and *knowledge* in the limelight.

Meaning of Indigenous

Semali and Kincheloe (1999) described the term “indigenous” as ambiguous because it has various meanings. Its former meaning, as construed by colonialists during colonialism era, is different from the current perception by some of the colonized people in the neocolonialism era. From colonial masters’ perspectives, the term indigenous was associated with the primitive, the wild, the ignorant, and the natural. All the descriptors of bearers of the term indigenous were implicated with condescension from the western observers (as depicted in most anthropological studies conducted earlier by Western anthropologists): An element that postcolonial theorists reveal to be a causal factor that leads to little appreciation of indigenous insights and understandings that indigenous people offered to the colonial masters’ pool of knowledge (Carter, 2006; McKinley, 2005; Semali & Kincheloe, 1999).

All people that Westerners labeled as indigenous were viewed as inadequate and the more the indigenous people saw themselves in that position, from implicit or explicit experiences, the more they accepted their knowledge and capabilities as lower in value. This trend led to attenuation of some forms of practices and knowledge that indigenous people used for thousands of years prior to the arrival of expansionist Europeans (Ocholla and Onyancha, 2005). However, as Semali and Kincheloe (1999) pointed out, some indigenous people do not share this subjugated view of their indigenous knowledge, Especially the millions of indigenous peoples of Africa, Latin America, Asia, and Oceania...some of such indigenous knowledges have been named native ways of knowing through which elements of local science and technology are highlighted (also see Kawagley, 1995).

A scan across several indigenous cultures reveals elements of knowledge, practices, artifacts that are closely associated with science and technology, but the colonialists did

not often recognize them as worthwhile contributions to the global collection of knowledge and practices. In their study, Ocholla and Onyancha (2005) processed infometrics on indigenous knowledge which cover a wide range of indigenous knowledge practices such as agriculture, environment, biodiversity, health and nutrition, just to mention a few. However, the low profile accorded to indigenous knowledges (although many) rendered such contributions valueless and resultantly such knowledge never featured as a commodity. Hence, indigenous people have reaped nothing out of their contributions. Instead, they suffered some disruptions in their productive practices, since the western science deskilled them and immediately after deskilling them they had to re-skill in order to become functional again. It was imperative for indigenous people to develop new skills under the changed socio-economic demands while living under colonialist governments (Katz, 2004; Maurial, 1999).

The greatest reason for neglecting indigenous knowledge was power. Since knowledge is power, money, and prestige (McKinley, 2005; Ocholla & Onyancha, 2005; Shizha, 2006), some schools of thought contended that recognition of indigenous knowledge (on the part of colonialists) would give indigenous people power to act or agency for identity. Therefore, to maintain power, the colonial masters' knowledge and voice had to remain superior to those of indigenous people. It is through such elements that some postcolonial scholars criticize the universalistic claim that science is the only way of knowing. Thus, such scholars lay pointers to or indeed reassemble the almost obliterated ideas, practices, and artifacts (produced by indigenous people) that are of scientific relevance (Sundar, 2002) while advancing the claim that Western science is not a unilateral practice for the Westerners alone but a universal practice for all people in the world (Sithole, 2004).

To some, this is a paradoxical argument. Instead of thinking about science as universal and of Western origin, post-colonialist, poststructuralists, and postmodern philosophers feel that the Western view is narrow and short of the credence it claims to bear because it neglects the source of hypotheses and wonderment which mostly come from everyday knowledge like indigenous knowledge. Additionally, some authors challenge the western science for claiming that science is value free and yet capitalism (a power base in disguise) is loaded with values (Sithole, 2004). Claiming universality of one set of

knowledge is also criticized because all parts of the world have their own local knowledge that changes as it interacts with other forms of knowledge (which is quite frequent in the modern world). Hence, the fluidity of population movements does not allow any set of knowledge to remain purely local, including the knowledge of indigenous people.

It is from such arguments and assertions that indigenous knowledge gains the scientific connotations and indeed the emergence of the term indigenous science. Indigenous knowledge is, however, locked up in spirituality because it “encapsulates the common good-sense ideas and cultural knowledges of local people concerning everyday realities of living”, according to Dei (2000). But why call it indigenous science and not just science? As Carter (2006) would say, this debate arises because there are perceptual borders between the two forms of knowledge, although the margins are leaky. Another reason is that the West has compartmentalized their knowledge, such that spiritual matters are not part of science, while indigenous knowledge remains holistic (Semali and Kincheloe, 1999). One interesting academic argument indicates that science and religions are not quite separate since they share sections of cosmologies. This brings us to an issue worthy pondering on in this debate.

Emergence of Indigenous Knowledge in The Academy

According to Brokensha, Warren, and Werner (1980), the emergence of indigenous knowledge in the academy was triggered by ethnographic studies conducted in nation-states that were once colonized by Europeans during their expansionist agenda. Through such studies, it was noted that prior to colonization some local people sustained themselves better when they owned locally developed knowledge than was the case after the colonial era. The aftermath of colonialism (in the twentieth Century) is thus viewed as having negatively transformed some of such nations to the extent that they lost vitality of their agricultural and other survival systems (Semali & Kincheloe, 1999, Katz, 2004).

For example, Thomson (2003) mentions the Republic of Congo (formerly Zaire) that experienced a downturn in its capacity to produce cereals due to the disruption of colonialism. Resultantly, Zaire reached a point where the local people’s cereal civilization (once upon a time a star cereal civilization) became almost dysfunctional and people could no longer sustain their food requirements. Through several of such critical

anthropological studies it was realized that reverting to the use of some indigenous knowledge and practices, that sustained people many years before colonization, was a gateway to revamping some colonial country's ailing sustainable living systems among indigenous people. Through consideration of such examples, and across the continent, the momentum for the indigenous science/knowledge debate has grown in strength at local, regional and global scales, and scientists have become active participants of this debate (ICSU, 2002; Iseke-Barnes, 2005).

To date, the debate increasingly continues as featured in many institutions and internet websites such as World Bank (under news columns for developing countries), Science and Development Network (SciDev.Net), Indigenous Science network (Australia), Alaska Native Knowledge Network, and India, just to mention a few from the wide range of networks mushrooming in developing countries. At the same time, there is high proliferation of published articles on indigenous knowledge. In an informetric analysis of indigenous knowledge, Ocholla and Onyancha (2005) found that there is a positive growth of literature that is written and published on indigenous knowledge in years spanning between 1990 and 2002 and such articles have been published in most of databases. Almost all networks mentioned above pursue the issue of legitimizing indigenous knowledge as a body of oral knowledge that has sustained people who have solely relied on oral transmission of such knowledge for all their survival until they were colonized and introduced to the world of print and education (Kawagley, 1998; Semali & Kincheloe, 1999; Snively & Corsiglia, 2001; McKinley, 2005).

This growing pressure for legitimization of indigenous knowledge has so far made international organizations such as UNESCO, World Bank and many others to seriously consider using indigenous knowledge when pursuing development and education support endeavors for some developing nations. However, among the articles written on indigenous knowledge, there are varied opinions about the role of indigenous knowledge in science education or use in development because of its nature. This turns us back to the earlier mentioned aspects of indigenous knowledge (a) characteristics, (b) production, (c) maintenance, (d) adaptation, (e) transmission, and (f) its use.

Characteristics Of Indigenous Knowledge

Indigenous knowledge is characteristically orally produced from everyday experiences (e.g. hunting, fishing, farming, and social interactions such as music) of all people in a community that are shared as narratives representing myths, beliefs, ceremonies, and pragmatic practices. Some narratives involve accurate observation and inquiry but others are from past experiences. Hence, indigenous knowledge is produced differently from science.

Production of Indigenous Knowledge

Indigenous knowledge is produced in an ongoing manner and accumulated from everyday experiences. Revision of knowledge is ongoing and all people accomplish this through direct use of knowledge. All people are actors in indigenous knowledge, both young and old. This is why Ocholla and Onyancha (2005) say, “indigenous knowledge is tacit or tangible knowledge which is inseparable from realistic knowledge” and laments that it is unfortunate that due to “ignorance and arrogance, indigenous knowledge has been neglected, vindicated, stigmatized, illegalized, and suppressed among majority of the world communities.” However, Ocholla and Onyancha (2005) jubilate for the fact that indigenous knowledge has recently been brought back to the front because of interventions by governments and civil societies through legislation and policies that pertain to intellectual property rights, research, alternative medicines, nutrition, sports, and business. These developments ease the fears that increasingly mounted due to globalization pressures and also increasingly fostered melting down of traditions and cultures as well (Ocholla & Onyancha, 2005, p. 248).

Maintenance of Indigenous Knowledge

Since indigenous knowledge is oral by nature and passed on from adults to younger generations, one would expect this kind of knowledge to remain exclusively historical. However, this is not the case. Reynar (1999) in his article, entitled, “Indigenous people’s knowledge and education: Tools for national development?” discusses how indigenous knowledge has kept evolving and improving to the extent that the past fifteen years have noted an increase in indigenous knowledge systems. This is observed through a phenomenal increase of literature (Ocholla & Onyancha, 2005); thereby signifying that indigenous knowledge has the capacity for adaptation. Although early ethnographers

mostly described indigenous knowledge with negative connotations, time has shown that some of the knowledge is worthwhile.

The International Council for Science (ICSU) recognizes the value of indigenous knowledge of the local peoples of the world. Today, this international science organization agrees that some of the science contributions like classification of animals was partly adapted and adopted from indigenous people, whereby, the local people's extensive knowledge of plants and animals were a source for compiling the extensive list for classifying living organisms and not a sole invention of Linnaeus. In the same token, the ICSU (2000) report indicates that the indigenous people accumulated knowledge about medicines, some of which have been upgraded using scientific techniques. Furthermore, recognition has been made that some indigenous people have their own science covering astronomy, meteorology, geology, ecology, botany, agriculture, physiology, psychology and health. The only difference is that indigenous knowledge tends to come as a whole set of knowledge (holistic) and not compartmentalized as done in the western science.

Utility of Indigenous Knowledge

It is well known that science and technology education are key to development in both developed and developing nations in the world (Bridgestock, Burch, Forge & Laurent, 1998). In the advent of integration of indigenous knowledge in science teaching, some educational policies that are tailored to national development are likely to favor accommodation of indigenous scientific knowledge: if the policy makers could get the sense of using indigenous knowledge in promoting the learning of science and technology or socio-cultural benefits. Policy makers are likely to get the feeling of what indigenous science can offer through advocacy systems if they could be clearly convinced about what it can offer.

Therefore, advocates of indigenous science in the academy are strapped with the responsibility to conduct research which will go beyond mere awareness about contributions that emanate from indigenous science, by providing researchable findings that clarifying relationships that exist between Western Modern Science (WSM) and indigenous knowledge that has a scientific slant (currently labeled as ethnoscience, ethnobotany, ethnoecology or traditional ecological knowledge). Some educators have

already named such categories of knowledge as indigenous science (Snively & Corsiglia, 2001; McKinley, 2005, Thomson, 2003).

However, indigenous science itself is a construct that needs cleaning up because there are many views about what it means. The persistent association of indigenous science with spirituality, cultural values, and myths casts some shadows of doubt on its alignment with science due to lack of evidence of this kind of knowledge. Interestingly, this is where some members of the academy feel that Western science may be missing out on an area worthy understanding (Corsiglia & Snively, 2001; McKinley, 2005). So far, only indigenous peoples are still heavily associated with spiritual and value laden knowledge while the Westerners are said to have departed from such valuation system.

Actually, spirituality and the oral transmission of such knowledge are relegated to primitivism. But, the intriguing part of this debate is that even the Westerners once believed in spirituality and still do to date. Historically, traces of spirituality and engagement in beliefs, prejudices, and magic have not spared Westerners (Bauspies, Croissant, & Restivo, 2006). It was from such understanding that those who hold multicultural and socio-cultural views feel that it is not strange to have cultural difference. However, what matters is that teaching and learning should tap this kind of knowledge in order to assist learners coming from particular cultural backgrounds that may assist or block their understanding of science (Aikenhead, 1999; Stephens, 2001; McKinley (2005). Stephen (2001), while talking about a culturally responsive curriculum, noted that a “culturally responsive curriculum attempts to integrate native and western knowledge systems around science topics with goals of enhancing cultural well being and science skills and knowledge of students.”

Due to the foregoing discussion, it may be noted that anyone who endeavors to transact with indigenous knowledge and practices ought to have a clear picture of its nature in order to properly align this kind of knowledge and practices to the broader scientific body of knowledge. An understanding of indigenous science in relation with Western Modern Science (WMS) is only the beginning of getting to know why indigenous science is being advocated and being proposed to be part of school science. Since indigenous science is up-coming and by nature not developed exactly like WMS, many educators receive this notion with questions that seek its compatibility with school

science. Therefore, there is need to clarify what it is and even explain the theoretical frameworks that support its consideration for integration in school science.

Indigenous Science

The definition of indigenous science is quite difficult to pin down because science itself is a complex learning area. Snively and Corsiglia (2001), quoting Ogawa (1995), stated,

We must distinguish between two levels of science: individual or personal science and cultural science or societal science. He (Ogawa) refers to science at the culture or society level as “indigenous science.” He defines indigenous science as “a culture-dependent collective rational perceiving of reality,” where collective means held in sufficiently similar form by many persons to allow effective communication, but independent of any particular mind or set of minds.

Although we all participate in indigenous science, to a greater or lesser degree, long resident, oral culture peoples may be thought of as specialists in local indigenous science. Indigenous science, sometimes referred to as ethnoscience, has been described as:

The study of systems of knowledge developed by a given culture to classify the objects, activities, and events of its given universe...Indigenous science interprets how the local world through a particular cultural perspective. Expressions of science thinking are abundant throughout indigenous agriculture, astronomy, navigation, mathematics, medical practices, engineering, military science, architecture, and ecology. In addition, processes of science that include rational observation of natural events, classification, and problem solving are woven into all aspects of indigenous cultures (Snively & Corsiglia, 2001, p. 10).

As it may be noted from the long quotation, the terms indigenous science covers a wide ground and many people just prefer to call it holistic science because it has many bodies of knowledge under one umbrella. There are multiple meanings and it should also be noted that the local people do not name indigenous science as science.

Indigenous science is encrusted in indigenous knowledge which is itself an ambiguous term that connotes many categories of knowledge. Before getting into the multiples of indigenous terms let us take a quick look at the broader body of knowledge in which indigenous science is a subset, that is, indigenous knowledge.

Indigenous Knowledge as Science

Mwadime (1999), also grappling with the meaning of indigenous science, cautioned that prior to advocacy of indigenous knowledge, it is important to have a thorough understanding of terminology. Starting with *knowledge*, he defined it as “the awareness or understanding of a practical or theoretical thing or fact” and further stated that this knowledge “embraces knowledge of tools and techniques for assessment, acquisition, transformation, and utilization of resources in their locality” (p. 247). Mwadime (1999) also noted, “it is indigenous (local or tacit or practical) because it differs from known forms of formal knowledge (scientific, western, modern, colonial) in the contextual sense (as IK is deeply rooted in its environment, history, and new experiences) and its epistemological nature IK is holistic”. This kind of knowledge remains the information base for a society, which facilitates communication and decision-making.

Mwadime (1999) attempted to isolate indigenous science from its holistic body of knowledge. A glance across Table 1 reveals that indigenous knowledge bears both scientific and technological threads but in its creation and use it is simply practical/pragmatic knowledge and not ordinarily identified as a science (Stephens, 2001; Snively & Corsiglia, 2001). Thus understanding and analysis of indigenous science tends to be done with reference to the well-established Western Modern Science (WMS), which people are already familiar with.

Indigenous Knowledge Ascent to Science

Turnbull (1997) persuasively illustrated that recent times are witnessing a definite change about the status of Western science and that this is apparently registered by “mainstream, orthodox, historians and sociologists of science, whose attitudes are generally changing their minds” (p. 551). The growing change indicates a growing recognition that there are other ways of knowing the World in addition to the European scientific way of knowing, formerly considered as universal. According to Turnbull (1997), this change arises from critiques of science by “sociologists of scientific knowledge, feminists, post-colonialist, and socialists” (p. 551).

Table 1: Identifying Scientific Explanations to Indigenous Behaviors

<i>Indigenous knowledge</i>	<i>Process</i>	<i>Scientific explanation</i>
Processing of cassava	Combination of drying, soaking, boiling, grating (and pressing), fermentation	Detoxification with regard to residual cyanogenic glycosides)
	Avoiding consumption of bruised cassava, “it increases the chances of stomach problems”	Bruising exposes tissues to oxygen, which leads to hydrolyses of cyanogenic glucosides to hydrocyanic acid (HCN) by endogenous enzyme Linamarase. It is HCN, which causes stomach problems and sometimes death.
Germination of cereals	Soaking for 2-5 days, followed by sun drying and milling. Mixing with water and cooking to gelatinization of starch and let to cool for 12 hours. Then dilute to drink.	Increased content of water – soluble vitamins and amino acids such as lysine and methionine and of soluble sugars in the malt.

Courtesy of Mwadime (1999, p. 257)

Among the arguments raised is the fact that the kind of knowledge which is recently called “modern science” is a relatively recent local activity that was co-produced with industrial capitalism and more importantly, “science in the general sense of systematic knowledge was never uniquely Western, having its origins in a wide variety of cultures including Islam, India and China” (p. 552). In other words, indigenous groups of people as well are recognized to have some scientific knowledge, but acceptance of the array of such knowledge in the standard account is a great struggle. The great problem related with recognition of knowledge is in the way it is produced. To those defending the standard account, dominant knowledge is that which ensues from experimental,

reductionist, and empirical processes which the west has deemed as privileged knowledge and indeed treated as universal knowledge. Under the Western standard account of scientific knowledge, other forms of knowledge fail to meet the rational rigors and whatever substance is found in such knowledge is only better placed in (appended to) the sections of Western science. And yet it is known that all parts of the world are potential spaces for knowledge creation because knowledge creation is determined by conditions under which one lives (Turnbull, 1997). A number of examples of scientific knowledge produced in different locales of the world are highlighted, such as, architectural knowledge used by early Europeans (before the birth of the current science), navigation knowledge among Polynesians that early explorers used and innumerable examples from all over the world such as contributions from folk science that went into taxonomy of plants and animals.

Turnbull (1997) also contends that there is no difference between production of local knowledge and scientific knowledge, because both emanate from local knowledge/practice that co-produces a knowledge space. He further argues that production of science is not a result of any universal principles of logic or method but by local contingent judgments and negotiations, which include not just cognitive and practical concerns but moral, political, and economic interests as well. However, Turnbull (1997) recognizes the fact that there is great diversity of knowledge traditions around the world and that a choice of which knowledge really counts is surrounded by power struggles. Turnbull's arguments are reiterated by Brown-Acquaye (2001) who accepts the value of both types of science (Western and local).

Brown-Acquaye (2001), in his synthesis of comparative value for Western and indigenous science, he contended that science and technology, both products of the West, have produced very impressive results such that developing countries look no where else in their pursuit for development, other than following the footprints of the Western development. Brown-Acquaye (2001) also recognizes the fact that each culture in the world has some form of science, agreeing with many who advance this thought (citing Ogawa, 1995), who made earlier contentions that each culture had its own science. Brown-Acquaye's (2001) claim was double edged. On one hand, he indicated that indigenous sciences in developing countries were far from answering the multitudes of

problems that developing countries are facing such as inadequate or substandard shelter, hunger, diseases, environmental degradation, and communication challenges. However, Brown-Acquaye encouraged research in developing countries to research in the indigenous science knowledge of their people. It is probably necessary at this point to look at the conventional nature of science before tackling pedagogical underpinnings of indigenous knowledge. Hence, let us digress a little bit into the nature of science and have an overview of what is involved in science and its pedagogy.

The Nature of Science

All teachers, especially at primary school level, where students are introduced to scientific approaches, need to have a better understanding of the nature of science (AAA, 1990). This is important because teachers bear the responsibility to introduce all young people to science. The way learners are introduced to science may either uphold or run down the achievements that the scientific community has realized so far. Therefore, teachers are expected to have not only scientific knowledge, but also the historical aspects of scientific endeavors and the current strides in this field. For example, knowledge about genetics has changed from past to present. At first, people like Gregory Mendel only speculated about inheritance traits, but later developments showed that chromosomes are responsible for genetic changes. Experimental procedures, in relation to genetics, have thus changed as time went by. This argument is well illustrated by Graves (2005) who showed how Francis Bacon criticized Aristotle's syllogistic reasoning, which depended on reasoning alone in search of scientific ideas. Bacon doubted if a syllogistic approach would help in finding new information in science (although it worked in politics). Instead of syllogism he advanced the use of senses in search of scientific knowledge, which demands complex ways of knowing beyond mere reasoning. This was the beginning of empirical research in science that translated to elements of *the current scientific approach* (p. 54). Due to such changes, teacher's vision of current practices and understandings in science should be tied to earlier developments that necessitated the transformation of earlier practices and understandings. In this way, teachers will understand why we currently have the forms of practices and knowledge (in science) that should be passed on to learners.

Knowledge and skills from science determine individuals' interaction with nature and survival success in the current world, as humans become predominantly dependent on scientific and technological artifacts in their strategies of interacting with their immediate surroundings and beyond. Technology, to a large extent, is currently driven by scientific knowledge although it also influences the generation of some scientific knowledge (Gauch, 2003; Steffens & Muller, 1974; Victor & Lerner, 1971). Furthermore, numerous jobs today demand understanding of scientific knowledge or manipulation of technological artifacts. Additionally, the changing environment and way of living makes it imperative for children to be scientifically literate if they are expected to successfully interact with nature and the current world.

A mention of scientific literacy raises a fully-fledged discourse, which may not fit into this paper. Suffice it to note that there has always ensued a huge debate about science endeavors and forms of knowledge to be passed on to learners, which have evolved based on varying philosophies of science, all the way from the days of Plato, Socrates, Thomas Huxley, Francis Bacon, Albert Einstein and, in more recent times, John Dewey (as stated by Shamos in Victor and Lerner, 1971). Science worthy knowledge has evolved in response to the philosophy of science along the time line, together with skills for acquiring such knowledge. Most arguments for ensuring scientific literacy in the citizenry have leaned towards knowing nature and how to utilize knowledge about nature in everyday life experiences. Hence, scientific literacy would be associated with acquisition of facts and the know-how that prepares people (both young and old) for the world of work and survival.

Victor and Lerner (1971) have pointed out that viewing science in terms of knowledge and its use alone falls short of the full meaning of science. Teachers who hold on to such view of science have resultantly taught science wrongly by omitting an important aspect of the nature of science. This brings us back to the need for teachers to understand the nature of science to ensure effective teaching. This need for teachers to understand the nature of science was noticed a long time ago since science got introduced in elementary curriculum as stipulated by various authors (Blough, 1958; Graig, 1937; Zafforoni & Selberg, 1963) whose articles were reprinted in Victor and Lerner (1967, p. 520-25). In these articles, Graig (1937) noted that:

Teaching science in elementary school is not a matter of the presentation of the content...instruction that may be shared with children are: proposing problems, defining problems, suggesting methods for solution of problems, relating experiences to the solution of a problem, suggesting observation that may be made, thinking through the problem, assisting in drawing conclusions, assisting with experiments...questioning superstitions, myths and unscientific materials, discarding opinions and recognizing the difference between the solution proposed by the class members and scientific information. (Victor & Lerner, 1971, p. 520)

Blough (1958), supporting Graig's stance, also stated that:

Through the study of science, pupils build concepts and ideas of their world, which they use in interpreting it. It is through the accumulation of concepts that they learn to understand what is happening around them and why it happens: Consequently, they are able to react more intelligently. It is through this process that they become better prepared to live in today's world.

Problem solving in science involves the use of scientific habits and attitudes, which include: careful observation, accurate interpretation of these observations, and skilful recording and communication..." (Victor & Lerner, 1971, p. 521). When commenting on the objectives for teaching science in elementary schools and other levels of education, Zafforoni and Selberg (1963) proposed that science instruction should aim at learners' "growth in understanding of science concepts and ability to participate in the process of scientific inquiry" (Victor and Lerner, 1971, p. 525).

Most of what was said in the three contributions described above, with respect to the teaching of science, reflects aspects of the nature of science. It is for this reason that the nature of science has been included among science content standards in the National Science Education Standards (1996). Such knowledge is expected to help teachers determine the nature of tasks that can be designed for learners in order to develop understandings and skills required in science and also in life as citizens. Realization of science literacy is the prime purpose of the education system in the United States of America (USA), through which it is hoped citizens will be prepared to lead personally fulfilling and responsible lives (American Association for the Advancement of Science [AAAS], 1990). Interestingly, the constructivist agenda also seeks to realize elements of

learning that were raised by Graig, Bough, and Zafforoni and Selberg in the three excerpts described above. This trend of thinking progressed and got polished or strengthened after some research work was done on these issues. Hence, the current tenets of the nature of science clearly articulate such aspects and more.

Literature is rich with epistemological tenets of science. I hereby give a brief account of the tenets stipulated under the nature of science as viewed recently by the AAAS (1990): (1) The scientific worldview, (2) Scientific method of inquiry, and (3) The nature of the scientific enterprise. Each of these aspects of the nature of science deserves elaboration in order to illustrate their implications for teaching.

The Scientific Worldview

Under the scientific worldview, four areas are discussed. First, the world is viewed as understandable. This notion presumes that phenomena in the universe occur in a consistent pattern that if carefully and systematically studied humans can comprehend them using senses and tools. The second view is that scientific ideas are subject to change. This way of thinking arises from the assumption that change, in knowledge, is inevitable. Hence, theories are bound to change in response to emergence of new evidence. The third perception is that scientific knowledge is durable, as evidenced by most of scientific ideas that have remained correct and viable for a long time from the time they were discovered by early scientists. The final view held by the scientists, under the worldview, is that science cannot provide complete answers to all questions. This view emerges because there are issues that cannot be usefully examined in scientific ways as they conflict with other beliefs, or indeed cannot be proved (AAAS, 1990). For example, it is very difficult to prove how the world was created using scientific approaches.

Pondering on the construction of scientific knowledge, Llewellyn, (2005) states that scientific ideas are usually found through investigations or inquiry, which rely on observable data. It is probably worthwhile to shed light on inquiry, which is also highlighted as the second aspect of the nature of science (AAAS, 1990).

Scientific Inquiry

Western modern science (WSM) is characterized by reliance on evidence and use of hypotheses and logic. However, the patterns of knowledge acquisition do not

necessarily follow the same track; neither could it be said that they use the same type of data acquisition processes. Some scientists rely on historical data, while others use experimental findings apart from qualitative and quantitative data (AAAS, 1990). Since the realized data differ, what matters is the kind of evidence they provide, coupled with a blend of logic and imagination by the scientist. Imagination is always the origin of hypotheses, which guide the inquiry process. The accuracy of ideas that are generalized from investigations is, however, dependent on reliability of the data collection processes and unbiased generalizations of patterns or principles emerging from the observed or inferred phenomena. Accurate explanation of phenomena or constructs may help in producing knowledge that can lead to predictions of future occurrences or repetition of such occurrences under specified natural or artificial parameters. Thus, the scientific approach of constructing ideas tallies with what is espoused in constructivism, which directs inquiry/investigations to authentic problems in life as stated in Brooks and Brooks (1999).

Inquiry translates into knowledge or ideas that are products of processes conducted by investigators, in this case, learners. It is for such reasons that some theorists advance the thought that constructivism is closely intertwined with science (Kruckeberg, 2006; Sherman & Sherman, 2004; Woolfolk, 2005). Hence, constructivism avails a theory of learning that is naturally aligned with the scientific principles and processes of acquiring knowledge, emerging from the shared assumptions (by constructivists and scientists) about knowledge construction. Constructivism, just like science, involves learners in knowledge creation processes that prepare them to meet and deal with issues in the world. This links us to the last aspect of the nature of science.

The Scientific Enterprise

Three dimensions come under play in the scientific enterprise, according to the AAAS (1990). The three dimensions are the individual, social, and institutional aspects. This means that science is a complex social activity. It is therefore expected that people from all walks of life do engage in some scientific endeavors that breeds scientists in fields like Biology, physics, engineering, medicine, and the list goes on. Scientific ideas find their application in numerous aspects of human life and naturally, scientific ideas are created by human beings to bring up understandings that enable them to conduct their

daily business or indeed just to bring awareness of certain natural phenomena (AAAS, 1990). It is also important to point out that some scientific ideas are unintentionally discovered as people go about doing certain life activities or defined experiments. What comes out of science is, due to this reason, based on both the observed data and interpretations, which are partly influenced by an individual's beliefs as a human being and also cultural experiences. Use of individual beliefs and cultural experiences makes scientists prone to biases, which they have to actively resist if durable knowledge is to be processed. This is the strongest position that members of the science community advance and use as a yardstick for delineating scientific knowledge from the rest. However, avoiding biases sometimes fails (AAAS, 1990). It is due to this factor that some knowledge is questioned, especially when the scientists work under powers that influence their decisions (be it organizations, cultural institutions or prejudice).

Such are some of the representations of the nature of science from the Western Modern Science (WMS), which claim superiority of understandings as well as universality of ideas that are viewed as a link to the understanding of the entire world network. This claim is apparently indisputable if one looks at all the successes of Western science so far.

Science and Culture

Snively and Corsiglia (2000) pointed out that Western modern science is actually a reflection of the western culture but not the global set of cultures. Snively and Corsiglia (2000) and other postcolonial scientists contended that all other cultures have developed their own ways of understanding the world realities and independently produced solutions to their own problems using their own understandings as echoed by Berger and Luckman (1966). Berger and Luckman (1966) argued that all forms of knowledge objectivation are determined by communities in which they live and the language plays a crucial role in meaning making. Hence, science heavily relies on social interactions and not unilateral thought.

Alternative ways of developing worldviews (or realities), besides the Western modern science, fall under indigenous knowledge, which according to Snively and Corsiglia (2000), is claimed to have also produced numerous examples of time-proven, ecologically relevant traditional ecological knowledge (TEK) and cost effective

indigenous science. The only stumbling block with indigenous knowledge is its high reliance on oral transmission, which at times curtails progression when elders who possess unique knowledge die before passing it on to younger generations. This is so because of heavy reliance on wisdom of elders (Boyne, 2003), as the sole custodians of knowledge. However, TEK is renowned for maintenance of culturally established structures, which makes it attractive at this point in time when many things are culturally and environmentally going amiss due to human activities.

Due to oral nature of indigenous science, there is no standard reference about its nature. This is worsened by the fact that most of indigenous science is done at personal level. Hence, it is difficult to compare indigenous science with Western science in terms of their tenets because indigenous knowledge was usually not meant for the academy and also ideas were not assembled to organize this kind of knowledge.

The three tenets under the nature of science, given above, condense vast arguments and philosophies that describe aspects of the nature of science provided by the scientific community. In the first place, it must be noted that science deals with findings about certain forms of ‘truth’ arising from empirical evidence. Inquiry serves as the main tool for realizing data that serve as empirical evidence after being scrutinized by a community of scientists. Accrued truths or ideas endure for a long time unless other types of evidence disapprove them.

The allowance for change of scientific ideas in presence of more suitable evidence is normal. The change of ideas, with respect to recently objectified reality (sometimes dependent on culture or situation), is known as ‘relativism’ according some theorists of knowledge and how it is realized (Berger & Luckmann, 1966; Gergen, 1999). To this end, even the AAAS (1990) agrees that scientific knowledge is tentative. Hence, scientific ideas are not held as absolute. In this respect, scientific ideas are constructed in a similar fashion to those constructed in constructivist theory. It is probably high time we switched to the indigenous science discourse, which potentially changes some few areas in the teaching and understanding of the nature of science.

As teachers endeavor to include indigenous knowledge (which has other worldviews), this information will create a dissonance and needs to be resolved by teachers themselves and all other stakeholders because the inclusion of indigenous

knowledge creates a new (and broader) dimension about the nature of science. This brings us back to pedagogy issues in relation to integration of indigenous knowledge in school science.

Pedagogical Underpinnings for Indigenous Science

Most educators will agree that effective teaching involves use of learners' *prior knowledge* (a set of ideas, concepts, data etc.) (Hewson & Hewson, 1983; Holiday, 2000; Sherman & Sherman, 2004). Good learning transitions start from learners' previous experiences before engaging in new, often more complex experiences. Constructivists believe that all learners can only manage to create new understandings or meanings based on what they have previously experienced. The nature of meanings and understanding of concepts are all influenced by the previous experiences on which they interpret new experiences. Teachers are, therefore, compelled to consider and draw learners' prior knowledge before introducing new concepts to learners. Since constructivism is a very influential paradigm and closely related to this study's theoretical framework, let us briefly look at what it offers.

Constructivism

Constructivism has increasingly influenced the teaching of science (beside other subjects) in modern times. This theory of learning is grounded in theoretical frameworks formulated by Piaget, Vygotsky, and Dewey. All these former theorists of learning articulated the processes that affect learning, which have greatly influenced pedagogical paradigms ever since they came to being.

Piaget clearly articulated that learners' development dictates their cognitive processing of knowledge and that their conceptual and psychomotor developments influence their achievement in academic enterprises involving reasoning, problem solving, and acting (Sherman & Sherman, 2004; Woolfolk, 2005). Piaget theorized a hierarchy of skills that are developmentally aligned, which could be attained based on readiness (sensorimotor, preoperational, concrete operational and formal operational skills). One outstanding observation raised by Piaget was the fact that learners come to school with a great deal of knowledge, termed prior knowledge which determines the reception or processing of information when they undergo school lessons. All theoretical dimensions in Piaget's theory involve the individual learner (Woolfolk, 2005).

Von Glasersfeld found an entry point in Piaget's theory and articulated a theory that is currently and popularly known as radical constructivism. Radical constructivism stipulates that learning is a result of mental constructs in an individual's mind that materializes from an individual's interpretation of new experiences by drawing from individual's past experiences (e.g. prior knowledge), such that new understandings are a product of an individual's capacity to combine, resolve, and recreate new understandings based on what each individual previously knew upon encountering new experiences. In this way, an individual uses old knowledge and experiences in the process of constructing new knowledge. Hence, the learner cannot be given already made knowledge and be expected to absorb like a sponge, without processing it. On the other hand, failure to process knowledge from new experiences is attributed to mismatch of new experience with what a learner holds in her/his schema (Von Glassersfeld, 1995).

It may be noted that, unlike Piaget's theory of learning, constructivists believe that the schema is not just an additive product (that grows linearly), but it rejects, augments, translates, and comes up with acceptable understandings to an individual that may not necessarily be the same as another learner/individual or dependent on an individual state of development (Sherman & Sherman, 2004; Woolfolk, 2005). Resultantly, those who hold onto behaviorism and rationalism in their theories of learning, criticize the constructivist's theory in that it precludes the value of reality of facts, which is the central focus of science. Hence people like Phillips (2000) and Matthews (1994) quarrel with the validity of such type of constructivist stance, especially in science where building up of accurate facts is a big agenda.

Dewey, on the other hand, believed in learner-centered approaches that align with constructivism in the sense that the learner is the center of focus and not the teacher. Dewey advocated inquiry just like constructivists believe in allowing learners to explore (inquire) authentic problems in everyday life. This prepares them for life after school, which is full of problem solving (Hickman, 1992).

Vygotsky found some weaknesses in individualistic constructivist learning theories and instead he proposed that learners understand and construct meanings better when they interact with expert elders or peers, especially when they are deficient of certain understandings or skills (Sherman, 2004; Woolfolk, 2005). Such deficiencies may be

linguistic, experiential, or reasoning capacities. Hence, an optimum learning environment, for Vygotsky, was that which availed a mediator for the learning process. This is the case when teachers and peers facilitate or mediate the learning process of the less experienced learners. When such mediation is available, a child who is less experience is afforded a scaffold to bridge the gap and lift the learner to the next level of understanding, that which the expert intends (e.g. as in the popular zone of proximal development theory). Hence, Vygotsky's theory of constructivism is situated in a social context.

As it may have been noted, there are various types of constructivism, and the latter type (social constructivism proposed by Vygotsky) spotted some weaknesses in former theories. Constructivists, in general, questioned former learning theories that advocated banking theory of learning, which regarded pupils as blank slates that waited to be filled with knowledge. By implication, constructivists uplifted the need to consider a child's prior knowledge that has implications on the learning process. Another implication, in my view, is that latter theorists were greatly influenced by their prior knowledge of former learning theories.

Before delving further into prior knowledge, it must be noted, from the above discussion, that new theories are formulated out of older theories. It is easy to identify weaknesses in an existing theory and build on it to propose a better theory, but it is difficult to start a theory from scratch. This is how we can connect theory formulation processes with knowledge construction processes. New theories are born based on educators' prior knowledge about theories. This needs to be kept in mind, as we will come back to it when discussing the connection between indigenous knowledge and constructivism in science instruction. At this point, let us turn back to prior knowledge.

Effects of Prior Knowledge on Learning

Theorists have shown that prior knowledge is a crucial learning factor. Galeen (1997) contends that learners are better able to process new information if they have related background knowledge. In this case, new learning is built on their background knowledge. Background knowledge could be language, concepts, or practical experiences (visual, motor, processing, etc.), which are often dependent on a child's geographical and environmental placement, and social economic status. Environmental

factors, on the other hand, determine the nature of material resources and artifacts that influence a learner's processing of information. This is crucial in science where the main object of learning is to understand natural phenomena in the environment or creating new materials that exist therein (Geelan, 1997).

The disparities of resources and experiences available for teaching and learning in different geographical locales in the World create heterogeneous learning environments, which demand critical analysis to identify experiences that learners bring to the science classroom. This includes indigenous knowledge experiences. People from different geographical places have developed varied indigenous knowledge practices to solve unique problems existent therein. Therefore, what learners develop as prior knowledge (partly indigenous knowledge) varies accordingly. Teachers from each geographical location will, therefore, need to relate their teaching of science to unique knowledge bases.

According to Taber (2001), meaningful learning occurs if learners can recognize the materials presented to them (as formerly proposed by Ausubel and Robinson, cited by Taber, 2001). However, it is important to note that sometimes, prior knowledge can actually hinder the learning process (Geelan, 1997), since some of experiences are misconceptions under the scientific realm of thinking and practice.

Indigenous Knowledge as Prior Knowledge

Various multicultural science educators have pointed out that some indigenous knowledge backgrounds can actually conflict with the western account of science. Aikenhead, (2001) presents some aboriginal knowledge experiences which conflict with science and feels that it would be better to avoid forcing learners to adopt western accounts, which would distort their worldview. For example, he cites the aboriginal people's belief in thirteen moons, instead of twelve as a disconnect of the two cultural accounts, that is, a disconnect of the aboriginal conception from the standard scientific account (p. 344). Kawagley (1995) presents a range of Yupiaq worldviews, which differ from the western account about their beluga whale tracking as well as their fishing techniques (capable of getting specific types and sizes) apart from their traditional medicines.

Another unique group is the Moken (Nomads in marine life from Thailand) whose ways of thinking emphasize the connection between human beings and spiritual worlds. For example, the Moken ask the spirit of the tree before logging it or indeed sharing the foraged food with ancestors' spirits before humans partake of it (Arunotai, 2006). Interestingly, the food sharing beliefs of the Moken of Thailand were also found among the Chewas of Malawi. But due to the interculturalization with Europeans during colonial era most of such beliefs have disappeared.

Hence, multicultural scientists ponder on best approaches that would help learners from such backgrounds to learn science or strike a balance in what they believe and what science says (Aikenhead, 2001; Stanley & Brickhouse, 2001). The answers are tricky but one is better off engaging in these understandings and learning how they play out in the science teaching. Somehow, some learners may move across the borders to understand science if such considerations are made in science teaching. Crossing borders is particularly important in very traditional populations (Aikenhead, 2001).

However, there are also many examples where indigenous knowledge serves as helpful prior knowledge. Putsoa's (1999) poem, quoted from Postman and Weingartner, speaks volumes about the need to use contextualized knowledge from the communities where students come from, as she says,

The institution we call *school* is what it is because we made it that way. If it is *irrelevant*, Marshall McLuhan says; if it shields children from *reality*, as Nobert Weiner says; if it educates the *obsolescence*, as John Gardner says; if it does not develop *intelligence*, as Jerome Bruner says, if it is based on *fear*, as John Holt says; if it avoids the promotion of *significant* learnings, as Carl Rogers says; if it induces alienation, as Paul Goodman says; if it punishes *creativity* and *independence*, as Edgar Friedenberg says; if, in short, it is not doing what it needs to be done, it can be changed; it must be changed. (Putsoa, 1999, p. 87)

The above poem and all the foregoing accounts on prior knowledge indicate the need for relating students' learning to their everyday experiences. All curricula that do not respond to the concerns raised in the poem by relating learning to learners' experiences only serve to alienate the student. The main issue that Putsoa (1999) emphasizes is the need for science educators to promote development of scientific knowledge and skills

that have practical bearing on the welfare of their societies (in developing countries). This follows a big shift in objectives for science teaching, in response to environmental changes that learners need to be aware of and help develop solutions to their environmental problems. Again, indigenous science and awareness of learners' local environment remains a great starting point for science education.

Putsoa (1999) also pointed out that emphasis for science education changed in the 1980s from knowledge accumulation to acquisition of relevant knowledge and specific knowledge that can be used to benefit learners' communities. It would seem, therefore, that effective teachers would be those who are aware of their environment and probably also work with elders in the environment to make use of relevant knowledge that affects the community in which one teaches. In case of indigenous knowledge teachers who tap knowledge from elders are likely to fulfill the science-teaching objective highlighted by Putsoa (1999). This is in line with use of funds of knowledge as advocated by Gonzales, Moll, and Amanti (2005).

Hybridization

Carter (2006) states that individuals who live in two life worlds, gaining knowledge from either side, develop knowledge that does not belong to one side. Hence, their lives thrive on hybrid knowledge bases. This usually happens to those who live on boundaries or margins, according to Carter (2006). This state of affairs presents different scenarios in the spaces of acting. The existence of margins denies some people from partaking in common goods and in most cases the Westerners tend to reinforce the boundaries. But other forms of hybridity are in terms of culture and would also be in classroom subjects like science, where one form of knowledge is barred from mixing with the other.

The Politics of Indigenous Knowledge

Sundar's (2002) rhetorical article entitled "Indigenize, nationalize and spiritualize – an agenda for education?" explores the relation between "indigenous knowledge" and "formal education" through the juxtaposition of two Indian projects connected with governments' agenda to "indigenize, nationalize and spiritualize" education. The first project involves the introduction of "Vedic" rituals and astrology into the university curriculum as a form of indigenous knowledge. The second relates to the typically

assimilationist project of educating “Adivas” or indigenous people in ways that highlight cultural “deprivation,” and educational deficiency and then deny them a distinct identity (Sundar, 2002, p. 373). In these two cases, Sundar (2002) shows that success in claiming identity was only possible among the Vedic people because the Hindu Right had political power to transmute their beliefs into certified knowledge as they backed them to advance Vedic indigenous science. On the other hand, Adivas (another group of people in India) have failed to assert themselves politically as distinctly indigenous people, which may resultantly lead to obliteration of their languages together with their systems of knowledge. The most important issue to note in Sundar’s article is that indigenous knowledge, in some cases, can be used quite well in the school system but the context under which it operates matters more than the substance it holds. It is from this background that Sundar (2002) concluded that politics matters more than the substance (quality of content) in some indigenous knowledge claims.

The Indian case of politics in indigenous education raises many issues such as what Carter (2006, p. 681) calls “constructs of cultural translation and representation, difference, multiculturalism, hybridism, localism, boundaries and borders, and pluralism in ways that reshape the categories of culture and identity, and difference.” The establishments of stratification of cultures in India, which may have arisen from the way colonialists categorized the people in the first place, may have disrupted identity factors whose effects are issues that Sundar (2002) views as politics of indigenous knowledge claims in a neo-colonial era.

The issue of borders and boundaries is echoed in Turnbull’s (2005) article, “Locating, negotiating, and crossing boundaries: a western desert land claim, the Tordesillas line, and the west Australian border” in which the author illustrates that both Western borders and Aboriginal borders are “messy, indeterminate, incomplete, fundamentally social and negotiated”, and that there is a “wide variety of something incommensurable, boundaries across and within cultures” (p. 767).

Turnbull (2005) further stated that narratives about boundaries are used, in some cases, “to assert and delimit authority and to differentiate between forms of rationality” (p. 767) and are also used to “divide territories politically and to make cognitive distinctions.” The three authors collectively raise many issues that apply in the call for

integration of indigenous science in school science, some of which are ontological, epistemological, as well as political. Some issues of spaces could be interpreted literally but these are more conceptual and bear application in curriculum development, policy-making, and philosophical frameworks but at the same time, they are not obviously seen by all minds.

This is more of a reason why it is necessary to probe and research issues that surround indigenous science (McKinley, 2005; Snively and Corsiglia, 2001; Thomson, 2003) as it is increasingly happening at this point in time (Turnbull, 1997). Some of the ideas that are currently treated as spiritual (and, therefore, not scientific) could change, just like the Indian University legitimized Vedic rituals and astrology (thereby making an entry of cosmologies in science).

This ascendance of Vedic science in India (Sundar, 2002) also shows that there are sciences among indigenous people (as earlier claimed by Thomson, 2003) that may spring up because of deliberate pursuits in the academy or nations, which would open up spaces for those ideas to be scrutinized further and probably open other understandings over and beyond the older understandings. This was also reiterated by Corsiglia and Snively, (2001) in their article entitled, “Rejoinder: Infusing indigenous science into Western modern science for sustainable future” in which they asserted, “indigenous science offers important science knowledge that WMS has not yet learned to produce” (Corsiglia and Snively, 2001, p. 81) and that scientific knowledge contributions from indigenous people may have been initially devalued for cultural, economic or political reasons” (Corsiglia and Snively, 2001, p. 82). Just like Western science has evolved over centuries, some indigenous sciences have the capacity to evolve and some indigenous knowledges would join the universal pool of western scientific knowledge. When people gain a voice, like the Vedic in India, they can assert themselves and negotiate for gaining spaces in the academy. In so doing they are crossing borders (conceptually, academically, socially, spatially) because of their assertion and legitimization of their ideas as echoed by Carter (2006), Jegede and Aikenhead (1999), and Corsiglia and Snively (2001). This is a good example that depicts the postcolonial critique of universalizing Western science because it blocks such developments, especially if those

without voices fail to speak for themselves as a result of colonial structures, which could be due to explicit or implicit arrangements.

Thomson's (2003) study of Keiyo science affirmed that there are sciences in people's languages, which science educators need to unravel. Just like Gonzales, Moll and Amanti (2005) illustrated, there are funds of knowledge (science inclusive) in elders' knowledge. Science teachers need to tap such knowledge by working with them, learning from them and better still documenting such knowledge. That way, they will not only teach children better but also become more knowledgeable about what is available among the members of their community. Their teaching, will therefore be contextualized, more helpful to their students, and probably better appreciated by the communities they are serving.

Postcolonial Theory on Representations

Post-colonial theorists (McKinley, 2005; Ninnes, 2000; Snively & Corsiglia, 2001) allude to the fact that the nature of representations like *origin*, *use*, and *delivery* of scientific ideas in textbooks and teaching environments, and indeed in daily life worlds, is repressive and designed to erase local peoples way of perceiving their world. They suggest that including local people's languages, ideas, practices and success stories in the science curriculum, inclusive of women, might serve as an identity restoration tool, as indigenous learners will celebrate their cultural heritage, which the advent of colonialism almost got it obliterated.

Michie, (2002) shares this notion as he strongly advocates the inclusion of indigenous science in the conventional science curriculum for purposes of encouraging minority students' advancement in the field of science. He asserts that it is crucial to think about including indigenous science in the school science curriculum as a way of facilitating cultural brokerage. Through his interaction with indigenous people, he claims to have developed a better understanding about how indigenous people's view of their world differs from that of westerners in ways of knowing. Michie (2002) acknowledges the fact that indigenous people train each other in their daily interactions in their spiritual, ceremonial, and environment management practices based on traditional laws. Additionally he clearly pointed out that indigenous science is a different way of knowing.

However, he asserts that there is a merit for including indigenous knowledge as a way of widening the knowledge base, which includes that of indigenous people.

To effectively teach indigenous science, Michie (2002) suggested that indigenous knowledge would best be taught in primary school levels where holistic approaches, like those used in indigenous settings, would be adapted. However, Michie (2002) pointed out that teacher's lack of knowledge about indigenous knowledge would necessitate that they get in touch with elders to develop better understanding of indigenous knowledge. In this way there would be two-way exchange of knowledge. Unfortunately, he did not clarify what would be exchanged, and if the Westerners in the scientific community are ready to accept ideas from the indigenous people.

Multiculturalists, who advocate inclusion of indigenous knowledge in school science curriculum, believe that cultural knowledge can be accessed and used in the process of teaching science (Cobern & Loving, 2001; Sutherland, 2002).

Historical Representations in Science

To other educators, the predominant representation of scientists and their history is considered to “enfranchise some groups’ cultural capital at the expense of other groups,” to the extent that the disenfranchised groups feel that the predominant history of westerners in the scientific literature and daily life endeavors is only a way of perpetuating the western hegemonies (Ninnes, 2000, p. 605). Hence, such educators glean for indigenous peoples’ scientific knowledge that could be featured in the science curriculum to reduce the Western dominance. This stance sounds political and it is mostly the elite members of the minority groups of people who attempt to reverse the history. However, reversing this state of affairs is not a straightforward process. There are stumbling blocks in the selection process for examples of indigenous knowledge to go into the curriculum, as we will see ahead.

One of the most outstanding issues in this debate is the representation of indigenous knowledge. Although much of what is said in literature are mostly people's opinions about inclusion of indigenous knowledge, a few researchers have conducted primary research studies that follow up on some of such claims and through such studies one sees gaps that open up insights for further research and deeper understanding of the pros and cons of including indigenous knowledge in school science.

At this point I will analyze views from three primary research studies that talk about the inclusion of indigenous knowledge from the angles of teacher education, value of cultural knowledge, and textbooks representations. This analysis will assess the position of assertions about the inclusion of indigenous knowledge that has, of late, propelled the establishment of numerous networks that advocate the inclusion of indigenous knowledge in the academy. The search for the position of indigenous knowledge in school science will be guided by the following question: What difference does the inclusion of indigenous science make in the learning of science for minority learners?

Pedagogy for Diverse Cultures

Contenders who advocate the inclusion of indigenous science using a pedagogical or psychosocial framework believe that learning difficulties faced by minority students can be ameliorated only if their prior knowledge is used in the process of teaching as espoused in the constructivist framework (Sutherland, 2002). Constructivists believe that minority learners, who are mostly alienated from science due to use of alien examples in the science textbooks and in the teaching process, fail to compete with learners from the popular culture due to the design of the curriculum. They claim that this could be reduced if science is taught in contexts that resonate with learners' backgrounds (Sutherland, 2002; Klos, 2006; Snively & Corsiglia, 2001).

However, the dichotomies in constructivist notions create a number of branches in this debate, which do not necessarily follow the multiculturalists' arguments. Multiculturalists believe in holistic creation of knowledge while some constructivists stress individualistic construction, such as radical constructivism, advanced by Von Glasersfeld (1995). However, social constructivism seems to work well for those advocating the inclusion of indigenous science since it values community participation in problem solving, which typifies the social actions among indigenous cultures (Sutherland, 2002). Indigenous knowledge is acted out in social settings hence knowledge and practices are owned by the whole society. Processes for acquiring and transmitting knowledge are on-going in everyday life and they take the form of dances, stories, work, ceremonies and so on (Settee, 2001). Hence, the constructivist line of argument needs refining rather than wholesale adoption of the ideology.

Teacher's Knowledge About Indigenous Science

Shumba (1999) carried out a quantitative research study in Zimbabwe, whose objective was to measure the extent to which secondary science teachers are oriented towards traditional culture and how their orientation towards indigenous culture is related to instructional cultural ideological preferences. Shumba's (1999) study design assumed that teacher's commitment to indigenous cultural values and beliefs would bear a relationship with their instructional ideology preferences. The study found that secondary school teachers were not strongly traditional but maintained a fairly traditional posture with regards to aspects of traditional authority, religion, view of nature, and social change. Additionally, the study revealed that secondary school teachers shifted further off from tradition with regards to sex roles, causality and problem solving. In summary, this study revealed a transformation of secondary school teachers in Zimbabwe (a former British colony) that led to loss of some traditional values.

On the point of methodology, Shumba (1999) realized that the instruments for validating cultural tenets need to be improved and that the next study could include observational data collection instead of sole reliance on thematic categories whose occurrence rates determined the prevalence of characters under study. These results were not really strange because Michie (2002) also pointed out that teachers, especially in secondary schools, tend to lack knowledge on indigenous science. This is why teachers are encouraged to conduct research in communities surrounding their schools as a way of upgrading their background knowledge in indigenous knowledge as also recommended by Gonzalez, Moll and Amanti (2005). Michie (2002) further contended that secondary schools might not be a good site for indigenous knowledge since the content, at that level, is more compartmentalized than holistic. For Michie, the best site for indigenous knowledge is primary schools, which tend to have integrated curricula.

Thomson (2003) affirmed the foregoing knowledge deficiency concerning secondary school teachers through his personal experience while in Africa. As a young secondary school teacher, he went out in the forest to catch a unique type of moth. He could see the moth flying around the canopy of the tree but it could not come down. An elderly man found him, with his eyes glued in the tree. When he explained his intention to catch the butterfly, the old man told him that the moth could only come down if there

was human dung. Using the elder's advice, he caught the scarce moth. This opened up his eyes and thereafter, he looked at indigenous elders as being loaded with wisdom which secondary school Biology teachers, like him, did not have. Through this experience and a few other experiences, with knowledge from elders, he conducted many other studies to search for validation of local people's knowledge as well as their languages.

Thomson (2003) contends that all indigenous cultures are harboring tones and tones of knowledge in their languages. However, he laments that unfortunately schools never think about teaching using local languages, which would unlock the buried knowledge. Again, Thomson's (2003) documentation of Keiyo knowledge of snakes revealed that local people knew more snake species than western scientists did. Although the stories that he collected about snakes were mixed up with myths and legends, valuable information was discerned from the stories. Spirituality and beliefs were also reflected in many stories that he collected. Thomson was surprised to discover that students were not being allowed to learn about the local snakes. In that study, the researcher also realized the need for science educators to become researchers in order to document indigenous knowledge and its development for classroom learning: which is lacking in many locales.

Textbooks and Representations of Indigenous Knowledge

Textbooks are the most predominant source of knowledge in science teaching but at times they could also be a source of problems. There has been a general outcry among some educators that some textbooks are not helpful to indigenous learners. Some have branded science textbooks as biased to Europeans and that this scenario disadvantages minority students. A follow up on the issue of textbooks was Ninnes' (2000) study of textbooks that were designed to reflect indigenous science in Australia. That study was specifically conducted in a bid to overcome ethnocentric, racist, and culturally imperialistic approaches in representation of knowledge. The study was specifically evaluative in nature, influenced by postcolonial theory, essentialism, and the prescription of identities. Hence, that study employed a qualitative research approach that targeted the representation of meanings coming out of the words in the books.

Findings, following evaluation of discourses in the books, revealed that “passive statements” associated with indigenous knowledge could mean that indigenous knowledge (IK) is of lower value and probably obsolete. Ninnes (2000) contended that the “past tense representations” were culprits for setting up IK as pieces for antiquities. Hence, although the study revealed that all forms of sciences would be represented by IK (though variedly, with biology being the highest, followed by chemistry and physics), the style of writing suggested some negative elements, which might reinforce hegemonic stereotypes. Among the most outstanding is the use of stories, which do not enhance the image of indigenous knowledge or people. This takes us to the last aspect, that is, spirituality in indigenous science. This element of indigenous knowledge warrants some attention, given its contentious nature in the field of science.

Spirituality in Indigenous Knowledge vs Nature of Science

Thomson (2003) briefly mentioned the fact that most foreign ethnographers stress on the negative elements of indigenous people’s knowledge instead of concentrating on clearly aligned indigenous ideas to school science. This is a very important observation, which I also feel that members of the academy should seriously consider when talking about indigenous science. In the first place, local people’s knowledge is not classified in compartments like those in science or arts. Therefore, the moment we mention local knowledge as scientific, there should be a clear connection between the kind of local practice or knowledge in relation to the scientific body of science. In this way, the choice of examples that are labeled scientific will not invite disparaging remarks from the public. It is well known and documented that the west has a historical record of spirituality. In fact the missionaries are tightly linked to that belief system. However, the west does not call spiritual work a science. One wonders why the indigenous spiritual elements are being featured as local science. It would appear that a normal scientific discourse need to desist from distorting the image of science by bringing in what has already been delineated from science in the western world. This will correct the distortions that surface in the course of discussing indigenous science.

On the other hand, it may be a better idea never to talk about indigenous science. We should be talking about indigenous knowledge being compatible with the knowledge windows in school science. Therefore, the debate about indigenous knowledge should

be freed from obvious distortions. In this way no one will have doubts about science and other people's knowledge that fit into the scientific frame of reference.

Conclusion

The foregoing discussions show that there is more to the thinking about integration of indigenous knowledge (IK) in science than the eyes can see. To gain better view of the association between indigenous knowledge and science, more researchers need to probe some of the many assertions that have been made in many position papers about indigenous knowledge. So far, the idea of inclusion of IK is accepted by the majority but to make it operational there is need to have many studies that can show (a) the effects of IK on students' learning, (b) the kind of content that fits the indigenous science paradigm, (c) the nature of books that would support inclusion of IK, and (d) whether IK is indeed unique to the indigenous masses that were formerly colonized or not.

Sutherland (2002) pointed out that science is alien to both Westerners and non-Westerners, as discerned by independent studies conducted by Ogawa (1995) and Kawagley (1997), although it is more alien to non-Western learners. In fact recent BBC reports (Early, 2007) have indicated that many British youths are shunning science. This is an indicator that failure in science is a result of deeper causes than what is sometimes speculated. Therefore, would we say that the assertions about inclusion of IK are only useful to indigenous learners or all people? If constructivism will be a bridge between IK and science, studies on how this indeed works need to be designed to determine the extent to which these assertions are true. I think that the scarcity of primary research under this topic means that there are a lot of untapped areas of research under indigenous knowledge integration in school science. The more the studies are done the clearer will be the picture about the role and value of indigenous knowledge in school science. According to Michie (2002) and Thomson (2003), it is also equally important for studies to compile examples of indigenous knowledge that are scarce to many teachers. Such knowledge cannot be determined merely by word of mouth but through intensive and well-designed studies. Hence, it was from this position that this study was proposed in order to unravel issues that could immerse from teacher's (and probably pupils') first-time experiences with having science lessons with indigenous knowledge slant.

Researcher's Theoretical Conceptual Position

As it may have been noticed from the foregoing discussion, various theoretical frameworks spring up in the indigenization discourses such as post-colonial theory, multiculturalism, place based learning, situated cognition, and constructivism (just to name a few). I engaged in this study with a strong posture in constructivism. Hence, my lens in teachers' implementation practices tended to focus on the construction of ideas from the activities that teachers organized under indigenous science topics. This was done to follow up the development of scientific ideas that would enhance learners' participation in the world's production economy highlighted in the PCAR curriculum. Other theoretical frameworks still came up but only to help discern more of issues that came up from this study.

Chapter 3: Research Methodology

Introduction

This qualitative study sought to unravel issues surrounding the implementation of a newly developed science and technology curriculum that integrated indigenous knowledge with science for the first time in Malawi. The following three questions guided this study:

1. How is indigenous knowledge featured in the standard five Primary Curriculum Assessment Reform (PCAR) science and technology curriculum in Malawi?
2. What issues did teachers face during the implementation of indigenous science topics in the Malawi primary science and technology curriculum?
3. How do teachers conceptualize the role of indigenous knowledge in the newly reformed primary science and technology curriculum?

The three questions targeted two main foci for data collection, that is, the curriculum documents, teachers' classroom practices, and their impressions about the curriculum. Hence, curriculum documents, on one hand, and classroom teaching practices and interviews with teachers, on the other hand, served as main data sources. To describe the process of data collection, the position of researcher, location of the study, participant selection, data collection and analysis procedures will be discussed. Since the researcher's position determines the insights and vision of phenomena in a qualitative study especially when collecting data as an observer or interviewer (Patton, 2002), discussion of data collection procedure will start with introducing the researcher.

Researcher's Background

As Patton (2002) justifies the value for research, he contends that qualitative researchers' capacity to make effective inquiry depends on their proximity to the program and procedures through which they develop opinions as they interact with people or materials. What the researcher deems interesting depends on his perceptions of meanings from the field. Hence, I consider it necessary to talk about my background that influenced my perceptions in this study.

First of all, I am a Malawian who spent most of my early life in the rural sectors of the country. My contact with indigenous knowledge and technologies began from my

childhood. Each day of my early life availed connections to the practices of indigenous people, of course starting with my family. My father taught me how to make hoe-handles, mats, granary-stores and snares for catching birds at a tender age. I also recall how local people in the neighborhood caught fish using simple technologies like fish traps and wooden fish spears (*Misompho* in Tumbuka). As I followed my father in his everyday masculine chores, both at work and at home or in the forest, I started building knowledge, which comes up as indigenous technologies or even indigenous science, as described by others in the academy (Semali & Kincheloe, 1999; Snively & Corsiglia, 2001).

Each day, on my way to school, I passed through a three and half mile stretch of thick forest, which connected me to nature. Through that exposure, I discovered the rhythm of nature and learned reasons why honey birds, eagles, and many other wild animals make particular sounds in the wild. On the other hand, through informal discussions with friends and adults I learned how to trap birds using sap from certain trees in the wild. The list of indigenous knowledges and technologies, relevant to science, is long and I hope this gives part of my connection with the people's practices in rural Malawi.

As an adult, I became a teacher in primary schools of Malawi. I spent five years of teaching in the primary school sector and also taught science each year, beside other subjects. My next fifteen years of teaching were in Teacher training colleges as a science teacher educator. Those years brought me in contact with more knowledge about teaching science and application of scientific ideas in everyday life. While serving as a science teacher educator, I met late Harold Gonthi for the second time. May his soul rest in peace. Harold Gonthi worked as a science curriculum specialist at Malawi Institute of Education (MIE), but before taking that job he was also my science educator during my pre-service training at Lilongwe Teacher's College. It was Harold Gonthi who first introduced me to a project known as "Linking Community Science With School Science."

As I participated in both curriculum development activities and projects, such as "Linking Community Technologies with School Science" my vision of science started changing and its application in everyday life broadened. Curriculum development experiences, at that time, invigorated my desire to bridge science with local knowledge

and practices. However, the climax of my pursuit for this kind of knowledge was when I started reading about the whole network of indigenous science while at Virginia Tech, under the stewardship of Dr George Glasson. It was at this point in my life that I realized that there is a great need to make connections between school science and indigenous people's knowledge. I started thinking about such connections with lots of enthusiasm, especially after seeing the link of such knowledge with the recently revised PCAR science and technology curriculum. I briefly participated in PCAR curriculum development prior to my enrolment for doctoral studies in the College of Liberal Arts and Human Sciences in the School of Education at Virginia Polytechnic and State University.

Hence, my interest to learn more about application of indigenous knowledge to the teaching of school science has tremendously grown from that exposure. This interest propelled my desire to search more and more ways of recovering and discovering local knowledge that relates with science. Such knowledge, to most Malawians of the younger generation, seems remote as they lose sight of its existence. My desire to recover such knowledge led to the proposal of this study; especially influenced by the fact that the Malawi curriculum specialists had endorsed the need to include indigenous technologies in the primary school curriculum.

Location of The Study

This study took place at three schools in Lilongwe City in Malawi. Lilongwe City is also the capital city of Malawi and since it is a large metropolitan area, the education districts are divided into three: Lilongwe Urban, Lilongwe Rural East, and Lilongwe Rural West. This study took place in the outskirts of Lilongwe Urban education district. All the three schools are under the city council and they are between two to three miles apart. Being in the city, the schools are mostly taught by female teachers because there are so many female teachers who come to town following their husbands.

Immigration of people into Lilongwe city brings together people from a wide cross-section of cultural backgrounds and languages. Although almost all people in town can speak Chichewa, their cultural roots are not homogenous. Hence, teachers in Lilongwe are of mixed cultural backgrounds.

Selection of Participants

To study implementation of the new standard five science and technology curriculum, the study participants were partly determined by availability of curriculum documents. At the time this study started, standard five curriculum documents were just developed and next to be implemented. Curriculum documents for standard five were still in camera ready form (not printed for public consumption) at the commencement of this study. That meant that I had to use standard five classes as research bases because of availability of finished documents. However, because curriculum documents were not in circulation, I had to apply for special permission to the Malawi Institute of Education to have the documents for this study (See appendix C).

Upon acquisition of the curriculum documents for grade five, the choice of participants was narrowed down to teachers of this class. Since there are only a few teachers in each class, the choice was then only dependent on their interest to participate in the study. The only condition that I put in place was to have teachers who had been teaching science in that class for two or more years before. The latter condition was used in order to ensure having teachers who had teaching experiences in the old curriculum whose experiences would help in dealing with the new curriculum. The assumption for doing this was that teacher's regular teaching practices might differ from the new topic. However, how different such practices would be was yet to be discovered.

This process of selecting participants gave me a typical sample according to Fraenkel and Warren (2006). Here, teachers in grade five and their pupils were automatically chosen as subjects by virtue of being in grade five. However, teachers' practices were the focus of the study because implementation of a curriculum is dependent on their choices, knowledge, and skills. On the other hand, their skills cannot be displayed in the absence of learners. Therefore, teachers' capability to teach was measured against their capability to engage pupils in learning the ideas stipulated in the science and technology curriculum as related with indigenous knowledge.

Choice of Schools and Teachers

Since the schools came from almost the same area, there was no significant difference in the local conditions at the school. Teachers were of equal qualifications. All the three teachers had T2 primary teacher qualification certificates. T2 certificates are

offered to primary school teachers who have a school certificate. This group of teachers normally have had four years of secondary school learning and obtained a Malawi school certificate of education, equivalent to O-level qualification under the British education system. One among the three teachers initially qualified as a T3 teacher, which was a qualification offered to trained teachers with a Junior Certificate of education. However, by the time this study commenced, the T3 teacher had upgraded her teaching qualification to T2, after upgrading her academic certificate to Malawi School Certificate level. The choice of teachers with the same professional qualification among teachers was not by design, but due to the fact that better-qualified teachers usually handle higher classes, where there is a choice.

To access teachers in the schools, I initially contacted the District education officers for Lilongwe Urban who allowed me to scout for schools in the area of my choice and contact the Head Teachers who have control over day-to-day teacher operations on the ground. Contacts with Head Teachers from six schools within my reach took place in early June 2007. The choice of schools, however, depended on cost of travel to the schools. Since I had to use my meager resources for fueling my car to these schools, shorter distances between schools were a better choice. However, shorter distances were also considered because of quick movements between schools to facilitate making a couple of observations in a day.

After accepting to use their schools for study as indicated in their verbal consent forms in Appendix D, head teachers of the three schools where I conducted this study helped connect me to the teachers. All teachers in standard five were invited to the Head teacher's office as I explained the purpose of my study and why I was looking for their participation. All the teachers were told that their participation would depend on their willingness to participate. One of the incentives was to gain early experience before the actual PCAR roll out of the curriculum. Interested teachers gave me their contact details so that when the curriculum documents were ready from MIE I would quickly communicate with them for purposes of distribution of curriculum documents.

Data Collection

Documentary Analysis

As soon as the curriculum documents landed in my hands, I started scrutinizing them for details of content labeled as indigenous, the clarity of success criteria (equivalent of objectives), and a comparison of details between regular and indigenous science topics. In my copy of each curriculum document that was circulated to teachers, I started jotting comments and also made some notes in my research log. Some of the observations made during documentary analysis shaped my observations in the classrooms. I was keen to see how teachers were dealing with a curriculum that was less explicit about scientific facts and how well the indigenous technologies were used to teach science.

My reactions and scrutiny of the documents increased as I saw teachers struggling with planning for and actual teaching about indigenous technologies and food taboos and beliefs. I picked out “food taboos and beliefs” as a topic of interest, not because the curriculum has labeled it as indigenous, but because I thought the topic deals with issues emanating from indigenous ways of knowing. Hence, instead of only covering indigenous technologies, which clearly bear connections with indigenous knowledge, I also decided to see how teachers were handling food taboos, especially at a point when indigenous knowledge starts to be recognized.

As teachers planned and taught work from these two topics, my impressions about the curriculum documents kept changing. The same evolution of impressions happened as I engaged in data analysis.

Lesson Observation Period

Classroom observations started towards the end of June, since the new curriculum documents were only available, in loose pages, by June 11, 2007. Copies of a syllabus, teacher’s guide and learner’s book were printed by June 15, 2007. Teachers had about a week of preparations before classroom observations started. Instead of observing one lesson per week, sometimes I had two lessons per week in order to cover the work planned within the limited time.

Number of Lessons Observed

Teachers planned differently because they had different commitments. Due to these factors, I observed varied numbers of lessons from the three teachers. Numbers of lesson observations ranged from four to seven. Teachers' experiences while planning and teaching and what they displayed during teaching also availed data for this study. Hence, teacher's anxieties, queries, and seeking clarification for or demand for more information were all recorded and turned into field notes as encouraged by Emerson, Fretz, and Shaw (1995).

Participant Observation

In this study, I engaged in more of a naturalistic observation to open possibilities of describing the experience without limitations. Teachers were free to ask me what they felt did not make sense as they taught. All teachers were told that their insights, struggles and successes were part of the lessons I wanted to learn from the study. As a result they did not shy away from expressing their experiences and needs. After all, they knew my background as a science teacher educator. Hence, I participated as an overt participant observer (Fraenkel & Wallen, 2006). I tried hard to suppress the power of my past position as a teacher educator by telling them to do whatever they felt comfortable to do because I was not interested in ideal practices but what they naturally felt comfortable to do. I participated in thinking through some of their problems in planning and teaching whenever they asked for help but also just observed at other times. Hence, I would say I took the role of a moderate participant observer, whereby I participated only when called upon.

Classroom Observation Procedures

Since I was a lone researcher, my capacity to collect as much information as possible was facilitated by video recording. Besides video recording, I jotted down notes of key events and these were processed as prototype notes from the lessons. Notes jotted in the classroom and replays of videos were turned into lesson vignettes. There were lots of reflections on each day's observations, written by the end of the class or day.

My classroom jottings were focused on lesson organization and the flow of ideas between the teacher and learners pertaining to indigenous knowledge. I was also interested in the assessment of learners and how teachers focused on helping learners to

acquire knowledge and skills as demanded by the curriculum documents. To understand what transpired in the classrooms, I checked teachers' lesson plans to see why they taught in particular ways. However, it was hard to have their lessons checked everyday because sometimes they came in class late and went straight into teaching when time was against them. However, at the end of each lesson, there was a chance to share notes.

Learners' responses shaped the classroom dynamics and interesting data about indigenous technologies and taboos emerged when learners participated in classroom activities. Learners' participation and the nature of participation also availed valuable data in this study.

To keep track of teachers' experiences and lessons, each teacher was given a notebook in which they wrote the schemes of work and lesson plans. Teachers were also asked to keep their teaching experiences in those notebooks. At the end, the notebooks were collected as part of data.

Interviews

Beside careful observation, watching, and listening, interviews are a powerful tool for obtaining qualitative research data (McMillan, 2004). Interviews, according to McMillan (2004), are a "more intrusive form of data collection procedure" that involves "asking participants questions, and recording answers." This strategy is very essential to gather data from participants and also on issues that may not be directly observed.

In this study, interviews took two forms. First, informal questions posed after the class and secondly, formal semi-structured interviews conducted at the end of the study. To help answer the three main questions in this study, ten questions were used in the interview protocol. I started with seven questions at the beginning of the study but added three more questions in order to learn more from the classroom experiences as shown in appendix E. Interviews formed a very rich source of data that confirmed or disconfirmed my speculations during classroom observations.

The process of interviews started by informing teachers about interviews through a memo (see appendix F). The memo informed the teachers about the interview and what was expected from them. Teachers were asked to choose a convenient date for the interviews. However, plans do not always work. One of the teachers had a funeral, and

so I only managed to have an interview with her on the morning that I departed Malawi coming back to Virginia Tech. It was amazing that it worked.

All interviews were conducted in quiet places to avoid distortions of recordings and disruptions of the interview processes. A digital recorder was used for audio recording, as was the case in the previous summer (2006) when this study begun probing issues of indigenous knowledge practices relevant to science in Malawi.

Prior to the date of interviews, teachers read the questions that were sent together with the notification memo for the interview. Teachers were also told to ask for clarification if they did not understand the questions, especially those used for probing issues.

Auto-Ethnography

The last but not least approach for data collection was auto ethnography. Patton (2002) describes auto ethnography as the latest and still emergent approach in research. Ethnography and auto ethnography fall on either extremes of the continuum of qualitative research. While ethnography emphasizes on studying other people, in auto ethnography one studies “his or her own culture and oneness as part of the culture” (p. 84). This approach was employed because I have a rich background in the indigenous knowledge developments in Malawi as indicated in my position as a researcher.

Research Ethics

Institutional Review Board

This study was a continuation of the study abroad research on indigenous knowledge in Malawi primary schools that took place in Summer 2006 (Appendix G). The team leader for that study was Dr Glasson while Ndalapa Mhango and I were research assistants. That study was done while the outgoing primary school syllabus was not yet revised. That study revealed inexistence of indigenous knowledge content in primary science curriculum while the current study came up after the revision of the curriculum that had included indigenous knowledge. Hence, this study tried to register both how much indigenous knowledge had been included in the revised curriculum and how the teachers were implementing it. Since this was in a similar field and context, the previous IRB was renewed to continue gathering extra data on indigenous knowledge in science curriculum in Malawi.

Confidentiality

During the interviews teachers were told about confidentiality issues and asked if they could choose pseudonyms. Some of them were naïve to confidentiality issues, such that they did not worry about their names being reflected as usual. However, I informed them that it was important to protect them from portrayals that research findings could bear on them. Two teachers gave me their preferred pseudonyms. The older teacher did not mind but all the same she bears a pseudonym in this report.

Limitations

This study used only three case studies. This size of study makes it hard to make generalizations out of its findings. However, the study had the capacity to reveal issues that can be used to improve the curriculum or inform further research after a thorough study of the few cases (Fraenkel & Wallen, 2006; McMillan, 2004).

Data Analysis

Researcher's Reflections

At the end of each class observation, I jotted down quick reflections and kept them in my research journal, since analysis for ethnography starts in the fieldwork phase (Hammersley & Atkinson, 1995). Further reflections were written after going through each research day's data from the schools. One diary had quick jottings from the classes, while interesting ideas were recast into issues from the study. These were typed on the computer and recorded in files bearing relevant issues. Each day's activity was analyzed and interpretations kept on evolving. Some observations triggered further search for information. All what I read, during and after data collection, contributed to interpretation of data. Interpretations were developed from mostly constructivist and postcolonial theories, and to a minor extent other theoretical frameworks engaged in this study. It was keen to see how constructivism would play out, which I anticipated would be enhanced by using indigenous knowledge as prior knowledge in science.

Analysis of Results

This section reports how the data were analyzed after gathering all the data to learn about issues surrounding the implementation of the newly developed science and technology curriculum (following the recent PCAR curriculum review in Malawi). The

results being reported are aligned to three main questions that were asked in order to explore the integration of indigenous science in the standard five PCAR science and technology curriculum in Malawi. Hence, the analysis was segmented into three sections in relation to the three questions.

To study issues that surrounded implementation of the above-mentioned curriculum, three sources of data were used as mentioned earlier. These sources included (a) official curriculum documents (syllabus, teacher's guide, and learner's book), (b) teacher-planned documents (schemes and lesson plans), (c) lesson observations, (d) informal after-class interviews or informal talks, and (e) formal semi-structured interviews of each case study teacher that was done at the end of the study. Therefore, results in chapters 4 -6 emerged from all these areas. In attempt to bring order to these results, themes that emerged from the curriculum are reported separately from themes that emerged from teacher's experiences and finally themes that emerged from teachers' opinions after teaching this work. Therefore, the analysis of results from curriculum documents preceded those from teacher's experiences, which coincidentally follow the order of the study questions.

A total of ten themes emerged from the three questions that guided this study as follows:

Question 1: How is indigenous knowledge featured in the standard five PCAR science and technology curriculum in Malawi?

Theme 1. The indigenous knowledge featured in the PCAR science and technology curriculum primarily focuses on indigenous technology rather than the science from indigenous knowledge.

Theme 2. The curriculum exclusively presents negative elements of indigenous knowledge about taboos and beliefs and provides no room for positive elements about taboos and beliefs.

Theme 3: PCAR science and technology curriculum documents bear structural inconsistencies and lack of connection to scientific principles in the presentation of indigenous knowledge in science.

Question 2: What issues did teachers face during the implementation of indigenous science topics in the Malawi primary science and technology curriculum?

Theme 4: Teachers faced multiple challenges while teaching about indigenous technologies because the design of activities in the curriculum does not clearly distinguish between types of technology and does not clearly articulate the scientific principles that come into play.

Theme 5: Integration of indigenous knowledge made teachers struggle to come up with scientific terms and vernacular words that bear scientifically relevant meanings.

Theme 6: Teachers' lessons on taboos deterred them from engaging learners in meaningful cultural issues that relate with science beyond stereotypical constructs influenced by negative representations of cultural practices as defined in the curriculum.

Question 3: How do teachers conceptualize the role of indigenous knowledge in the newly reformed primary science and technology curriculum?

Theme 7: Teachers expressed misunderstandings about the difference between indigenous science and indigenous technologies.

Theme 8: Teachers' lack of academic scientific knowledge detracted them from making connections with indigenous knowledge.

Theme 9: The provision and utility of resources for teaching indigenous science and technology solely depend on teachers' initiatives.

Theme 10: Teachers expressed both positive and negative valuation of the effect of integrating indigenous knowledge in the science and technology curriculum with respect to learners' benefits.

The above themes accrued from a categorical analysis of codes and categories that were processed from the raw data gathered from the documents, field notes, lesson observations, informal talks with the teachers, curriculum specialists and other stakeholders, and also from interviews (Ely, Ansul, Friedman, Garner & Steinmetz, 1991). The processes of coding partly followed grounded theory (Patton 2002) and evaluative analysis. Main sources of interview data were the three teachers although informally, two curriculum specialists and other stakeholders in curriculum development were consulted for clarifications on relevant issues pertaining to processes of curriculum development.

Table 2 (a): Themes and their Sources for Question 1.

Theme	Category & Codes	Evidence
Research Question 1: How is indigenous knowledge featured in standard five PCAR science and technology curriculum in Malawi?		
<i>Theme 1:</i> The indigenous knowledge featured in the PCAR science and technology curriculum primarily focuses on indigenous technology rather than the science from indigenous knowledge.	<ul style="list-style-type: none"> • Unbalanced representation of Indigenous Knowledge (IK) across topics • Weak relationship between indigenous technologies and other topics in the curriculum 	<ul style="list-style-type: none"> • Documentary analysis (syllabuses, Teacher's guides, and Learner's books)
<i>Theme 2:</i> The curriculum documents exclusively present negative elements of indigenous knowledge about taboos and beliefs and provide no room for positive elements about taboos and beliefs.	<ul style="list-style-type: none"> • Teaching taboos and beliefs only to discourage students • Variety of indigenous food resources are not linked to nutritional needs 	<ul style="list-style-type: none"> • Classroom observations • Interviews • Vignettes
<i>Theme 3:</i> PCAR science and technology curriculum documents bear structural inconsistencies and lack of connection to scientific principles in the presentation of indigenous knowledge in science.	<ul style="list-style-type: none"> • Differences in content detail between IK related topics and regular science topics • Mismatch of developed content in Teacher's guides and syllabus • Lack of unifying concepts in IK related topics. 	<ul style="list-style-type: none"> • Curriculum documents

Table 2 (b): Themes and their Sources for Question 2.

Question 2: What issues did teachers face during the implementation of the indigenous science topics in Malawi primary school science?		
<i>Theme 4:</i> Teachers faced multiple challenges while teaching about indigenous technologies because the design of activities in the curriculum does not clearly distinguish between types of technology and does not clearly articulate the scientific principles that come into play.	<ul style="list-style-type: none"> Partially defined learning outcomes and effects on lesson organization Complexity of technologies and choices of scope of content Struggles with provision of resources for unclear curriculum concepts Dealing with mismatch between syllabus and support documents (Teacher's guides and Learner's books) 	<ul style="list-style-type: none"> Documentary analysis Observed lessons Interviews
<i>Theme 5:</i> Integration of indigenous knowledge made teachers struggle to come up with scientific terms and vernacular words that bear scientifically relevant meanings	<ul style="list-style-type: none"> Struggles with using vernacular words to explain scientific meanings Struggles with changing scientific terms into vernacular language 	<ul style="list-style-type: none"> After-class interview with Stella and Vignettes
<i>Theme 6:</i> Teachers' lessons on taboos deterred them from engaging learners in meaningful cultural issues that relate with science beyond stereotypical constructs influenced by negative representations of cultural practices as defined in the curriculum.	<ul style="list-style-type: none"> Blurred initiatives due to negative attitudes Absolute belief in print authority subdued reasoning Neglect of culture lowers teaching and learning opportunities 	<ul style="list-style-type: none"> Interviews Lesson observations

Table 2 (c): Themes and their Sources for Question 3.

Question 3: How do teachers perceive the role of indigenous knowledge in the newly reformed primary science curriculum?		
<i>Theme 7:</i> Teachers expressed misunderstandings about the difference between indigenous science and indigenous technologies.	<ul style="list-style-type: none"> • Teacher misconceptions about indigenous knowledge • No distinction between indigenous science and technology 	<ul style="list-style-type: none"> • Interviews
<i>Theme 8:</i> Teacher's lack of academic scientific knowledge detracted them from making connections with indigenous knowledge.	<ul style="list-style-type: none"> • Lack of academic knowledge to draw from to enhance instruction • Conceptual distortions <ul style="list-style-type: none"> ○ Poor distinction of technologies ○ Inaccurate definition of key terms • Losing teachable moments • Poor provision of feedback during teaching • Planning for teaching 	<ul style="list-style-type: none"> • Interviews • Vignettes
<i>Theme 9:</i> The provision and utility of resources for teaching indigenous science depend on a teacher's initiatives.	<ul style="list-style-type: none"> • Availability of resources for teaching IK • Varied experiences with acquisition of resources • Use of indigenous technological resources for teaching 	<ul style="list-style-type: none"> • Interviews • Vignettes
<i>Theme 10:</i> Teachers expressed both positive and negative valuation of the effect of integrating indigenous knowledge in the science and technology curriculum with respect to learners' benefits.	<ul style="list-style-type: none"> • Positive value only related to indigenous technologies and not other forms of IK • IK concerning taboos must be discouraged 	<ul style="list-style-type: none"> • Interviews • Lesson observations

Data from interviews and curriculum documents clarified my understandings developed from lesson observations. Hence, more details of the evidence in support of each theme emanate from documentary analysis, lesson observations (through vignettes), after-class interviews, and also from semi-structured interviews. Tables 2 (a) to (c) show the summary of the categorical analysis that led to the development of the themes.

Before further delving into the results in chapters 4-6, let me say that the emergence of the ten themes was not a straight process. There were so many iterative steps taken back and forth between the raw data, literature, questions (both those guiding the study and supporting it), reflections during the study, reflections during coding and theme development, and many other spur of the moment thoughts which I scribbled down whenever interesting ideas dashed across my mind. As more engagement with the data took place, analysis started becoming more complex and new ideas slowly emerged; both new and those modified from previous ones.

The early analysis was done by constructing a series of concept maps to identify categories of data (see example in Appendix H). Hence, the current themes are indeed just an attempt to present some meanings that came up within the time frame I analyzed the data. It is likely that further engagement with the data would have yielded more understandings because I tended to see more each time I went back to the data, especially after reading around the ideas which seemed to emerge from the data. For the time being, let me turn to the description of the themes as outlined above, starting with those related with the PCAR science and technology curriculum. The next chapter (4) will present the “analysis of the Curriculum,” followed by chapter 5 that describes “pedagogical practices”, and chapter 6 finalizes analysis of findings as it tackles “teacher’s conceptions of indigenous knowledge.” Finally chapter 7 will provide the discussion of entire results and recommendations.

Chapter 4: Analysis of The Curriculum

Question 1: How is indigenous knowledge featured in the standard five PCAR science and technology curriculum in Malawi?

In attempt to answer question 1, three themes emerged from the documentary analysis. The documentary analysis looked at both structural details in the documents and content details which revealed the purpose for prescribed content, patterns of details of concepts in each unit, clarity of ideas, sequence and scope of content, suggested activities to help realize the goals of curriculum, methodologies, resources, and modes of assessment. Of paramount interest was to check the way indigenous knowledge was represented across the curriculum documents and within science topics that had clearly expressed integration with indigenous knowledge. Comparisons of such parameters led to the evolution of three themes, generated from curriculum documentary analysis, whose discussion follows below.

Representation of IK in the Science and Technology Curriculum

Theme 1: The indigenous knowledge featured in the PCAR science and technology curriculum primarily focuses on indigenous technology rather than the science from indigenous knowledge.

This theme reflects a general pattern observed from curriculum documents, which portrayed selective use of the term *indigenous* in all the three curriculum documents (syllabus, teacher's guide and learner's book). A perusal through the curriculum documents showed two groups of data which could be described pertaining to: (1) representation of indigenous knowledge in the curriculum and (2) curriculum structural variations between topics that deal with indigenous knowledge and regular topics.

Skewed Focus

Considering the manifested representation of indigenous knowledge, the entire new PCAR syllabus clearly highlights the word *indigenous* only under the rationale and one topic, named "indigenous technologies". Under the rationale the word indigenous is associated with knowledge (e.g. indigenous knowledge or IK), while in the next position the word indigenous is tied to technologies (indigenous technologies). Hence, the word indigenous is only featured in those two areas. At this point, let us see the representation

of IK as outlined in the rationale, extracted from the syllabus (also indicated in the Teacher's Guide) as follows:

This subject will contribute to the intellectual development of the learners to enable them to manage the changes that modern science and technology bring to all sectors of the modern economy. Learners will achieve this through accessing *indigenous knowledge* and applying *indigenous* and modern *technologies* in everyday life.

Science and technology will enable learners, through investigation and inquiry, acquire basic scientific and technological knowledge, skills and attitudes. The learners will use the knowledge, skills and attitudes to investigate and understand the relationships between health and nutrition, production and marketing process, among other things, to improve the quality of their life and that of other people in their communities. (PCAR grade five science syllabus, 2007)

At the outset I was thrilled with the robust representation of indigenous knowledge in the syllabus rationale (above) as a guiding statement of the entire syllabus. However, after the rationale, the syllabus is quiet about indigenous knowledge across all the six core elements and their outcomes. Under each core element and its associated primary outcome, the syllabus specifies the main categories of content to be covered. The following is the list of core elements and their primary outcomes:

- a) *Basic Scientific knowledge, skills and attitudes*. The learner will be able to understand and apply scientific knowledge, skills and attitudes to solve everyday life problems and provide a base for further learning.
- b) *Scientific investigations for application*. The learner will be able to investigate relationships, identify and solve practical problems in science and technology.
- c) *Knowledge for development*. The learner will be able to interpret and apply scientific and technological knowledge with ethical responsibility for the environment as well as to make improvements in the quality of life and develop a respect for vocational work.
- d) *Nutrition and health*. The learner will be able to demonstrate an understanding of the relationship between nutrition and health in order to effectively deal with nutritional and health problems in homes, community and the world.

- e) *Marketing*. The learner will be able to apply scientific and technological understandings of production, use, and marketing processes in economic activities in order to increase local productivity and contribute to the market economy of the country.
- f) *Managing change*. The learner will be able to understand, innovate, and manage scientific and technological changes in everyday life with particular reference to the homes and communities in Malawi.

As I read the preamble of the syllabus, the silence of the term “indigenous” across the core elements forced me to speculate that all core elements will have to be carriers of indigenous knowledge since indigenous knowledge has been foregrounded in the rationale. However a further scan across the contents of the core elements in the syllabus showed that the entire syllabus only explicitly mentions the word “indigenous” under one core element: *Knowledge for Development*. Before describing the most striking representation of indigenous knowledge (IK) in the syllabus, let me explain that for each core element and primary outcome, the content is organized around the following headings: assessment standards; success criteria; theme /topic; suggested teaching and learning activities; suggested teaching, learning and assessment methods; and suggested resources, as shown in the curriculum organization (Appendix I). Appendix I shows some extracts of the content of the new PCAR syllabus, which bear the word indigenous.

As mentioned earlier, one striking observation was that the only topic that bears the word indigenous only deals with *indigenous technologies*. In the teacher’s guide, two success criteria (equivalents of objectives) are named associated with indigenous technologies are: (1) explain scientific principles applied in some indigenous technologies and, (2) improve some of the indigenous technologies. Under the entire set of success criteria in the syllabus, these two are the only ones that are associated with the word indigenous. Likewise, these two success criteria are associated with only one assessment standard that bears the word indigenous, which reads, “We will know this when learners are able to demonstrate an understanding of *indigenous technologies*.” Obviously, one would guess that this must be the only section of the syllabus that would show suggested activities related with indigenous technologies (as detailed in Appendix I). However, this is not the only section where technologies are covered.

The next topics that deal exclusively with technologies come under the following core elements: *managing change* (dealing with technologies for sending messages), *knowledge for development* (technological innovations, as covered in second term), and *marketing* (covering technologies for marketing). As it may be guessed, the word indigenous is not mentioned under all these core elements. The only trace of items that could relate with the term “indigenous” (but not obviously so) is the drum (under technologies for sending messages) and a mention of a bow and arrow under activities on technological innovations. Other core elements that deal with food and nutrition, energy, plant and animal classification, and the like, do not bear explicit relationship with the word indigenous. The same trend of representation also applies to the standard five teacher’s guide and the learners’ book.

Table 3 shows the whole range of units in the teacher’s guides and learners books, which provide details of the content highlighted under the twelve topics in the syllabus as outlined below.

A quick glance at the table shows how indigenous knowledge has been predominantly associated with technologies. Only topic 4 clearly mentions the word *indigenous* but some aspects of indigenous items are sparsely mentioned under technology related topics. Topic 3 covers food taboos and beliefs but there is no word that associates taboos with indigenous knowledge. Topic 9 avails opportunities to cover technologies for generating energy (such as fire making technologies), but there is no mention of such connections.

Again, topic 3 covers a wide range of foods (including examples of indigenous foods) but the syllabus does not label such foods as indigenous and relate them with nutritional levels. There is also no mention about advantages of indigenous foodstuffs in relation with groups of food. These observations appeared to me as indicators of some omissions of possible elements of indigenous knowledge that would be relevant in the curriculum beside the technologies that have been highlighted in conjunction with indigenous knowledge.

Such representation was noted to selectively place high value of indigenous knowledge only on technologies and not other types of traditional knowledge, which would come out in other topics as well. If representations of indigenous knowledge were

broadly perceived, there would be indigenous practices related with energy, food and health, and worm infections as well. Besides exclusive alignment of the word *indigenous* to technology, indigenous ways of knowing are also exclusively discouraged, for example, food taboos and beliefs. Such representation reflects partial validation of indigenous knowledge. At this point let us turn to disparities of content coverage between regular science topics and those related with indigenous knowledge.

Table 3: Topics covered in curriculum and representation of indigenous elements.

Unit	Topic	Presence
1	Scientific investigations	Nil
2	Worm infections	Nil
3	Food and health	Trace of indigenous foods but not labeled as indigenous
4	Indigenous technologies	Predominant in all activities
5	Technological innovations	A few items but not labeled indigenous (hoe, medicinal herbs, catapult)
6	Problems of marketing	Nil
7	Technologies for sending and receiving messages	Trace. Only drum but not specified to indigenous source
8	Classification of animals	Nil
9	Types of energy	Nil
10	Technologies for marketing	Nil
11	The relationship between plants and animals	Nil
12	Nutrition and health	Nil

Unbalanced Depth of Content

The Teacher's Guide shows another representation issue. While the syllabus selectively associates the term indigenous with technologies and mainly in one topic, the Teacher's guides and learner's books also show a disparity of the scope of content covered between topics that bear indigenous technologies (on one hand) and the regular topics in science (on the other hand). Regular science topics bear clearer and explicit

concepts while content under indigenous technologies bear general and less explicit concepts and outcomes. Hence, besides selective representations of indigenous knowledge across the curriculum, there was also an indication that content related with indigenous knowledge is less explicit in both nature of concepts and scope of coverage.

Content disparities are revealed through details like the scientific principles that are mentioned as goals for teaching indigenous technologies and these are shown in the introductory sections of each unit. The introductory segments for indigenous technologies are more general and not clearly articulated beyond a mere mention of the technologies and how they are used, in contrast with regular science topics. For example, the principles that enable indigenous technologies to work are not clearly articulated by way of naming and giving possible ways of achieving them, as it is done in regular topics. The success criteria for indigenous technologies merely ask learners to achieve the following general goals:

- Explain scientific principles applied in some of the indigenous technologies
- Improve some of the indigenous technologies

While content details are easy to visualize for regular topics, it is hard to see such details under indigenous technologies. In a regular science unit like “Worm infections,” the introduction clearly states types of worms, points of infestation in human body, the need to control worms and their signs and symptoms. When it comes to success criteria, it is easy to see phrases like: identify signs, symptoms and effects of numerous worms (tape, round, and hook worms). Furthermore, when it comes to concepts, it is easy to figure them out such as: types of worms, signs and symptoms, and ways of controlling them. In contrast, the introduction of indigenous technologies, simply touches on generalities about indigenous technologies, as shown in the introduction for indigenous technologies which reads as follows:

Technologies are used to solve everyday problems in everyday life. People can use scientific knowledge in order to come up with different technologies such as aero planes, tractors, computers, winnowers, fish traps, videos, grinding stones, bicycles, maize mills, and treadle pumps. Some of these technologies are locally developed, and are called indigenous or local technologies.

From the above introductory passage to indigenous technologies, you may also have noticed that instead of only talking about indigenous technologies, the teacher's guide mentions all technologies in general, which fails to focus on specifically identified indigenous technologies. Hence, indigenous knowledge content apparently looks shallow. It was also noted that it is not well linked to other topics.

Indigenous Knowledge Linkage with other Topics

The relationships between indigenous knowledge and other topics, other than indigenous technologies, are not clearly visible and in many cases absent. For example, indigenous knowledge is absent in *unit 9* (Types of energy) in which it is possible to learn from traditional uses of energy and what people used or still use as energy sources. Although, technological innovations include some examples of indigenous items, nothing is purposefully labeled as indigenous. This omission gives the impression that the topic on innovations does not involve indigenous knowledge aspects. In topics that are outside technologies, the word indigenous is not highlighted, even when dealing with topics related to indigenous issues like food taboos and beliefs. This shows a narrow concept for the application of indigenous knowledge into the curriculum. Actually, since indigenous knowledge, in general, is not mentioned or described in other topics and that the word indigenous is only mentioned under technologies, this could be the source of lack of linkage between indigenous technologies and other topics.

The other units that could be carriers of indigenous knowledge are not pursued further in the teacher's guide. For example, food preservation is mentioned in the syllabus, but the teacher's guide does not spend time on it. When it comes to innovations of technologies, pupils are asked to design toys and not authentic solutions to real life problems. This brings up the question as to why so many indigenous technologies are mentioned and not pursued to the end in some examples of activities in the teacher's guides.

Both the syllabus and the teacher's guide present a simplistic view of content derived from indigenous knowledge. The syllabus lists indigenous technologies without following the hierarchy of ideas involved. For example, the following are listed under the same list as indigenous technologies: food preservation, separation of mixtures, corn flour production, water purification, chidulo production (traditional soda production), and

removal of cyanide. A close scrutiny of this list shows that there are different categories of science that come under play from these technologies. Food preservation engages various types of strategies or technologies (e.g. direct heating, osmotic principles, using mixtures, e.t.c.), while chidulo making could fall under solubility principles (that is, separation of mixtures when liquids and solids are mixed), corn flour production can use grinding, sieving (which separates mixtures with different sizes of particles), and finally, cyanide removal can use fermentation, diffusion, or any other mechanism. It is such principles that should have been showing up in the teacher's guide but also considering children's developmental level. Nothing like that is mentioned for catapults, bows and arrows, which could make it very hard to interpret what to teach.

Furthermore, the curriculum documents do not show the relationship between the topics on indigenous technologies and the topic on scientific investigations. Instead of using investigations for application as a base for improving technologies, the teacher's guide does not suggest how investigations are supposed to be applied across the topics including that of indigenous technologies. Hence, teachers may think that activities under indigenous technologies are supposed to be done in isolation of the topic on investigations. Obviously, lack of such details about such connections makes the curriculum prone to being misinterpreted.

Biased Representation of Indigenous Knowledge

Theme 2: The curriculum exclusively presents negative elements of indigenous knowledge in taboos and beliefs and provides no room for positive elements from taboos and beliefs.

The curriculum documents present food beliefs and taboos under the topic entitled "Food and Health." However, the curriculum only highlights discouragement of food taboos and beliefs and does not consider the reasoning behind their institution. In the following statement, extracted from the introduction of "Unit 3: Food and Health," we notice the purpose for teaching taboos and how they are represented:

Food taboos and beliefs are common in some homes. These taboos are beliefs that stop some groups of people from eating certain foods and can cause poor health in people.

In this unit, the learners will learn about the functions of food, the effects of common food taboos and beliefs, and appreciate the importance of eating a variety of foods.

The above statement reflects only the negative effects of food taboos and says nothing about possible positive elements concerning taboos. Likewise, the Teacher's guide also stress the same notion. Note how the Teacher's guide outlines instructions in respects to concepts under food taboos:

Concepts and knowledge

Ensure that the learners understand and acquire the following concepts and knowledge:

- Functions of different types of foods
- Common food beliefs and taboos
- Effects of beliefs and taboos
- Importance of eating a variety of foods.

As it may be noted, the third bullet indicates a leaning towards negative aspects of food taboos and beliefs. The teacher's guide further indicates that food beliefs and taboos have negative effects on people's nutritional status. Hence, although the Teacher's guide indicates that some food beliefs are good, the development of activities does not include a discussion of positive elements because it stresses negative effects of food taboos and beliefs as indicated in the following extract:

Effects of the food taboos and beliefs

The following are some of the negative effects of the food taboos and beliefs on people's health:

- A mother can give birth to a weak baby that has low birth weight if she does not eat foods rich in protein.
- Malnutrition results in young children and pregnant women.
- There is stunted growth in young children.
- There is low productivity in everyday activities because time is spent on looking after children or women suffering from malnutrition.

My quick reaction to the above information singled out some exaggerations or biases of representations. Although, it was mentioned that *some* taboos would have positive

effects, the above representations portray only negative representations. Besides presenting taboos as all negative, the curriculum also portrays food taboos as inflicting negative effects exclusively to women and children and that males are not affected by negative effects of food taboos and beliefs.

This portrayal misses the alternative reasons why the instituted food taboos came up. It mentions the low birth weight of babies but does not bring up the reasons why a smaller baby was an advantage when people did not have chances of having caesarian births (if a normal birth failed). By then, smaller babies were viewed to be less prone to kill their mothers during birth. It is possible in the curriculum to learn more about the reasoning behind the taboos, which may even have scientific explanations. The current curriculum does not pursue any advantages of taboos. Hence, I feel that the curriculum is biased and creates no room for understanding of some cultural practices, as portrayed in food beliefs and taboos. Interestingly, under attitudes to be developed from this topic, the curriculum mentions appreciation, curiosity (among other attitudes), but does not seem to relate such attitudes to food taboos in a positive way. I feel that discussion of positive elements of taboos could have promoted pupils' appreciation of cultural understandings, which may lead to a discussion of how the beliefs and taboos would be associated or dissociated from science.

The topic on food and health also mentions some traditional foods like bwemba, malambe, and katope. However, there is no mention that malnutrition was not an issue in the past because of the diversity and variety of indigenous foods. Again this example illustrates the biases, which are likely to blind teachers from fully exploring the issues about nutrition and health in various places of the world. Recognizing the importance of food beliefs and taboos would, on the other hand, maximize place-based education while on the other hand, it would broaden the view of food and health, thereby extending learning opportunities.

Curriculum Structural Inconsistencies

Theme 3: PCAR science and technology curriculum documents bear structural inconsistencies and lack of connection to scientific principles in the presentation of indigenous knowledge in science.

The pattern of content presentation in standard five PCAR science and technology curriculum documents displays some structural inconsistencies. There are a few structural anomalies that are likely to interfere with smooth interpretation of the new PCAR curriculum. In the first place, there is a loose design of activities. By loose design I am referring to issues like asking teachers and learners to explore about the indigenous technologies within communities without providing examples, especially when it is known that there is a considerable diversity of technologies across communities. Furthermore, when it is stated that students should learn the principles of some indigenous technologies and how to improve them, there is no unifying factor about the scientific principles to be explored and the nature of technologies that teachers and learners should dwell on across the country in Malawi. Lack of such instructions is likely to let teachers go in whichever direction. Furthermore, the outcomes of such knowledge will be very hard to reconcile, especially in examinations.

While it is appreciated that there could be liberty on choice of technologies to suit the environments and places where learners come from, it would be easier for teachers to think about predetermining learning outcomes if specific types of technologies. That prescription would be the unifying factor and all teachers would work on similar technologies. Better still, it would be even easier if the curriculum specified the categories of technologies such as food preservation technologies, flour-producing technologies, water-cooling technologies, and the like. On such technologies, all teachers might look at principles that make such technologies work. The teacher's guides would further specify preservation through desiccation, mixing food with salt or ash, and covering food with materials such as soil. Unfortunately, most work on indigenous technologies is on the general end.

Secondly, the sequencing of activities in the term-by-term sequence and within activities creates a problem about the normal conceptual development practices. It is generally known that learning experiences are springboards for developing concepts. Concepts are developed from learning experiences and the teacher organizes learning experiences to develop certain concepts. The activities prescribed under indigenous knowledge put so much emphasis on learners' experiences but loosely spell out the nature of concepts to cover. The following extract of an activity under indigenous

technologies in the teacher's guide (Unit 4) shows the loose design that I am alluding to and how the suggested learning experiences might not end with common results in different locations:

Activity 2: Identifying some of the problems of technologies used in the communities.

Suggested teaching and learning resources

You will need the following resources:

- The learner's experiences
- Various technologies from the local communities
- An observational checklist

Instruction

1. Let the learners describe the technologies in their communities.
2. Let the learners suggest which of the indigenous technologies need improvement.
3. Let them discuss the improvements that can be made on some of the named indigenous technologies, such as catapults, ball, trap, and bow and arrow.
4. Let the learners carry out the improvements on some of the identified indigenous technologies.
5. Ask the learners to test the improved indigenous technologies.
6. Let them report their findings to the whole class for discussion.
7. Summarize all the reports.
8. Assess the learners on what they have done.

The above-described activity is a good one but it assumes that teachers and learners are already capable of telling which local technologies are in need of improvement. This may not be the case. It does not take pupils through experiences that may help them discover the problems with some of the local technologies. It also assumes that before identification of scientific principles that work in the technologies, learners will manage to improve any of the indigenous technologies. At the same time, the design of the activity assumes that the teacher will know what to assess from this activity, as shown in the assessment segment below in table 4:

Table 4: Assessment

Are the learners able to:	Yes	No	Comment
1. identify technologies that need improvement?			
2. discuss the improvements to be made on the technologies?			
3. make improvements on the technologies?			
4. assess whether the improved technologies work better?			

There are both good elements and negative ones from the assessment activity that follows activity 2 (suggested above). On one hand, this mode of assessment allows pupils to know the criteria for making improvements (as in assessment items 1 and 2, which allows for peer assessment) and also to assess their own work (as in item 4, which allows for self assessment). On the other hand, I feel that this presentation of a learning experience (that is, expecting to cover all issues like those listed in the assessment table over a short time in a lesson) is over simplified; considering the difficulties that lie in the process of making improvements to existing technologies. If the process was that simple, the indigenous technologies would not exist in the form they are used today. My argument is that improvements of something demands a better understanding of functional knowledge about how something works and that such understanding might come up during the process of using it. It is from such experiences that one can identify its weaknesses and probably start thinking about aspects to be improved. Furthermore, as there are many technologies in communities, I feel that specification of a few technologies and the underlying scientific principles would give learners a focus and opportunities to resolve important issues on how to improve technologies. Therefore, asking learners to deal with all technologies suggested in the activities might be far fetched.

It was observed that many activities under technologies tend to focus on broader ideas and not specifics as in other regular science topics. For example, a topic on classification of animals directs learners to body structure of animals (e.g. skeletal structure), which are characteristics for classification. Hence, the activities pave the way for learners to discover the useful structures that lead to animal classification. There is

nothing like ask learners to explore how they can classify animals, classify them and report their classification, without directing them to learn the structures that help in classification. It was from such observations that I noticed that there are structural inconsistencies in the presentation of content under indigenous technologies, which depart from the trend of presentation of content from the regular approach.

Summary

In summary, the curriculum sections involving indigenous technologies have many activities that are characterized by obscure and over generalized learning outcomes. The lack of details can lead to a wrong generalization that there are no precise science concepts under indigenous technologies. The sequence of activities is also not realistic because more complex activities sometimes precede simpler ones. For example, it would be easier to learn how something works (and talk about principles) before talking about its weaknesses and then suggest how to improve it. The syllabus mentions the need to let pupils learn principles on which technologies work but does not present activities with clearly defined principles, especially those used in indigenous technologies. In terms of timing, these activities cannot take place in a single activity (lasting two periods or 70 minutes) as suggested. Furthermore, there is no special focus on the distinction of indigenous technology principles, which would be equated or differentiated from regular technologies. Hence, the curriculum assumes that indigenous technologies function on the same principles as western technologies but does not show how learners would learn those principles. In the next chapter (5), I will discuss the issues faced by three primary school teachers when implementing the PCAR curriculum.

Chapter 5: Pedagogical Practices

Question 2: What issues did teachers face during the implementation of indigenous science topics in the Malawi primary science and technology curriculum?

In this study, question 2 sought to unravel issues that teachers faced during the implementation of the new curriculum. The analysis of data accrued from this study yielded three themes reflecting issues of curriculum design, language, and taboos. However, all these issues will be discussed in relation with instruction; focused on how integration of indigenous knowledge played out in the pilot implementation phase. Before the themes that emerged in relation to this question are addressed and analyzed, the three teachers will be introduced with a description of their background.

Description of Teacher's Background

Stella

Stella was one of the forty-five teachers at Mtengo primary school whose staff comprised forty-three female and two male teachers. In standard five, she was one of the three teachers who were responsible for teaching science in each of the three streams of standard five. She shared her class with a fellow female teacher who took half of the subjects.

Professionally, Stella qualified as a T2 primary school teacher from Lilongwe Teachers College in the year 2000, under the Malawi Integrated In-service Teacher Education Program (MIITEP). T2 is one of the highest primary school teacher's professional qualifications in Malawi. MIITEP was a fast track program for training teachers, which was launched in response to the high demand of teachers following a declaration of free primary education in Malawi. So, she was trained in a piece-meal program that followed a modular training arrangement, which was mostly accomplished through self-study, but punctuated with short periods of on campus (residential) sessions. The brief residential training sessions ranged between thirteen and sixteen weeks, which changed as the program was constantly reviewed for its quality of products.

During her teacher training days, Stella learned how to teach science as demanded by the previous curriculum, which has just been revised under the recent PCAR process. Hence, she was familiar with science teaching as stipulated in the previous (outgoing) science curriculum.

By the time this study commenced, Stella had five years of teaching science in different classes. Her class comprised 89 pupils in total, while Mtengo primary school enrolled a total of 1500 pupils. Members of staff at Mtengo primary school were predominantly female teachers. Between the only two male teachers one was the Head teacher.

When she was approached to be involved in this study, Stella was partially willing to participate. At first, all the three teachers from the three standard five class streams offered to participate (upon the request from the head teacher) and in fact all of them begun analyzing the new curriculum documents and also tried planning for the teaching of some topics. However, only Stella remained willing to go through the study up to the end. One teacher among the other two only taught one lesson, while the other teacher, in the third standard five stream, never taught even a single lesson. Due to this situation, Stella remained the prominent participant in this study from Mtengo primary school and I later realized that she was the only teacher who taught the highest number of lessons, amounting to seven. As a result, most of what she did in class exemplified a fair representation of teacher's response to the new curriculum and the report of this study feature more of what she did as compared to the other two teachers from the two other schools.

Personally, Stella is a mother of three and she originally comes from the southern part of Malawi, but her family lives in Lilongwe, the Capital city of Malawi.

Mary

Mary was one of the twenty-seven teachers at Umbu primary school but also one of the four standard five teachers at that school. Mary taught science in one of the two classes in standard five and she shared her class with a fellow female teacher. Her class comprised 115 pupils. Umbu primary school enrolled 850 pupils who were taught by predominantly female teachers. The entire school staff comprised of only two male teachers while there were twenty-five female teachers. One of the male teachers was the deputy head teacher while the head teacher was female.

Professionally, Mary qualified as a T3 primary school teacher from Lilongwe Teachers College in 1996, under a "One Year" primary teacher education program, which

ended in 1996. So, she was one of the last graduates of the one-year program and upgraded to T2 while in the field.

The one-year program started in the early eighties and at first it was only offered at Domasi Teacher's College as a trial version while the rest of teacher training colleges followed the conventional two-year training program. Formerly, the one-year program targeted temporary teachers who had classroom experience but never had a chance to go to college. However, as the demand for more teachers rose, all colleges ceased to use the two-year program by 1992 and reverted to the one-year program, which was considered helpful because of the high output of teachers.

The curriculum for the one-year program was almost like that of the two-year program (in the 1980s and also after curriculum revision in the 1990s), but the one year training program had reduced load of curriculum content because of the brief period of training. However, most of the content was the same. The one-year program had less methodology but more of content because the teachers were considered already conversant with teaching. When all the eight teacher training colleges began that one-year training, the requirement of prior teaching experience could no longer hold because the number swelled beyond the possible rate of existence of temporary teachers. Actually, "school leavers" (or ordinary level school certificate holders) were also recruited for that one-year program.

During her teacher training days, Mary (just like Stella), also learned how to teach science as demanded by the previous curriculum, which has just been revised under the recent PCAR process. Hence, she was familiar with science teaching as stipulated in the outgoing science curriculum. When she was approached to be involved in this study, Mary was very willing to participate although not very sure about how to tackle the teaching of the new curriculum. As the study progressed she was only capable of teaching four lessons because she was also busy with Girl Guide responsibilities at district level, but also went out to a funeral of one of her class pupils who was involved in a car accident. These two involvements run down her intention to teach all what she planned. However, the four lessons that she taught yielded worthwhile findings that informed this study.

Mary, just like Stella, originally comes from the Southern region of Malawi. She belongs to the Ngoni clans in the Southern region but mostly associated with Chewa practices. She is a mother of one teen-age daughter. Her life has been spent in Lilongwe where most of her family members are also staying. Hence, she held a cultural background linked to both southern and central regions.

Chamose

Chamose was one of the three standard five teachers at Utwa primary school. She taught science in both classes for standard five and each class was taught by a pair of teachers. Therefore, Chamose was a floating teacher. The two classes together had 110 pupils. When one teacher failed to report for duties, she taught a class as large as 110 after combining the two classes. Utwa had a school enrolment of 1200 and was under management of a headmistress. The entire school staff comprised of only two male teachers, none of these males participated in administration. The Head teacher and her deputy were both females.

Chamose qualified as a T2 primary school teacher from Lilongwe Teachers College in 1980, under the Two Year primary teacher education program. During the time this study was conducted, she was co-teaching with a male teacher who shared some subjects with her and the third teacher was also female.

During her teacher training days, Chamose learned how to teach science as demanded by the old curriculum, which was also replaced by the outgoing curriculum. However, she had already started teaching when the outgoing curriculum came on the scene. Therefore, she had a broad background from three generations of curriculums. When the headmistress approached her to be involved in this study, she was willing to participate but wondered if there was any remuneration out of the study. Although I told her that there was no money involved, she still decided to participate. However, her comment made me seriously consider looking for a small token of thanks to each participant who went through the study up to the end of the study, although I did not promise anything to anybody. So, her question rewarded her because I thanked all participants with some monetary token which none of them was expecting.

Chamose was a mother of four whose family stayed in Lilongwe for almost twenty-five years. Hence, although she came from the Northern part of Malawi, her life

was mostly spent in the Central region, where her family has settled. She belongs to Tumbuka ethnic group but her husband belongs to Chewa ethnic group. Hence, she is linked to two cultures.

Having described teacher's backgrounds, let us now turn back to the themes that emerged from question 2, starting with the issues related to curriculum design. In this section, five vignettes will be presented which provide evidence for theme 4. Reflective comments by the researcher are embedded in each vignette and are also included in more detailed analysis at the end.

Challenges in Teaching About Indigenous Technologies

Theme 4: Teachers faced multiple challenges while teaching about indigenous technologies because the design of activities in the curriculum does not clearly distinguish between types of technology and does not clearly articulate the scientific principles that come into play.

In this section, let us look at teachers' experiences, while teaching indigenous technologies, that reflect the challenges alluded in theme 4.

Stella's Vignette from Lesson 3 (July 4, 2007)

I arrived at the school around 8.00 am. As I approached the classroom block for standard 5, Stella saw me coming and came out of her class to welcome me. As she approached me, to help with carrying my data collection gear, I asked, "Are you ready?" Stella's response was, "Not so very." I was not sure about what to expect from her lesson that morning. Inside her classroom, I set my video camera on the tripod at the back of the classroom (where the teacher set the chair in readiness for my arrival) and had the video switched on and set it in pause mode in readiness for recording. Thereafter, I sat down and grabbed my notebook and pen to jot down interesting points as the lesson progressed.

Stella introduced the lesson by asking pupils to state some of the indigenous technologies. Pupils mentioned a knife, a ridger, a catapult, and remembered the mortar and pestle (which they learned the previous day). Stella wrote the following topic for the lesson on the chalkboard: "Improving some of the indigenous technologies."

She then began the lesson by trying to prompt pupils to think about how to improve some indigenous technologies. As a class, pupils seemed to fail suggesting such

improvements and due to that Stella asked them to discuss in groups. However, by this time, Stella had not covered problems with some indigenous technologies.

Pupils went into group discussions without being told which indigenous item to consider improving. The teacher came back later with instructions to let pupils choose two technology pieces on which they were asked to think about ways of improving them. Stella formed ten groups but group sizes ranged between 4-9 pupils per group. I wondered why she made such varied group compositions but continued following her lesson. However, all groups were mixed in terms of gender.

As group work proceeded, I observed that students took time before they could find what to do because the teacher skipped the problems associated with some indigenous technologies. She had to re-explain and said, “You are supposed to think about ways to make the technologies work better – by way of increasing their efficiency or strength”.

Stella’s remarks made me wonder if children would understand meanings of the words *efficiency* and *strength*. All these explanations could have been avoided if pupils had a preliminary activity to reveal the weaknesses of the chosen indigenous technologies. Stella seemed to be having some activity-sequencing problem. As she went around her class explaining what they should do I started thinking that the teacher could also have spelled out types of improvements such as speed of production, refining of products, distance covered, amount of force used (e.g. reduce effort, etc.) so that pupils could work on activities that are task-focused within the short class time.

As I saw pupils failing to come up with reasonable ways of improving the named technologies, I started feeling that group work on improving indigenous technologies was quite challenging to pupils. It occurred to me that there was need to think about clearer ways of involving learners to think about *innovations*. There was also need to be more systematic on distribution of tasks. Some of the items that Stella listed on the blackboard were not quite good examples of indigenous technologies. For example, a ridger, a wheelbarrow, an ox-cart, a shovel, a hand fork, a rake, and a watering can were not typically indigenous (or originally developed by local people). They are foreign technologies or hybrid technologies (sharing both local and foreign ideas).

Stella wrote the above named technologies on the blackboard and she probably saw no discord in considering these items as indigenous technologies. This experience made me wonder if teachers had sound knowledge about technologies. As pupils struggled, Stella joined one group and explained that at first they had big cell phones but later they made smaller ones and then she said, “This is what I want you to think about when improving your technologies?”

My reflective comment at that time was, “The teacher’s remark is good but she could have started with an explanation at first or a learning experience that would inform learners about their task.” Better still, she could have given a more realistic problem with one technology characteristic and show the need for the stated improvement and probably ask pupils to think about what could be done in order to improve that characteristic in the technology. A better example would also have been a local technology. As I continued reflecting on this (while Stella went around groups), an interesting incident happened. As Stella talked about the phones, her phone rang. I wondered how phones are managed in classes in our schools during these mobile phone days. Stella did something to her ringing phone and moved on to another group and gave them another example of phones. She said, in the past we had ground phones but later cell phones were produced to improve communication. This was Stella’s strategy of prompting students to think about what they could do to improve some of the indigenous technologies. The ensuing group discussions took a long time because pupils were stuck and the teacher had to keep explaining to individual groups much more than was necessary. Reflecting on these experiences, I thought that the extensive follow up explanations might have been avoided if she had initially explained the task or if preliminary lessons prepared pupils on how they were to tackle improving technologies.

Groups reported in turns and the first turn went to group 1. James, representing group 1, talked about making a stick from *mpira* (*mpira* means rubber in Chichewa and he said that word because he could not produce the English name for an object that he usually called ‘mpira’ in his local language). I could not grasp what he meant. Another boy stood up, his name was not mentioned, and he explained in Chichewa and said, “they should not use a wooden stick but replace it with a rubber

band”. This answer did not make any better meaning either because it did not show what was being improved by the rubber band.

The report from group 2 came in form of a brief phrase as follows: ‘Sharpen a knife.’ After giving this phrase, the group representative also talked about removing the speed of the bicycle. (This did not make any sense because sharpening a knife is always done and on the other hand removing speed in a bicycle does not bring any improvement). I wondered what improvement that would be? Members of group 3 presented their ways of improving their indigenous technologies and the following points came up: (a) We can improve a knife by buying a new one. (b) We can improve a hoe by buying a new one.

As these responses came up, I started feeling that the teacher’s example seemed to have misled pupils somehow. It seemed like her example about new phones meant that buying a new thing results in improvements and pupils thought the teacher was asking them to think that way. Hence, Stella’s example seemed to bear no fruits. Members of group 4 seemed to have been completely at a loss. They did not know what they were supposed to improve. The first two groups tried to think about something, which may not have been very brilliant but could have been shifted to make better sense. I think the teacher needed to give them a better feedback so that they could start thinking in the right direction. The lesson ended without solid resolutions on how to improve technologies.

After-Class Discussion

At the end of the lesson, the teacher asked if there could be additional information provided in the teacher’s guide and learner’s books. She also requested if there could be additional texts and activities in the Teacher’s guide. The teacher finally pointed out the need for teachers to specialize in particular subjects. She pointed out that when they changed classes and subjects they never really grounded themselves so well in *knowledge* of particular subjects.

Stella’s Vignette from Lesson 5 (July 13, 2007)

As I approached the standard five classroom, one child welcomed me right from the car. This was 8:03 a.m. and I was expected to have a lesson observation from 8.05 a.m., running through to 9.15 a.m. as previously arranged with the class teacher. As I walked into Stella’s class on July 13, 2007, pupils stood up and greeted me loudly, as

usual, “Hello Sir!” I answered, “Hello class!” Thereafter I went over to the back of the classroom where my chair was placed. Stella came in around 8.20 a.m. Apparently, the whole school was starting around that time. From the window, I could see pupils milling around and all classrooms were still buzzing with the noise from pupils who shouted at the top of their voices.

The class came to order at around 8.24 a.m. and Stella started her lesson by asking pupils to name indigenous technologies that are used at home. Children named a bow and arrow, mortar and pestle, a ridger, an axe, a sickle, a rake, and so on. It was interesting to note that the teacher rejected a car as an indigenous technology and yet she accepted a wheelbarrow, bicycle, catapult, and a rake. This made me think about technologies once again as in the following digression of thoughts (while I kept my ear close to what the teacher was doing).

It may be interesting to comment that a wheelbarrow is so common in Malawian communities today but they are not indigenous. Missionaries and colonialists who engaged in construction such as building churches, dwelling houses, and offices brought in wheelbarrows that were not originally in Malawi. Obviously, the same group also brought bicycles, which they used for going round the narrow paths before better roads were developed. Rakes too, were not originally part of the implements that Malawians used. Early European settlers or planters brought rakes from their homes. These may have been indigenous technologies from their homes at that time.

Malawians locally make catapults (slings), but the raw materials are a mixture of foreign products and local ones. For example, indigenous people do not make the rubbers that are used in what is termed as a catapult. Indigenous people gather rubbers from bicycle or motorcar tubes, which are foreign. Hence, these are better described as hybrid technologies. However, since people locally produce some of these, it is very easy to confuse them as typically indigenous technologies. This example probably shows complexity of issues surrounding the topic about indigenous technologies. Teachers may need more information and go beyond the taken for granted knowledge to clearly represent issues that they will be dealing with under this topic. I am sure there are many other cases of technologies that are misrepresented as indigenous because of such

complex issues. Teachers may do better if more information would be available to them on the range of technologies and their origins.

As the class went on, I found myself going through reflections over what the teacher was doing. I seemed to notice that the teacher was not quite sure about indigenous technologies. This confusion could have emanated from the Teacher's guides or learners' books since all these technologies were mixed, as I noticed during the preliminary documentary analysis. Therefore, I felt the teacher could have failed to distinguish indigenous technologies from other technologies.

Stella spent some time on uses of indigenous technologies, which I knew were already covered in the previous lesson. I was not sure why she brought this up again. Since, she came in late, she did not show me the lesson plan as she usually did in previous lessons. A few minutes after, she moved on and wrote "Improvements of a bow and arrow" on the chalkboard.

To start with, she orally discussed with pupils how to improve the bow and arrow. Thereafter, she asked pupils to mention some improvements that can be made on a bow and arrow and the following responses came up, which Stella listed on the board:

1. Hard sticks
2. Animal skin – for making a line.
3. Additional sticks for arrows.

Christopher attempted to speak about improvements on a bow and said a *chingwe* (meaning string) would make an arrow go far and not a rubber. The teacher asked pupils to vote if a string would be better than a rubber. Christopher's idea had less votes when the teacher asked the pupils to vote. Christopher's idea was countered by Tiyanjane's who said a rubber would do better. She got more votes than Christopher when the class voted.

At that point, I noted that the ensuing activity started the learning process with a predicting exercise. Pupils were drawn into thinking about possibilities as they were asked to predict what would happen. It was exciting to see what would follow. Unfortunately, the time was coming to the end of the first part of the lesson and so the teacher started winding up, paving way for another topic. She asked pupils to think about making improvements on that lesson, which she said would be done in the next week's

lesson. Inwardly, I said, “This was good. I was then anxious to see what would happen the following week.” This lesson came after we had discussed the weaknesses of her previous lesson.

Mary’s Vignette from Lesson 4 (July 17, 2007)

This lesson was postponed from July 12, when Mary was supposed to teach but failed to do so because one of her students died due to car accident. So she went out to the funeral of her pupil at that time.

As I walked into that classroom, pupils greeted me with the usual “Welcome Sir!” Mary introduced her lesson by saying, “We are continuing with indigenous technologies. In this lesson, you will try using the winnower, catapult, and also a bow and arrow.” One child after looking at the bow and arrow equipment made the following remark in Chichewa: “Ndichosakokeka” meaning the string on the bow is not tight.

The teacher showed various indigenous technologies that she brought for that class. She started with a winnower and pupils shouted, “Winnower!” Then she showed a bow and arrow and pupils shouted, “Bow and arrow.” After showing the two technologies, she asked, “Can we use these two things in the same way?” Pupils replied, “No!” After the introductory exchanges with pupils Mary brought out chidulo (ash), catapults, and bow and arrow. She told pupils that they were going to use the technologies shown to observe problems that are faced when using them. She explained that both the winnower and the bow and arrow were to be used in that class. Then she told the class to go outside and practice using the indigenous technologies.

While outside, Mary started by setting up the target for the catapult shooting. Pupils took turns shooting at the target. More boys participated in catapult shooting than girls. Thereafter, the shooting game turned to bow and arrow and pupils were lined up in readiness for the activity. Pupils took turns in shooting arrows using the bow. The activity proceeded as if the objective was merely shooting using the bow and arrow. Although the objective in her lesson was improving some indigenous technologies, I could not see any trace of activities that would realize such a goal. However, I patiently waited to see what she would make out of that lesson.

Mary changed her shooting activity to “chidulo-making.” She explained, “This is a filtration process, whose filtrate works like soda water.” Two girls came forward to

help Mary set the chidulo-making apparatus. At some point, she explained that what they got from that process was chidulo. Thereafter, she asked children to say what chidulo can be used for in their homes. Pupils unanimously stated that chidulo could be used for cooking “therere”, “chigumu” (corn bread), “masamba” (green vegetables), and the like; just like soda is used. Children unanimously mentioned soda as a parallel for chidulo. An interesting participation scenario was that girls spent more time on chidulo making and only one boy was invited to participate. On the other hand, many boys participated in catapult shooting and bow and arrow shooting than did girls, who were only invited to participate when the teacher noticed that they were not volunteering to participate.

The filtrate from the chidulo-making activity was so dirty. I wondered if the teacher just wanted to show pupils what items are used in filtration or if the aim was to produce a clear filtrate. After using the winnower (as a strainer) pupils tried using the tea strainer for filtration. Two girls were still heavily involved in carrying out the filtration activity.

After the outdoor activity, pupils went back to class. While in the classroom, Mary asked pupils to keep quiet and thereafter said, “Ok. We have tried out the catapult. What were the problems associated with the catapult?” Pupils responded as follows:

- The rubber gets broken
- If you do not handle it properly you can hurt yourself
- If the rubbers are long, it does not go far. (The teacher transposed this statement and said, “If it is short, it does not go far”)

The teacher went on and showed the bow and arrow before asking, “What are the problems with this technology?” Pupils said, “A light arrow is blown by wind”. The teacher further asked, “What can be done to improve it?” One pupil said, “Put it in a heavy stick.” The teacher added, “Or use a heavy metal.” Apparently, this was the answer she was looking for.

Finally, Mary brought out a winnower and asked, “What is this used for?” Tawina mentioned both winnowing and filtration. Then, Mary pointed out that the water which came out was dirty and asked, “What is done to make it clear?” Pupils failed to say it and Mary simply resorted to explaining and she said, “We keep pouring it back into the

filtration basket until it becomes clear.” But surprisingly she did not focus on this as a problem with the technology.

Generally, she concluded the lesson without nailing down the problems observed from the three activities and there was no mention about how to improve the technologies. That lesson proceeded with predominant oral exchanges, such that nothing more than the topic was written on the board up to the end of the lesson.

After Class Discussion

After that class, I asked Mary to say if she had things that she had not done due to any constraints but she said, “No!” I realized that she could not figure out important scientific elements to include in her lesson. We arranged to plan together for the following week’s lesson and see how she would teach one more aspect of the topics on indigenous technologies. We agreed to do so over the weekend and I planned to see her teach that lesson the following week. Unfortunately the lesson, which we agreed to plan together, did not materialize because the teacher was busy with preprogrammed educational activities (Girl-guide activities that she was in charge). However, we partially discussed several possible things she could try. The next vignette shows what Chamose presented in her lesson.

Chamose’s Vignette from Lesson 2 (July 23, 2007)

Chamose’s vignette shows some struggles with improving technologies, misconceptions, planning challenges, and also constructivism issues. Chamose started this lesson by reviewing previous work on types of indigenous technologies. She also talked about scientific technologies (I was not sure what she meant by scientific technology, but just suspected she meant indigenous ones). Afterwards she started talking about *local materials* used at home.

Pupils’ responded to her questions as if they had previously rehearsed the lesson. After introduction, the teacher displayed a chart on which there were local technologies, which she referred to as local materials. The teacher drew most of the local technologies on the board. She then focused her attention on local things used in the home. Among such local things, she developed a list of items as follows: a clay pot, toilet, pestle and mortar, lichero (winnow), chikwatu (leaf storage bag for preserved vegetable’s), and mbaula (local stove). The teacher had to guide learners to mention “mbaula” but

surprisingly nothing was said following pupils mentioning of mbaula. Following this discussion, Chamose categorized indigenous technologies (as shown in table 5) into three groups as follows:

Table 5: Classification of Indigenous Technologies

Farming	Hunting	Fishing
Hoe	Stones	Fish trap
Sickle	Bow and arrow	Hook and line
Panga	Catapult	
Axe		
Folk		
Shovel		

After showing the classification of indigenous technologies, Chamose commented that indigenous technologies have improved over time. For example, grinding stones were used to make millet or flour but now grinding mills perform this function. This explanation made me start reflecting on the objectives outlined in the PCAR curriculum. To me, the PCAR curriculum aimed to explore ways of improving existing technologies and not what has already been improved. Looking at the flow of her lesson, Chamose did not previously decide the groups that were going to deal with specific topics. In addition to that, the way she approached the lesson, made me think that she was only covering the topic superficially, as she dwelt more on discussions about groups of technologies other than their functional aspects.

As the lesson progressed, group discussions took more than 20 minutes but many pupils practically said nothing tangible. I talked to two groups. One group was discussing improvements on hunting with stones while the other talked about fishing improvements. Interestingly, the group that talked about fishing did not even know the Chichewa name of a *fish trap* (*Mono*). They had never fished and probably had never seen a hook and line for fishing. Their discussion was, apparently, out of a vacuum.

Inwardly I thought, “This was one example of a lesson that would best be taught through practical work.” Immediate things that came to my mind were: developing a fishpond, stocking fish, and harvesting them. Just like vegetable growing or farming, this

would bring up all the uses of indigenous technologies. Under uses, students would learn the strengths and weaknesses of indigenous technologies, which would lead to discussion of the types of weaknesses. It is from such realization of weaknesses that students would clearly start thinking about what could be done to improve the technologies and then they would engage in meaningful planning for making some improvements on such technologies. In this way, thinking about improvements on the implements that they have used would not be as hard to think about, as was the case in this more abstract lesson.

Focusing back on the lesson, I noticed that English communication in Chamose's class also made children give wrong expression of their ideas and yet their Chichewa discussions were brilliant. When students had completed their presentation of group discussions, the teacher said, "Now let us go over" and the following came up from the teacher as she said, "Chidulo in the past is now replaced by soda." The teacher elaborated (adding Chichewa expression) "they *tcheza* chidulo and after the water has drained, they turn it into the salt." Through this comment, Chamose had loosely introduced a misconception about the relationship between *chidulo* (locally made soda) and common salt. Chidulo is similar to soda but not common salt. Therefore, this was an example of words that have loaded meanings in vernacular languages. In Chichewa, chidulo and common salt can both be called salt (*mchere*) but the products are not exactly the same in their properties. Soon after talking about chidulo, Chamose's less

After Class

At the end of the lesson, I talked to Chamose to check what she planned to do next. She said that she wanted to hear from me about what she could teach next. Chamose's request demonstrated planning problems. Earlier on, she asked me if she could plan per week in order to look for information, but Chamose's request (about what she could do next) appeared to indicate she thought all expected work was covered under the topic of indigenous technologies. However, despite her planning problems, Chamose seemed to be aware about activities that can be carriers of many scientific concepts (e.g. farming and house chores) but she did not make use of that knowledge at the planning and teaching phases. Hence, I engaged her in a conversation about possible things she could think about and later asked her to go ahead and plan another lesson on the same topic.

Chamose's Vignette from Lesson 3 (July 24, 2007)

July 24 2007 was a cool day and students were still writing the end of term examinations. When I arrived at the school, the teacher was busy grading. I pronounced my arrival in readiness for the 9.30 (a.m.) class. I arrived at the school 20 minutes earlier to give Chamose time to settle down and get prepared for the class. At 9.40 a.m., the teacher came but only to say, "Excuse me! I am not yet ready". She was waiting for a meal to abate the effects of diabetes. By the time pupils entered the classroom (around 9.45 a.m.), forty-four pupils were present (21 girls and 23 Boys). There was a very low attendance on that day.

The lesson begun at 9.50 a.m. Chamose started the lesson by saying, "Yesterday, we categorized indigenous technologies in the following categories: (1) In house, (2) Farming, (3) Hunting, (4) Fishing, and (5) Rhythm." This was a good recap of previous day's work. Following this introduction, she asked pupils to list examples of technologies under each of the named categories. Eventually the following list under each category came up:

Home: clay pot, Lichero (winnowing basket), toilet, grinding stone, pestle and mortar.

Farming: Hoe, sickle, gun, spear.

Fishing: Net, fish trap, hook and line.

Rhythm: Drum.

Chamose repeated talking about old technologies and current technologies, which replace the old ones. In her own words, she referred to old technologies as, "what they used that time." For example under rhythm, she explained that in the past drums were used for communication such as announcing that there was beer but today people use telephones. She also singled out a treadle pump as a new technology and engaged pupils to talk about its advantages and disadvantages as follows:

Advantages

Supplies water to a large area

Disadvantages

One gets tired (said by a student)

After talking about advantages and disadvantages of a treadle pump, Chamose engaged pupils in talking about advantages and disadvantages of a gun. Under this example, pupils gave the following points, which were listed on the chalkboard:

- You kill animals (Chamose added, "You kill an animal at a distance.")

- It is expensive.

Notice that Chamose's focus was not specifically on indigenous technologies. She covered all technologies in general. Furthermore, her discussion with children was basically focused on utility and not scientific elements.

At that point I started realizing that Chamose followed the syllabus according to how it is prescribed and not according to what I asked her to do, which was to select topics that are dealing exclusively with indigenous knowledge. As I thought about this, she distributed pieces of paper on which pupils were asked to write advantages and disadvantages of some technologies. This activity went on for so many minutes after sending pupils in their groups. Being interested in what pupils were doing in groups, I joined one group (of six pupils) but surprisingly, pupils were extremely quiet. In that group, one pupil held a piece of paper, which had some points written on it. I only wondered when such points were written given the quietness of the group. I barely stood one and a half meters away from that group (with my camera) but hardly heard any contributions from group members.

Seven groups were made, each having 6-7 pupils. Pupils mumbled inaudible sounds in their groups. On this particular day, the teacher did not bring teaching resources for this class. After some time, the teacher ordered pupils to go back to their places as she said, "Now in your places." The following activity was group reports, which went as follows:

Group 1:

Toilets – encourage hygiene (advantage) but are difficult to take care of (disadvantage)

Group 2:

Clay pot – The child who was supposed to report failed to say out what the group had put forward. The teacher checked with the group's piece of paper. What was written was: One disadvantage of clay pots is that "it expands when heated and mixes with water." I said, "Really?" That sounded like a wild guess?

In this lesson, pupils' participation was mostly passive. The teacher did extensive writing on the chalkboard. At some point she just called for all the papers from group work and kept them on her table and jotted the points on the board one at a time. So much time was spent on group plenary, which mostly involved jotting the notes across

the whole chalkboard and yet pupils did not copy that work. I started wishing she had a faster way of dealing with the plenary in order to spare more time for issues that can lead to spotting weaknesses of the technologies, which would lead to thinking about improving technologies. After some time Chamose said, “On a pit latrine, you can put ash in the pit latrine to avoid smell.” However, she did not say what category of science this was, that is, whether it was indigenous or mainstream science. This went on up to a point where Chamose said this is the end of the lesson.

Interaction With Chamose After Class

At the end of the lesson Chamose admitted that she could not handle some of the topics under technologies, e.g. *improvements*, because she had no knowledge. In her own words she said, “I do not want to cheat there.” She also stated that it was not easy for her to teach this lesson. She had to send children to ask their parents about some technologies. I told her that what she did was actually what she was supposed to do when she did not have knowledge but she took it as a weakness and was trying to hide it. Hence, her lesson had funny arrangements during group work because she was trying to conceal that pupils had brought their group responses from home. This was a good example about use of funds of knowledge but the teacher did not want me to know that she was using elder’s knowledge.

Planning Challenges

All Teachers Generally Felt Challenged Right From The first time I handed over the curriculum documents. Mary could not immediately start writing her scheme of work because she was not sure about what to write. It took time for her to write her scheme, which finally happened because her colleague, who taught in standard one, helped her. Her colleague had already been oriented to the roll out of PCAR curriculum for class P (formerly called standard 1). At this point let me walk you through the challenges that came to my attention.

Although only Mary expressed the need to be helped with scheming, Chamose had similar problems. In fact, she failed to make a four weeks’ scheme of work. Instead, she asked if I could allow her to plan on weekly basis so that she could gather more information to help her make a good scheme. Stella’s scheme was rather shallow, although she did not complain. She probably had no idea about details to be filled there

because the design of the PCAR science and technology curriculum did not include more details, especially on indigenous technologies. Therefore, it was not surprising that her scheme of work lacked details.

So, practically, making good schemes was challenge number one because the content presented under indigenous technologies was not densely supplied with content details such as learning outcomes, scientific facts or principles about indigenous technologies, and the scope of content to be covered was not obvious from both the syllabus and the Teacher's guides. Even the content shown under activities lacked details of scientific principles, which meant teachers had to figure out the kinds of concepts to teach on their own. This also made lesson planning difficult because the fine details of content were elusive in the Teacher's guides and learners' book.

While the content was that scarce, both the syllabus and the teacher's guides approached the work on indigenous knowledge somewhat differently. The syllabus presented some indigenous technologies separately (such as the topic of indigenous technologies is not mixed with other technologies in the syllabus) but the teacher's guides mixed all technologies together. The mixture of technologies in the teacher's guides might have given teachers a wrong impression that all those technologies are indigenous. Hence, some of them failed to distinguish indigenous technologies from the rest of technologies. In some cases the new PCAR syllabus omitted advantages of indigenous technologies as well as advantages of some taboos (to be discussed under theme 6). Such omissions might have affected teacher's planning because they were not sure about what to do. Hence, the design of the curriculum documents affected teachers' efforts to plan for teaching as well as delivery of their planned lessons.

Complexity of Technologies

Some activities under indigenous technologies were noted to bear challenging concepts or more complex principles than the level of pupils' thinking, as remarked by Mary. Mary pointed out that work on innovations was "tougher for the level of pupils". My assessment was that the topic was not only tough for pupils alone but for teachers as well because they all confessed that the work was difficult for them. Improvements on mortars were clearly mentioned to be difficult by all teachers. Therefore, teacher's remarks about content level of difficulty agree with my findings during documentary

analysis. My assessment showed that different technologies worked on varied principles, some of which could be more complex than imagined. Hence, giving pupils a wide range of technologies (in the curriculum documents) may be impractical to teach, just as giving activities without stating the kinds of principles would be a problem for teachers to decide what to teach. For example, cyanide extraction is mentioned in the syllabus, but not mentioned in the teacher's guide. I suspect that during the writing of the teacher's guide, curriculum developers noticed that the ideas involved in cyanide extraction would be more complex than they imagined at an earlier curriculum development stage. To handle cyanide extraction, teachers need higher knowledge of chemistry to understand how cyanide is neutralized and extracted from cassava. The chemical nature of cyanide needs to be known and its effects understood too, if teachers are to successfully handle this work. Furthermore, if this work has to be taught at primary school level, this content needs to be toned down to suit pupils' level of knowledge. Otherwise, the topic has to go to secondary level or above. Now, presenting such kinds of items under the big title of indigenous technologies demands that teachers must decide what to teach and how far to go (in terms of scope). On the other hand, existence of a topic in the syllabus but not in the teachers guide presents a dilemma in decision making as to whether to cover that work or not. When details are missing in the curriculum documents, the challenge of planning and teaching grows even bigger for teachers.

As I saw teachers trying to teach work on catapults and arrows, I discovered that female teachers struggled to explain how catapults, bows, and arrows worked, since they never used such items in everyday life due to their gender roles. Hence, asking a female teacher to explain the intricacies of how a bow or catapult works forces her into tough choices about what aspects to consider in her teaching. Besides being ignorant, the teacher might fail to make appropriate choices of materials to use and assess learners' work as to whether it is done correctly or not (according to cultural specifications as well as the science involved). If the curriculum documents fail to show such details, it puts teachers without such knowledge in a tough situation. Hence, all teachers expressed that they had problems.

This brings us to think about curriculum designers' assumptions (that may be wrong in this case) about teacher's capability to teach prescribed curriculum. The

foregoing experiences reveal that not all teachers may be well equipped to teach some work on technologies as it might have been assumed. There seemed to be knowledge gaps created by gender roles, which curtail exposure to some forms of cultural knowledge (which the current curriculum puts value on). Those who lack such knowledge will obviously fail to do a good job on teaching, unless something is done to show them what to do.

Range of Technologies

Most of technologies required organization of practical work. Given the nature of activities involved under indigenous technologies, there is very limited time that teachers would accomplish even just three improvements of technologies with a real sense of improvement. The suggested range of technologies to be covered in the syllabus and teacher's guides present a big challenge on how to cover technologies of various types in terms of understanding their principles and also improving *some*. The use of the word *some* in relation to types of technologies used in the curriculum is indefinite. If a teacher would try *some* technologies with great zest to enable learners to have good exposure to the technology, one other big challenge would be the provision of resources to go round the large classes in Malawi. The issue of resources in general will be discussed in detail in theme 9. For now, let us focus our attention on language issues that emerged from this study.

Propriety of Instructional Language

Theme 5: Integration of indigenous knowledge made teachers struggle to come up with scientific terms and vernacular words that bear scientifically relevant meanings.

Instruction in science largely depends on the use of words, both in the vernacular and in scientific terms. One would ask, "How do words matter when teaching about indigenous technologies?" Integration of indigenous knowledge brought up a new dimension of operations in a science and technology class. Teachers found themselves with new tasks that required new knowledge and skills. One of the essential assets that teachers required to function well as they helped learners to make the most out of their learning was knowledge about words that would relay appropriate meanings to pupils. This became necessary since standard five pupils are in the first class, where instruction begins to use English, as opposed to vernacular language which learners were used to in

the lower classes. Since standard five is a transitional class, teachers are forced to use both English and vernacular languages. The issue that sprung up in this study was the use of appropriate words which can help learners understand science and also using words, in vernacular language, that maintain scientific meanings. Selection of appropriate words by the teachers proved to be an issue worthy of discussing in relation to effects on teaching and learning. Hence, I turn to the issue of language on learning as played out in this study.

As I talked to teachers and saw them teach, I noticed that the integration of indigenous knowledge in science and technology forced teachers to search for vernacular words that bear scientifically relevant meanings to fit explanations during instruction of indigenous technologies. Choice of appropriate words became necessary as teachers dealt with (a) measurements in investigations, (b) thinking and helping learners talk about parameters for investigations, and (c) explanation of concepts under study.

As teachers organized and taught lessons on indigenous technologies, they tried hard to choose words for instruction that they considered helpful but in some cases they could not precisely articulate meanings or explain ideas about indigenous technologies. The following lesson vignette from Stella illustrates typical language issues that came up in relation to explaining scientific concepts and processes.

Making and Using a Bow

Stella's Vignette from Lesson 7: (July 19, 2007)

Stella's last lesson was taught on July 19. July 19 is an education day in Malawi. As a result fewer students came to school for this specially arranged lesson because it was a day of celebrations. That lesson was basically an extra lesson after negotiating with the teacher that she needed to extend the ideas that she left hanging under indigenous technologies. The teacher started the lesson by explaining that they were continuing with indigenous technologies. She introduced the lesson by asking pupils to list indigenous technologies. Pupils listed the following items in response to Stella's question: Sickle, wheelbarrow, bow and arrow, a hoe, bicycle, catapult and an axe. Stella asked Mseka to come up front and demonstrate shooting out an arrow within the class. Stella cautioned Mseka not to throw the arrow very far.

After a brief arrow shooting demonstration (which sort of represented pupils practice about using the bow and arrow), the teacher wrote the following on the board:

Things needed for making a bow

- Line made from a rubber band,
- Tire,
- Twine
- Animal skin

Thereafter, the teacher explained about the parts of a bow as she said, “The line of a bow is made from a car tire”. By saying ‘line’, I suspected, Stella meant “a string from a car tire.” Her instruction was not very clear to me and I suspect pupils as well were not sure, unless they were used to what she meant by line. All the items that Stella wrote on the board were materials for making bowstring. However, some of the items listed were not conventional types of materials such as rubber, twine, and tire. As that lesson progressed I recalled that the string for a bow is traditionally made from an animal string. The best string for a bow also comes for specific parts of the animal skin, for example the neck region of an animal.

Stella proceeded with her lesson and asked one pupil to go up front, to demonstrate how to shoot varied sizes of arrows. This was her way of making the source of force uniform in order to correct mistakes from the previous lesson, whereby the child broke two bows. However, it was not a solution to conducting meaningful investigations, which demand that all pupils should experience and discover what goes on when doing activities such as shooting arrows using a bow. Her approach disengaged many children from thinking about strengths and weaknesses of the indigenous technologies.

Bows with different types of string were used. At the end, Stella asked pupils to state or point out the type of bow “which gave good results”. At that point I wondered from which learning experience pupils could have gained knowledge to respond to her question since there was no time when she asked pupils to say or measure the distance covered by the arrows shot from different bows. Again, the arrow shootings were only done once, such that there was no chance to gather sufficient data, which could be averaged to come up with a figure that is close to the realistic one. Stella did not seem to follow experimental procedures as demanded in science. I also wondered if the arrows

were of the same type, size and weight. These parameters would bring out varied results in the shooting exercise, which may not necessarily have arisen from the source of force, which the teacher was thinking of controlling.

As the lesson went on, one boy explained that *linya* (a string from tires) does not do well because “it gets stuck in the arrow”. That comment was from a child’s reasoning. I wondered if the teacher would probe its validity. However Stella did not pursue this way of thinking, neither did she try to practically support or disapprove this kind of reasoning? I wished she followed up the hypothesis from her pupils, but she did not. She moved on to the next part of the lesson in which she asked pupils to compare two bows and this time she asked someone to collect the arrows and check how far apart they were. After a couple of arrows were shot, the boy who collected the arrows and checked how far apart they landed said, “The arrows were almost on the same position.” Another boy was asked to throw the arrows and that boy broke two arrows. Stella remarked, “You are overstretching the bows!”

This experience made me look back at the need for instructions that could avoid such experiences. I still thought, “Pupils needed instructions about how they could pull a bow string. Such instructions would include stating the distance that a string would be pulled away from the bow stick. The teacher could have predetermined a range of reasonable distances that an arrow could move through away from the starting point. Prior trials could have helped generate instructions about best distances to pull the arrow through (without breaking the bows) but significant enough to show the differences of arrow movements. The set of data obtained from that range of arrow shootings would avail meaningful data from which to draw conclusions.” Otherwise, in that lesson, I noticed that the teacher and the pupils were drawing conclusions from mere reasoning and not from the data collected from the classroom experiences/activities. Pupils gave their opinions - some from class experiences but others from mere reasoning.

During that part of the lesson, I noticed that the teacher found it hard to find convincing explanations. In the next stage of the lesson, the teacher used pupils’ reasoning and asked them to tighten the strings as a way of improving performance of the bows. At that point, I started seeing pupils thinking about what could be done to improve the bow and arrow’s performance. Stella used Chichewa language to prompt learners to

explain some issues in Chichewa. This strategy enhanced pupils' participation, reasoning, and expression of ideas. Then, the outdoor activities ended and the pupils went back to class.

Inside the classroom, the teacher began classroom work by asking questions in English as she said, "What kind of tree should we use for making a good bow?" Pupils were quiet until she rephrased her question in Chichewa. Then, Chimwemwe responded and said, "a hard stick." Many pupils could not respond and so Stella decided to end her lesson, after those brief responses and without consolidation. That was Stella's last lesson for the whole study session as well.

Stella's Reflections

A good example of issues about words are illustrated in the following dialogue with Stella, which took place after observing this lesson, which also represents what I saw in other classes as well. In the following dialogue, take note of my comments (reflecting my analysis) inserted in segments of what was recorded as a free running dialogue:

A: Ok. I remember that at one time one pupil was trying to shoot an arrow and the bow got broken. How would you avoid the breakage of the bow, like at that time?

S: Ok. I think you can avoid that by controlling the pulling.

A: How would you control the pulling?

S: You can pull bit by bit and not using all the strength. You have to study it by pulling slow by slow using little strength and not all the strength that you have.

In the above dialogue Stella struggled to explain how she could give instructions that would avoid breakage of arrows. She used words like 'bit-by-bit' and 'slow-by-slow', which miss precision of factors, that led to breakage of the bow such as amount of force and critical tension the bow could withstand. Use of words, like bit-by-bit, did not clearly convey the meaning of the magnitude of force that resulted in breakage of the bows. This gave me the impression that Stella's instructions could affect the precision of meanings she wished to convey in English words. Let us see how she thought in the next segment of the dialogue,

A: Let us suppose that you were giving instructions to children. What would bit-by-bit mean to them? Or how would you put it so that they could know exactly how to do it?

S: I would express it in our vernacular language so that they get what I want them to do.

A: Like what would you say in vernacular language?

S: Mukamafuna kuponya muyambe kaye kukoka pang'onopang'ono.

Musagwiritse ntchito mpamvu zanu zones kuti muwone kuti mtengo omwe mukugwiritsa ntchito ugwirizane ndi mphamvu zomwe mukugwiritsa ntchito.

(Stella's statement translated to English reads as follows: When you want to throw an arrow using a bow, start by pulling little by little. Don't use all your strength so that your strength matches the wood that you will use)

As you may have noticed, giving instructions about manipulation of a bow demanded specifications about units of measurement or force of pulling but such units did not come out of Stella's words. However, linguistically, Stella was forced to swing between Chichewa and English, but even then, pulling "bit by bit" and "kukoka pang'onopang'ono" did not change the meaning and clarification of the measure of force which could save the bows from breaking. Here was a case in which the teacher thought she would clarify issues in local language but failed to do so. This could arise from the teacher's inability to figure out appropriate meaning but also lack of idea about issues she were dealing with. Hence, the use of English as well as Chichewa to come up with appropriate meanings may depend on what the teacher understands about the goals or outcomes of the activities. In this case, the teacher was dealing with a new situation and therefore she could only do what her knowledge could provide. I would imagine that many teachers would face similar struggles to come up with appropriate words.

This far, you may have spotted some language issues from the vignette that you have gone through. One of these, which almost came as a chronic mistake, was the use of the word "line" which Stella used in reference to a bowstring and rubber bands. If a child knew the word line in mathematical understanding or other meanings, it could easily confuse that learner unless the teacher explains the meaning of that word. Use of words with multiple meanings (like line) could affect communication even between

learners, and in the process jeopardize peer assessment, which is suggested as one of the methods of assessment. Hence, learning would be greatly hampered because of wrong choice of words. At some point, Stella simply mentioned the words *efficiency* and *strength*, but she did not explain what she meant. That may have contributed to learners' failure to understand what to improve.

More Reflections On Stella's Class

As I saw the bows breaking again, I realized that they were not using the right materials for making bows. This experience made me recall some names of the best trees for making bows in my Tumbuka language (mtowo and thomboji), and this reminded me that I never learned these names from school but informally from my father and other elders who made bows when I was young.

My father used to make bows and so I clearly recalled the requirements for making a strong bow. My father particularly liked using thomboji tree when making bows. He used to say that the wood for thomboji resisted attack from weevils and made a strong bow. To make a good bow, he used to cut a tree of reasonable size and age. While fresh, he shaped it so that either ends tapered to allow shaping while the wood was still fresh. To shape the bow he used dry wooden pieces, shaped as desired in a bow. The pieces of wood used for shaping the bow were tough enough to support the slender shaped parts of the bow-ends. My father shaped the bow-ends by tying them in close contact with the curved dry wooden frames (using tough ropes or hides) and he let them remain like that until the bow dried. When the bow was fairly dry, he removed the hard wooden pieces used for shaping the bow ends. As I reflected on these details I started thinking that the length of the bow was probably according to preference and a person's height. The tapering ends of a bow were then bored to allow the fitting of a string. Holes were made using a sharp red-hot needle that was first put in red-hot charcoal fire. After boring the holes the bow was smoothened using broken glasses. Extreme ends of the bows were beautified using animal strings or fire markings and finally some castor seed oil was applied on the surface of the bow. The oil from castor seeds (*Mono* in Tumbuka and *Nsatsi* in Chichewa) was very popular by then and this helped prevent cracking and also made the bow last longer.

This flashback only reflects on the processes for making a bow and not the making of arrows. Arrows too were made in various shapes of arrowheads, made from wood (assorted shapes) and metal (assorted shapes too). Arrowheads had different shapes and weight, which could have had an influence on how far they could go. And yet, turning back to the lesson, the teacher had diffuse ideas about all these. Stella was not aware that the broken arrows were the result of using wrong types of trees for making bows. She kept on asking pupils to suggest improvements of a bow by referring to types of string and yet the force for shooting an arrow comes from the bow and not the string. Stella's experiences with bows started giving me a feeling about the cause of lack of insights on design of lessons and extension of classroom ideas, which arose in the course of teaching. Through the brief discussion with the teacher I reflected on all these things and noticed that there would be wide variation on how teachers would handle the lessons on indigenous technologies, based on their prior cultural experiences and how they make use of elders who know some interesting ideas on these technologies, in particular. Stella may also have not developed cultural knowledge about bow making because she is a woman. In Malawi, women do not use bows. Hence, teaching about some of these technologies might be affected by gender roles, which may advantage or disadvantage certain categories of teachers.

As I reflect on these lessons, I started feeling that while cultural knowledge was distant to draw relevant ideas from, for some teachers, the science involved in the indigenous technologies seemed even more distant. Teachers with low academic knowledge (as is the case in Malawi) seemed to have big challenges in embracing the teaching of work on indigenous technologies. This arises because of complexity of ideas involved in the technologies. Having mentioned cultural knowledge disparities, let us now turn to issues that came up in relation with cultural knowledge in a topic, other than technologies.

Conflict Between Science and Food Taboos

Theme 6: Teachers lessons on taboos deterred them from engaging learners in meaningful cultural issues that relate with science beyond stereotypical constructs influenced by negative representations of cultural practices as defined in the curriculum.

Stella's Lesson Vignette: Food Taboos (July 13, 2007)

On that day, Stella's lesson was broken into two segments. In this part of the lesson, she was teaching about food taboos. She spent some time trying to recollect what she had planned for that lesson. She spent about five minutes looking at her notes. *She was trying hard to avoid making mistakes.* Before starting the next lesson, she asked if I could give her two minutes for her to look at her lesson plan. Then, I noticed that she had her lesson plan but only failed to give me at the beginning of the lesson.

After a quick perusal through her lesson plan, Stella started her second part of the lesson by asking pupils to mention the foods that they ate in the morning. Pupils, in turn, listed porridge, groundnuts (peanuts), bread, rice, zitumbuwa (Malawian corn bread), sweet potatoes, cake, doughnuts, oranges, cassava, Irish potatoes etc.

Stella asked pupils to say the reason why they ate before coming to school?

Mzondi said, "Because it is energy"

The teacher corrected the sentence (by writing on the board as follows: "Food gives us energy") without telling the child what was wrong with her sentence. As this happened, I started thinking that Stella's actions displayed pedagogical flaws, since she did not say what was wrong with the statement given by the child. Later on another child said we eat because we get carbohydrates, while another child mentioned vitamins. Then Tamara stood up and said, "We get legumes from food."

At that point I noticed that the linguistic problems seemed rampant in the ensuing exchanges in that class. Interestingly, as the teacher introduced food taboos and beliefs, some pupils were busy talking to each other. Apparently, they were trying to make sense of what was going on. The teacher tried to clarify the meaning of beliefs and taboos. Upon mentioning food taboos, one pupil mentioned *pork* but the teacher told pupils to concentrate on those foods that they are stopped to eat *but it is not true*. She added '*ndizabodza*' (meaning untrue in Chichewa). Following that comment from Stella, I noticed that there could be some miscommunication from the teacher but patiently waited to see where the lesson was going. Then one girl mentioned eating "mbewa" (mice) as a taboo but this met a big interjection from other pupils.

A large group of pupils told her that nobody should talk about Mbewa as a taboo. They spoke in Chichewa, in unison, "Mbewa zokha ayi mutilekere!" (Meaning do not

tamper with mice in this debate of taboos). It really became emotional and cultural. That class was likely to have pupils from different parts of the country and so there was a clash of ethnic beliefs and food preference. Let me point out that the site of the study was in central region of Malawi, in which mice eating is highly popular. Therefore, most of the pupils were from that mice-eating culture (different from Stella's) as measured from the interjection. However, Stella did not see it as a big deal. Meanwhile, she turned to the chalkboard and wrote the following responses from children on taboos and the reasons attached as they came along:

- Eggs are a taboo. (Why?)
 - People die.
 - Will not bear children when grown up.
 - Ena amati mumapezeka mwana ndiye akamudya amatulutsa ziwengo (meaning, some people say that if one eats an egg with a growing embryo one gets some skin reactions).
 - Eggs for ducks? (This was totally off the point)
 - Ena amati mukadya mazira a bilimankhwe (meaning, some people say if you eat eggs of a Chameleon)... Before Tsala could not finish her statement, a great noise erupted from the rest of the class. It appeared Tsala misunderstood the issue under discussion. The topic was only dealing with eggs, which were eaten (and not of wild reptiles like Chameleon).
 - Mitu imakhala youma. (Eating eggs makes people to have low intelligence at school). This response was more like a wild guess.

I noticed that there were new versions of taboos and beliefs. I wondered what that could mean about existence of taboos and their proliferations in the society? Was this a display of ignorance or a recreation of taboos or place-based taboos? I could not tell. Stella continued writing pupils' responses on the chalkboard.

- Peppers (what about them?)
 - Makes people to have bad vision (*I think she was talking about pregnant women*). There is a belief that pepper eaten by pregnant women would affect the child sight (poor vision). Later on Stella explained to the class and indeed

she meant a pregnant woman. The teacher wrote, “Pepper – women should not eat because when they conceive that child will have eyes affected. The teacher used Chichewa to clarify the taboo.

- *There* (a king of Okra) (Why?)
 - A child who eats *there* will have epilepsy and the epilepsy never ends.
- Bakayao (a kind of Tilapia fish) – Why so?
 - Izi ndi zoonu. (Meaning this is true) I wondered if some of the taboos mentioned were really true?
- Sugarcane (What about it?)
 - Another child said that people said that eating sugarcanes causes dry skin but she vowed that she would not stop eating sugarcanes.

After going through all the taboos, the teacher refuted that eggs would make people unproductive. She asked the class, “Is it better to eat different foods?” Pupils said, “Yes!” Pupils also said that eating eggs or certain foods that are forbidden does not create a problem. [*This was quite a sweeping statement and a clear expression of resistance against cultural beliefs*]. Children vehemently said NO to taboos for eggs. Their reason was, “Mazira amakoma” (eggs are tasty). Another child said Mazira amapeleka mphamvu (eggs give energy). There was a clear indication that children in this class valued eggs as their good food and therefore did not believe in the taboos concerning eggs.

Following this discussion, the teacher put up a chart showing all the food groups and took pupils through all the foods that they are supposed to eat. After doing that, there being no questions, the lesson ended.

Reflections on The Lesson

The lesson on taboos provoked cultural conflicts among the learners. Although, this was not planned, I felt it was a healthy development that ought to justify why science should also include debate of ideas and not only following the prescribed notions about knowledge. The controversial debate could open pupils’ minds to many alternative ideas, as they engage in reasoning processes, as constructivists contended.

Stella’s perception that all taboos are negative curtailed her initiative to capitalize on pupils’ conflicting views during her lesson. Pupils raised a heated debate about taboos

in connection with eating mice as a taboo. As pupils emotionally debated and differed in opinions about labeling mice-eating as a taboo, Stella simply dismissed their arguments and said, “That is not a good example because a taboo is only that which is not true (*ndizabodza*).” Stella stressed in Chichewa. Her single extreme notion about taboos, in relation with what she considers as having negative effects, made her miss the teachable moment. The ensuing debate opened a window for engaging learners in a meaningful debate about diet and the issues that surround some cultural beliefs.

Stella failed to connect pupils’ debate to the six food groups and score her point about mice being a source of meat products to those who partake in mice as a meal and that the current nutritionist in Malawi Ministry of Education (MOE) has listed mbewa as one of the meat food products among some indigenous people. However, this way of thinking does not mean that all people will eat mbewa. Hence it would be naïve to ignore the assertions of one group of pupils who thought that mice-eating was a taboo. In that class, it was possible for Stella to show pupils that taboos are actually created based on preference and other reasons. For example, those who shun eating mice may have experienced reactions to eating mice. So, it cannot be totally dismissed that their perception of taboo is wrong because people have different ways of knowing.

Just as pupils differed in class, people will always differ on their choices about what to eat. Some people choose not to eat certain foods by choice, therefore not eating that particular food could be labeled as a taboo to them but it does not mean that it has to be stopped by all means. She could have educated pupils that different societies practice different food habits. If such preferences go to extremes they could affect people but not that the act of eating something automatically brings negative effects. She could also have justified why some foods are treated as taboos. This way, she could balance the argument and resolve the conflict without locking learners to one way of thinking.

In this class, Stella could also have engaged learners to think about substitutes for mbewa. She could also ask pupils to mention all other small animals that people eat including birds, insects, caterpillars and the like. Hence, instead of merely stressing that food taboos are wrong beliefs about foods that must not be eaten, she could have also engaged pupils in thinking about how taboos are instituted and that there are multiple reasons why taboos could emerge. Such a debate would bring up better understanding of

cultural values that could influence food choices. It could be even better to slot in advantages and disadvantages of taboos.

The teacher could have assessed her pupils from their choices of food and renegotiate the meanings of taboos, other than holding onto a single notion about taboos, which made Stella miss the teachable moments.

Absolute Belief in Print Authority Subdued Reasoning.

Teacher's beliefs about taboos seemed to mirror the ideas in the teacher's guides. This seemed to indicate that teachers have absolute belief in authority, and in this case print authority. While it is good to submit to authority, issues of education do not work so well if you present them in a closed fashion. Due to that way of thinking, I believe that teacher's attitudes, if all teachers could have such dispositions, would compromise their initiatives in promoting meaningful learning in science. Additionally, stereotypes developed by such attitudes would also reduce teachers reasoning and make them work like programmed machines. Instead of kindling creative thinking, this approach to teaching would lead to passive learning leading to neglect of culture. As proposed by Stella, food taboos could as well be left out from the syllabus because they are not helpful.

In the next chapter (6), we further discuss teacher's conceptions and issues with integrating indigenous knowledge and technologies in the science curriculum.

Chapter 6: Teacher's Conceptions of Indigenous Knowledge

Question 3: How do teachers conceptualize the role of indigenous knowledge in the newly reformed primary science and technology curriculum?

Since indigenous knowledge (IK) has been freshly introduced in the science and technology curriculum, research question 3 was asked as one of the three main research questions in this study. This research question aimed at learning what were teacher's understandings about application of indigenous knowledge and its considered role or value in the new curriculum in connection with benefits to learners. An opportunity to learn teacher's impressions about the role of IK to learners arose during the interviews that were conducted at the end of the classroom observations. Because indigenous knowledge was new to teachers, interview question 1 in the interview protocol (What is your understanding of the following terms: indigenous, technology and indigenous science?) was asked to tap teacher's understandings about key terms related with indigenous knowledge, which influenced how they taught the topic and also their evaluation of the role of such knowledge to learners. Teachers also responded to interview question 10 (How helpful to learners is the content under indigenous technologies and food taboos and beliefs? See the interview protocol in appendix E).

Asking teachers to respond to questions 1 and 10, at the end of the study, was done in order to give them a chance to see the play out of indigenous knowledge in the curriculum before seeking their impressions of the meaning of terms and the role of indigenous science in learners' lives, respectively. Research question 3 was not tied to indigenous knowledge and technologies alone but also to food beliefs and taboos, which I felt were relevant connections to cultural issues that go along with the general movement of indigenizing science curriculum. Teacher's responses to question 10 in the interview helped generate understandings that resulted into themes 7-10.

Teacher's Understandings of Indigenous Knowledge

Theme 7: Teachers expressed misunderstandings about the difference between indigenous science and indigenous technologies.

In the section that follows, I will discuss teacher's understandings about key terms, which displayed their extent of knowledge on the content on indigenous technologies. I believe that such knowledge might also have influenced their valuation of indigenous knowledge to learners. In a nutshell, I would say that what I learned from teacher's definition of terms (indigenous, technology and indigenous science) was that, to them, there was no clear distinction between indigenous science and technology. Their

perceptions of science and technology were intermingled. The following excerpts indicate how the three teachers perceived science and technology. Take note of extra issues that I probed as I searched for their understanding, from Mary's (M) , Chamose's (C), and Stella's (S) responses concerning definitions of terms:

A: What is your understanding of the following terms: First *Indigenous*?

M: Umm...indigenous...they are local things, which we use in our daily life.

A: So, indigenous means local things? How about *technology*?

M: Technology is the use of scientific things in our everyday life in order to – to make life easier. A: So, you are saying technology is the use of scientific things to make life easier?

M: Umm.

A: Ok. What do you understand by the term *indigenous science*?

M: Aaa – indigenous science, I think, is the use of both local things and scientific things to make for... the ... sorry...

A: You can repeat, no problem.

M: Indigenous science, I think, is the use of both local things and scientific things.

A: Have you ever heard of indigenous science before?

M: Yes.

A: And what were people saying when they talked about indigenous science?

M: Umm. I have heard about this term but I have never had interest to find out what it means?

Mary tried to describe the first two terms to the best of her understanding. Her understanding of indigenous and technology both relate to materials. To her, technology bears utilitarian meaning (as reflected in the word “use” in descriptions) while the word indigenous relates with objects (as discerned from the word “thing” in the descriptions). One interesting thing Mary said was that she had heard about indigenous science but never had interest to find out. That statement made me speculate that she had low opinion about indigenous knowledge and I started looking at my data carefully to check for attitudes.

When I interviewed Chamose our conversation was very short because she seemed to say very little about each term description. Her understandings of terms were

almost like Mary's but technology was slightly different and she said nothing about indigenous science. Our dialogue went as follows:

A: What is your understanding of the following terms, first, *Indigenous*?

C: Indigenous means the local things which people use locally in their villages or in town in their homes.

A: How about *technology*?

C: Technology is the science.

A: So technology is the science?

C: Technology is the science how they use those things or how they can implement the things.

A: How do you describe the third term, *indigenous science*?

C: [mumbled something that I could not hear clearly]

A: When we say technology, there is of course a wide range of connotations.

When did you first come across knowledge about indigenous technology?

C: As from when you gave us pamphlets and when I asked fellow teachers to assist me on this topic.

A: So, you never had any idea about indigenous technologies previously?

C: No. I didn't.

Chamose's answers showed that this kind of information was new to her as verified in her latter part of the dialogue. She could not distinguish between science and technology but also added use in her latter attempt to define technologies. My interaction with Stella (third case) was slightly different because Stella's answers leaned towards science practices, and our discussion went as follows:

A: From your own understanding, what do you understand by the following terms: First, indigenous?

S: I understand that indigenous means local.

A: How about technology?

S: To my understanding, technology means the things that are made out of science knowledge. Anything made out of science knowledge.

A: Does that mean technology is only done by scientists?

S: Yes. Technology is made by scientists because they study things and they try to

make – aaa – some objects from the studies. So to me technology is made by the scientists.

A: Ok. I will come back to you on that issue later because there is another question concerning that. What would you say is the meaning of indigenous science?

S: Indigenous science means the study of things in their environment that are used locally.

A: Would you come again? I did not hear you properly.

S: Ok. It is the study of things in the environment and finding ways of making local things used in our homes.

A: So that is what you understand by indigenous science?

S: Yes.

A: Do you believe that local people have also practiced some science?

S: Yes, because they make local things like mud stoves – aaa – mats made from leaves, catapult rubbers, and pestles and mortars. Those are some examples of the indigenous technologies that are made by local people who did not even go to school.

A: You have mixed science with indigenous technologies. What do you think indigenous technologies are, independently?

S: Indigenous technologies are the things made from local materials and they are made mainly by local people in the villages.

A: Let me take you back to what you said about indigenous science and technology. Are you saying that local people have the science that is used for making indigenous technologies?

S; Yes.

As I analyzed all their answers, I noticed that the three teachers agree on *local nature* of the term indigenous, but two of them also included the word *things* in their descriptions. A mention of the word ‘things’ signified the material nature of the term *indigenous*. My analysis of definitions of the word technology also revealed that teachers considered technologies in relation to materials, as described in relation to the term

indigenous. However, some teachers built in “utility concepts” (C and M) and “science aspects” (S) in their definitions.

Each teacher’s description of the term technology was close to prototype definitions but they were suffused with errors. This only gave me their perceptions but I least expected them to have very precise meanings. Some of their descriptions were probably guessed from their knowledge about machines (when they said to make work easier), which they encountered during their teacher training. The previous curriculum review brought machines in the curriculum and so Mary and Stella, who were trained in the late 1990s and early 2000 (respectively), had some knowledge from their teacher-training curriculum. However, Chamose did not have that background because she was trained twenty-seven years ago when the Teacher’s College curriculum did not include machines in science. That probably got reflected in her failure to define some of the basic terms during interviews. The short time that she had the new curriculum may not have given her enough time to learn about these terms. This could also explain why she said very little in her definitions. These were my speculations and analyses about teacher’s understandings of the key terms in the topic they were teaching about.

However, all the teachers struggled with the term indigenous science. This seemed very new to them. Although Mary said she had heard about it, I only doubted if she did because she mixed up indigenous science with technologies. Having positioned teacher’s background knowledge on indigenous knowledge and technologies, let us now look at the other themes that came up from the main study question 2, starting with teacher’s valuation of recently introduced knowledge to learners.

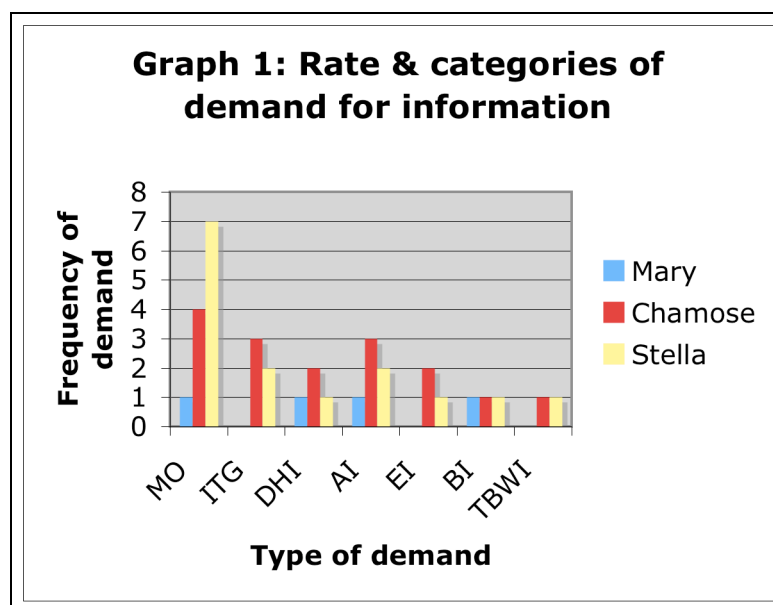
Connecting Scientific Knowledge and Indigenous Knowledge

Theme 8: Teacher’s lack of academic scientific knowledge detracted them from making connections to indigenous knowledge.

Too little of something tends to be problematic in life. Similarly, a deficiency of knowledge is so devastating to teachers. The majority of teachers consider themselves as guardians of knowledge such that when they get into a situation that threatens their security with knowledge, it creates so much anxiety. Such was the experience as the teachers embarked on teaching science and technology integrated with indigenous knowledge.

Revisualizing The Trend

From the lesson vignettes in chapter 5, we saw that teachers personally demanded more information to help them teach work on indigenous technologies. Their teaching practices also confirmed their lack of academic knowledge, which could help them handle the scientific principles involved in the technologies. Upon realization about a trend of high demand for information, through statements alluding to inexistence of knowledge, a count of the number of times each teacher stated something pertaining to the absence or need of more information or knowledge was searched through the interview transcripts for each case. The frequencies of such demands (in various categories) were collated and graphed as shown in Figure 1 below:



The key to the categories on x axis of graph 1 is as follows: MO = more information, ITG = information to give (to learners), DHI = did not have information, AI = add information (to the curriculum documents), BI = background information (needed in Teacher's guides), TBWI = teach better with information.

As it may be noted "MO" was highest in demand in the cases of Chamose and Stella but at the same time all teachers asked for more information. This has also been demonstrated in the way teachers taught as shown in the lesson vignettes. The amount of excerpts that demanded more information is over whelming; hence I decided to report in this pictorial form to bolster the results graphically (showing the degree of knowledge demand in various categories). The high number of categories pertaining to the need for

information that teachers thought would help them handle work on indigenous technologies, reveal this theme (8) that took us through all these experiences.

Teacher's Reflections on Academic Knowledge

Knowledge is a broad term because it can be placed into categories such as cultural, pedagogical, academic and so on. In this discussion, I will talk about knowledge in terms of the three categories but mainly focused on academic knowledge as it affects pedagogical knowledge. All the three teachers needed these forms of knowledge as they participated in teaching indigenous technologies in this study. To begin the discussion and also in attempt to paint a picture of the kind of experiences that teachers went through, let us go through a dialogue between Stella and I (during an interview at the end of the study), as she responded to question 3 in the interview protocol:

A: What did you experience as you taught topics on indigenous technologies?

S: I had problems at first because I had no knowledge on that. Even in the teacher's guide, that you gave me, there was inadequate information for me to deliver to the pupils. So, I had problems.

As it may be noticed in this conversation, Stella attributed her experienced problems to her inadequacy of knowledge, but quickly extended the cause of her knowledge deficiency to the curriculum deficiency of information. However, she maintained the same remark when it came to her experiences with teaching food taboos and beliefs, which she said was boring because she did not have knowledge about taboos. She also said, "Even the pupils were struggling to learn that topic because they were ignorant of taboos as well." As our conversation proceeded, I asked her about what she thought could be done to improve the curriculum documents, as follows:

A: OK. When you say there was inadequate information in the teacher's guides, what would you want inserted in the teacher's guide to help you teach the topic well?

S: I will need enough information on that. The information that ... the one they are introducing that technology, they should put in the teacher's guide so that when we read it we have to deliver what they want us to do, because if they put inadequate information we won't do or we won't deliver or the teacher will not be able to deliver what they want him or her to deliver to pupils.

A: Would you like to have more content or more guidance on how to teach it?

S: We need more content in the Teacher's guides.

A: Do you need content in terms of examples, drawings, facts or what exactly?

S: The drawings should be there, even the facts.

A: Even the facts?

S: Yes, because if you have enough information, you can even plan on your own.

From the foregoing dialogue, you may have noticed that Stella directly points out that inadequacy of information in curriculum documents affected her planning and delivery of her lessons. She pointed out that availability of facts would allow her to teach as she wished, even if the guidance was not available. She, therefore, did not miss words about her experiences and out-rightly suggested what she wanted to be improved in the curriculum. As I talked further with her, I inquired more about the exact type of problems she experienced due to lack of information and this is how it went:

A: Would you recall exactly something that gave you problems when you were teaching?

S: At first I did not know what indigenous knowledge meant. [laughed]. To me it was a new thing. I did not know what to think. So it gave me problems.

As I thought about Stella's response something struck my mind when I realized that she was almost at the edge of frustration due to her involvement in this study. She seemed far short of knowledge to the point of halting her mind as she thought about what to do. As she explained her experiences, I started realizing that lack of sources of academic or content knowledge resources in the primary schools will be a big problem, especially if the curriculum remains in the same style of design that excluded details of critical information. I also started thinking that Stella's experience was not unique to her. Other teachers in primary school were likely to face the same problem because primary school teachers generally tend to depend on the teacher's guides for all lesson planning because it is the only authority around. I went on with the dialogue to learn more about what Stella thought about innovations, which all teachers (but much more by Mary) pointed out that it was the most difficult to teach. Our discussion proceeded as follows:

A: Ok. You also did something about innovations of indigenous technologies.

How did you look at this topic?

S: On that too, I had inadequate information because I didn't have information on indigenous technologies and so I did not know what to do. There I did not even know what to improve. So that also gave me problems.

A: So, you did not know what to improve on the technologies?

S: Yes, because it was a new concept to me.

As you may have already noted, Stella attributed her failure to teach the topic on improvement of technologies because of lack of information. Since she repeatedly talked about problems in her experiences, I decided to hear more of her problems and the following came up:

A: Ok. Given the range of indigenous technologies that are listed in the materials that you were given, which ones were difficult to organize a lesson for your class?

S: Ok. Like I tried to improve a catapult I had few problems with that. So I had at least a good lesson in that. But when I started thinking about a mortar and a pestle – aaa – it gave me a headache because I said, how can I improve a mortar and pestle so that it can work better?

A: So you had a problem?

S: Yaah!

At that point I realized that the teacher had been going through strenuous times in carrying out her lessons, which did not seem obvious when I saw her teaching. She apparently worked under pressure to meet the requirements of participating in this study but did not enjoy teaching indigenous technologies due to lack of knowledge. According to Stella, the main culprit for her problems were the curriculum documents.

A: Ok. You have reminded me about your lesson that dealt with a catapult and the shooting that children did. You were supposed to discover things that are not working very well with a catapult. Would you remember some of the things that were not easy to do as you taught how catapults worked?

S: Yeah. There, I needed to draw lines where the stone was thrown. So I had problems to measure the exact height [I wondered whether she meant height or length?"]. Even with the catapult, they were throwing stones in the air, so I had problems to measure from the air. How can I do it? So, I had problems.

If you are closely following Stella's experiences, you will notice that she had problems with organizing learning experiences on some indigenous technologies. However, she seemed to say that some technologies were extremely difficult to think about how to improve them. Again, she almost reached a point of frustration as she thought about how to measure from the air. Hence, those simple indigenous technologies, although somewhat familiar to her, were seen to be so far from her academic conception about how they worked and how they could be improved. It was new to her. She was in a situation that demanded to think about how cultural technologies relate with academic knowledge. However, the concepts involved were, at times, beyond her knowledge.

The dialogue with Stella went on and on but this far, I hope you can see that knowledge was indeed a big challenge to Stella, as explained in her experiences. As a teacher, she lacked knowledge about how to organize fruitful learning experiences while dealing with indigenous technologies. The technologies at stake were both dealing with trajectories but her knowledge seemed deficient of concepts from trajectories, which made me think that her academic knowledge in science was short of required knowledge in the activities she was doing. She really showed lack of instructional vocabulary, but I suspect that was so because the teacher's guide did not lead her to thinking that way. She was only left with the option of using her experience which did not offer much to determine what to do with children. So her problems came from various deficiencies of knowledge, which could be labeled as academic, common life experiences, and pedagogical.

Stella's lesson vignettes and her responses to questions in an impromptu interviews and after-class interviews also revealed the same traits. But these experiences were not unique to her. When I asked Chamose, about her experiences, she similarly responded as follows:

A: Ok. What did you experience when you taught topics on indigenous technologies?

CM: I had some problems. Firstly, I had no knowledge about that. Even after asking others, I was still hesitating somehow.

A: Would you say that the curriculum materials that I gave you were difficult to use?

CM: No, they were not difficult to use but I wanted more information than what is given that I would give to the pupils. I had nowhere to read apart from your pamphlet.

A: Would you say that you had some knowledge gaps?

CM: Yes some gaps.

A: So you feel that not all information was readily available?

CM: Yes, the information, which I wanted to give to the children, was not all there. Some of the information was there ...but not all.

Chamose concurred with Stella that their problems stemmed from inadequacy of information and interestingly, both wanted information to pass on to pupils. This gave me the impression that they both aligned with the banking teaching theory, which looks at teaching as transmission of knowledge from the source to the receiver. Such philosophy of teaching may not be very conducive to the Outcome Based Education curriculum (OBE), which expects pupils to participate in knowledge creation or processing. Hence, their perception of problems with the curriculum could partly arise from that philosophy of teaching. They could not visualize themselves and their pupils as actors in the knowledge creation process. As the dialogue went on, Chamose even requested for an additional textbook to solve the knowledge deficit issue.

Resources for Teaching Indigenous Knowledge

Theme 9: Provision and utility of resources for teaching indigenous science and technology solely depends on teacher initiatives.

The word *resource* is highly loaded but it is also very popular in different organizations because it is very adaptable to multiples of applications. In education as well, the word is applied to many things such as materials, infrastructure, humans, time, economic status and the most common are items for teaching. In this segment of the discussion, as we continue discussing teacher's experiences during implementation of indigenous knowledge in science and technology, we will mostly engage the latter meaning of the word resources which may also include humans and time.

As I observed teachers teaching indigenous knowledge related topics, it dawned on me that the topic involving indigenous technologies can be richly supplied with teaching and learning resources because all the items under demand are local. I noticed that all teachers managed to find some catapults, hoes, winnowers, bows and arrows, which were either borrowed or improvised. Therefore, each teacher tried to bring relevant items that are named as indigenous technologies. However, this was not as smooth as described here. There were a couple of issues involving resource provision, quality and utility. Let me start by highlighting issues that came up in connection with acquisition of resources.

Provision of Resources

All teachers tried their best to find technological artifacts for teaching indigenous technologies. Soon after teachers stabilized in thinking about how to teach indigenous technologies (after some discussions with them), each teacher tried to bring teaching materials in form of charts, concrete items, and models. However, the ease of acquisition and provision of resources for lessons was not the same across the board. Two teachers found it easy to provide teaching and learning resources, while one felt it was difficult.

On one of the days that I visited Umbu primary school for research, Mary complained that children did not help in bringing materials for a lesson. On that day she taught without resources. According to her, she had to buy rubbers for improvising catapults because pupils were not readily willing to bring such items. Her experience was different from Chamose and Stella, who highly felt that the activities they chose to do were chosen because of availability of locally available resources. Chamose and Stella highly talked about teaching and learning using locally available resources (TALULAR). Hence, in terms of experiences, teachers differed in opinion about how readily resources can be availed for teaching indigenous technologies. Although, Mary was the only one who had this opinion out of the three teachers, I started thinking that there is a likelihood of existence of such differences in experiences about use of TALULAR. The rate of adoption of the TALULAR ideology, which is actively promoted in Malawi, could be run down by such observations. If we were to apply crude statistics, the ratio of those who feel comfortable in using TALULAR and those who do not is already 2:1. This is by no means close to reality but it is strongly mind jogging to

make one think about possible circumstances that work for or against the TALULAR ideology, in terms of adoption.

For a poor country like Malawi the choice to use TALULAR as a means of provision of resources, is an answer to low financial support of educational activities. Anything that could work against a solution to financial shortcomings is worthy thinking about and monitoring what goes on in relation to it. Upon registration of this scenario, I started thinking that TALULAR needs a better strategy for its dissemination than loosely allowing teachers to take it or leave its successes. Otherwise, teachers will end up using lecture methodologies all the time because practical work would not work without resources. This will be even more necessary as teachers will engage in teaching indigenous technologies in science and technology curriculum. More resources will be needed because so many technologies are suggested as indicated in theme 1, but also to allow many learners to experience using the technologies, in order to learn how they work. Experiences from this study revealed that demand for resources might go beyond mere materials or artifacts but books as well.

The need for extra books came up as teachers responded to question 6 in the interview protocol (Which asked about how helpful teacher's guides and learners books were in respect to their teaching) and according to Chamose, the following was her response to a probing question, which was part of my sixth question:

A: If we were to improve the materials, how would you want the materials to be presented in the syllabus, teacher's guides and learners' books?

C: At least, there should be another book to find more information so that I should compare the pamphlet and the book.

Chamose's response indicated that resources in demand must go beyond locally available ones. Extra textbooks will be needed to supplement the information in the teacher's guides and learners' books (which apparently were deemed shallow by teachers). However, a good question will be, "which text books are written to cater for integration of indigenous technologies and indigenous science in general?" Therefore, provision of resources, although most of them could be locally available, some extra resources in form of books must come from somewhere.

However, use of indigenous technologies (both improvised and borrowed) deserves a special attention, concerning their utility. In this study, I realized that teachers thought a mere use and practice in using indigenous technologies would make learners achieve learning outcomes, even if it simply meant taking pupils out and start shooting catapults and using bows and arrows (as indicated in lesson vignettes). While it is possible for pupils to gain functional knowledge of the indigenous technologies, there is need to think accurately about the science that can develop from indigenous technologies.

Most of the lessons that I saw (as may be observed in the lesson vignettes, that used catapults, bows and arrows, winnowers) hardly showed any direction about the science that was developed using the technological artifacts brought in by teachers. Hence, I noticed that teachers would spend so much of their precious time and money looking for indigenous technologies, but end up with minimal output from their effort if we could consider the scientific principles, stipulated in the success criteria.

As I went through these experiences, I realized that it is easier to think about turning to indigenous technologies or knowledge, but operationalizing the ideas will take much more time and effort. For example, there will be need for human capacity development, responsible for researching into indigenous technologies and science and writing textbooks to supply the much-needed information to teachers.

Furthermore, new studies will have to come up to provide well-researched ideas about indigenous technologies, which will eventually become available for teachers' and learners' consumption. Such information, to the best of my knowledge, is currently not available. This far, we only accomplished putting items on the table for use, but not how they are used for teaching. Let us now turn to utility of resources.

Utility of Teaching Resources

Use of indigenous technological artifacts in the teaching of science presents challenges that are new in the teaching arena. Teachers, in this study struggled to make good use of the teaching resources but because of lack of experience and lack of guidance on what to do in the teacher's guides, they mostly just ended at exposing learners to how technologies work. There were very few moments (if any) when learners had opportunities to learn scientific principles from the indigenous technologies. Most of lesson vignettes on indigenous technologies show this lack of scientific principles in the

lessons. However, teachers did only as much as they could, based on their own initiatives. They had no ideas about how to organize lessons on the new topic, as Stella said, “I can do some practical work but only up to a point”.

In this study, there were varied experiences about access to technologies but there was a clear sign that teachers need extra help in making good use of technological artifacts in creation of worthwhile knowledge (be it cultural or scientific). There are two or three issues to be considered, namely: (a) means of acquisition of indigenous technologies, (b) correct use of artifacts to develop science, and (c) the range of technologies to be used to strengthen learners’ understanding of the technologies. So far, teachers only relied on their personal initiatives about which technologies to use for teaching.

Teacher’s Valuation of Integrating Indigenous Knowledge into Curriculum

Theme 10: Teachers expressed both positive and negative valuation of the effect of integrating indigenous knowledge in the science and technology curriculum with respect to learners’ benefits.

This theme was developed from teacher’s responses to question 10 (as indicated in the introduction to this section), which expressed both positive and negative valuation of the role of integration of indigenous knowledge in science and technology, in regards to learners’ benefits. To give you an impression of what teachers said, I hereby give some excerpts from the interview that I conducted with teachers at the end of the study. First, will be an extract of my discussion with Stella (continuing from other questions), which went as follows:

A: Ok. That is well understood. Let us imagine that those concepts have been included in the syllabus. How helpful to learners is this work on indigenous technologies and some information that you taught on food taboos and beliefs?

S: It will be good and it will be...I think, it will be nice to learn because they will learn to appreciate what the local people do because most of us think that when people don’t go to school they don’t know anything about science. So pupils will appreciate what the local people do because they will know this concept of science.

A: Let us talk about indigenous technology. Local people in ordinary life do not think that they are doing science. And may be, they do what they do because that is what they have to. Now I would like to ask you. How helpful is this to learners, that is, to know something about indigenous technologies?

S: [Silence]

A: If you would just pick out the indigenous technologies and given the kind of activities that are written in the curriculum books. What would be the benefit to children if these were covered to let them understand how they work?

S: They will be well equipped so that even if they don't finish school...because they will use that knowledge in making their own technologies and in so doing they will be having the money after the sales of those things. [Reason for teaching it]

A: So, are you saying that it can be a kind of preparation for life after school?

S: Yeah.

My preceding dialogue with Stella obviously showed a positive attitude toward indigenous technologies. However, when I asked her specifically to talk about food taboos and beliefs, our conversation went as follows:

A: How about food taboos and beliefs? What would be the benefits for teaching these things to children?

S: Ok. It is good to teach food taboos and beliefs to children because they would know what is right and wrong. They would have correct information. Even when they finish school and are back at home, they will be able to explain to whoever is telling them about that.

A: Is this just for their personal good or for passing on these ideas to the younger generation of their time?

S: But they have to pass it to the younger generation.

A: What benefits will that bring in their lives?

S: They will have to avoid some of the diseases like malnutrition diseases.

A: Ok. From what you have said, are you trying to say that children should try to avoid or encourage taboos?

S: They should avoid taboos. [Her position about taboos]

A: Do you think there should be any explanation as to why those taboos were put in place?

S: Yes. It will be good for us to explain to them so that they can understand what you want to tell them.

A: Do you think ancestors had some explanation for introducing those taboos and beliefs?

S: I think so.

A: What would you do in order to find out about these?

S: You can even ask pupils to go to grand parents at home and ask them why they introduced that. [She proposes research from communities]

A: Ok. Part of this has already come from tradition or culture. Do you think we should teach about cultural ideas in science?

S: Yes of course. Some cultural ideas are good. Not all.

A: But not all?

S: Yes.

A: So these examples of food taboos and beliefs should not be included?

S: Yes, because taboos and beliefs are not good for this generation.

Perceptions of Taboos

My dialogue with Stella oscillated between positive and negative perceptions of the role of teaching food taboos and beliefs. At some stages she thought it is good to teach them, but as I questioned her further, her notion of good was primarily to let pupils avoid practicing taboos. Her attitude towards indigenous knowledge differed between what she said about indigenous technologies and what she said about beliefs and taboos. While she valued teaching cultural ideas, her sense of value was, in respect to taboos, focused on their discontinuity. In fact, at some point in our discussion, she even said that she felt bored with teaching taboos because she did not know them very well; just like her pupils also did not have ideas. This made me wonder because pupils were capable of stating some taboos in her class. So, the question was, “where did they pick the ideas that they produced during group and class discussions?” This gave me the impression that she just went through the lesson about taboos halfheartedly.

A similar response (in response to the same question) came from an interview with Mary who responded as follows:

A: Let me ask you another question. How helpful do you think that content, included in the science and technology syllabus, will be to the pupils?

R: It will be helpful for pupils not to follow the taboos.

A: How will knowledge about indigenous technologies help learners in their lives?

R: They will help pupils develop interest to learn more.

A: To learn more about what?

R: About the indigenous technologies so as to improve their everyday lives.

Although we had a brief exchange, Mary's stance on taboos was just like Stella's and likewise was her attitude towards technologies. Both teachers positively treated indigenous technologies and negatively perceived food beliefs and taboos. My third interviewee, Chamose, concurred with Stella and Mary about the benefits of indigenous technologies and the need to avoid food taboos. However, she differed with the other two teachers because she wanted more taboos to be given in the curriculum documents. Her reason for asking for more taboos in the curriculum guides probably stemmed from the high demand for information that all teachers presented.

In summary, all teachers considered inclusion of indigenous knowledge in curriculum as a means for learners' preparation for life after school in the community, but only in relation to indigenous technologies, otherwise indigenous knowledge concerning taboos must be discouraged because it is against health. I must say that it was such kinds of teacher's perceptions that lead to the generation of theme 6 (concerning taboos). I was struck by teacher's ambivalence about the benefits of indigenous knowledge to learners in relation to the two camps of topics (technologies vs. food taboos). From the foregoing dialogues we may have seen that teachers aligned their attitudes to the way content is presented in curriculum documents, as previously discussed in theme 1. Teachers could not say anything beyond what has been stipulated in the curriculum, although some were suggesting that indigenous people have valuable scientific knowledge (which they use for making technologies, according to Stella).

Blurred Initiatives Due to Negative Attitudes

My Second Thoughts About The Dialogue that I had with Stella (about food taboos, whose stance was shared by the other two teachers) lead me to think about another facet of meaning from our exchange of ideas. Instead of merely registering the way teachers reacted to my question, I retrospectively saw another angle of meaning from teacher's reaction to the issue about taboos, which could affect instruction in general. Teacher's strong negative attitude toward food taboos and beliefs could unknowingly impair their teaching initiatives.

Teachers seemed to have been convinced beyond doubt that food taboos and beliefs result into malnutrition and all other associated ills named in schools or books. As they taught lessons on taboos they failed to educate learners about taboos but instead ended up indoctrinating them about taboos as false constructs. Such approach to teaching might have made pupils go out of such lessons with only negative attitudes towards taboos and yet there are possible arguments that some taboos were actually instituted on sound reasons and not necessarily bearing negative connotations. As noted from all the three teachers, taboos have to be avoided by everyone if they are to remain healthy. I feel that by taking that stance teachers failed to realize that people from all over the world choose not to eat certain foods because of personal reasons. There is very little difference between leaving food by choice or belief. In fact leaving food due to belief may come from a suspicion of something negative, which might protect the consumer.

Neglect of Culture Lowered Teaching and Learning Opportunities

Neglect of culture can easily happen when people are easily swayed off from their ways of living. This usually happens from forces like the teaching approach displayed by the teachers in this study. Although they did not do anything with ill intention, since they were following the syllabus and their own knowledge learned from their early education, the end result would be a total neglect of culture to the extent that people schooled this way would fail to recognize good elements from their own cultural setting. The experiences observed from teacher's perceptions about taboos made me think that encouraging balanced debates about cultural issues is a positive way to avoid misrepresentations of knowledge and practices. Balanced representation of ideas is the only way that we can keep the wealth of knowledge that science builds upon.

In the next chapter (7), the results from the thematic analysis will be discussed in relation to emerging literature in the field. Recommendations related to curriculum development, pedagogical practices, and teacher knowledge and self-efficacy will be made.

Chapter 7: Discussion and Recommendations

Introduction

This chapter discusses the findings from the entire study by looking at main issues that came out of the ten themes and how these findings interact in the implementation of the new science and technology curriculum. I will discuss some of the results under the umbrella of more prominent and encompassing issues. Generally, the discussion will focus on curriculum implementation and how the findings affected the process of implementation. In the following sections, I will be substantiating my claim that teachers faced some pedagogical problems in the process of pilot implementation of the indigenous knowledge curriculum because of the design of the curriculum, their lack of knowledge (academic, pedagogical and cultural), and their ambivalent attitudes towards indigenous knowledge.

My analysis showed that teacher's limited knowledge about the content of indigenous knowledge affected achievement of learning outcomes demanded in curriculum because limited knowledge affected their ability to devise strategies for achieving the learning outcomes. Teachers limited knowledge about technologies and taboos demeaned their insights in the organization of lessons on indigenous technologies, thus lowering the quality of pupils' learning. I therefore, advance an argument that teachers can only embrace effective teaching of indigenous technologies and food taboos and beliefs if they are theoretically enlightened or supported in acquiring resources (such as literature) and also exposing them to strategies that might help in developing learners' knowledge on such content. The latter observation is the basis for my proposal of a model teaching unit, presented towards the end of this chapter on how to practically teach indigenous science lessons. The proposed unit stems from the results of this study, which showed that teachers lacked knowledge and ideas about how to organize effective practical work. The recommendations also extend to all teachers who will engage in the implementation of the PCAR science and technology curriculum. I feel this is essential because this study revealed that teachers are in serious need for assistance, especially now that they are treading on unfamiliar grounds involving indigenous technologies.

Prior to the thorough discussion of the findings, let me point out that this study revealed that the development of the science and technology curriculum that includes

indigenous knowledge bears great optimism (from curriculum developers) for using indigenous technologies as a tool for furthering knowledge development in science and fostering problem solving among the learners. However, although the rationale for the standard five science and technology PCAR curriculum highlights that intent, by showing how access to both indigenous and modern technologies would help learners to solve everyday problems, the curriculum design is limited because it fails to spell out the nature of indigenous knowledge (IK) that will come under play.

Indigenous knowledge, as portrayed in literature, tends to be all encompassing (holistic), like Yupiaq worldviews as described by Kawagley et al. (1998) and many others involved in the indigenizing discussion (Klos, 2006; Michie, 2004; Semali & Kincheloe, 1999, Snively & Corsiglia, 2001). Many theorists in the indigenizing movement also highlight the importance of myth and spiritual knowledge (Jegede & Aikenhead, 1999; Snively & Corsiglia, 2000) as part and parcel of the indigenous science content. This study revealed that teachers lacked of connection to and understanding of indigenous knowledge. This situation presented many challenges that might affect the desired outcomes or prospective benefits for using indigenous technologies in science and technology curriculum. In the following discussion, I will elaborate the findings about the science and technology curriculum, teacher's pedagogical experiences and their origin, and teacher's perceptions about the role of the indigenous knowledge in the curriculum. I will also recommend areas for future research and will also propose a model curriculum unit and pedagogical approaches that would foster the teaching of indigenous technologies in practical approach befitting the processing of scientific knowledge.

Curriculum and Pedagogical Issues

Integration of indigenous technologies with science created a new task for teachers. Their greatest challenge was how to link the two sets of knowledge, as we will see ahead.

Connecting Scientific Principles to Indigenous Knowledge

Some of the teacher's challenges arose from the curriculum itself, which was noted to be less articulate in terms of scientific principles and how to teach them. To make matters worse, the types of technologies suggested to help learners in problem

solving approaches involved challenging scientific principles, which made it very difficult for teachers to design helpful lessons. Hence, curriculum design affected the frail teacher's pedagogical knowledge since teacher's academic background knowledge is already weak because primary school teachers only hold school certificate education prior to entry into the teaching profession. Hence, both curriculum design and teacher's knowledge affected their perceptions about what to teach and how to organize and provide resources for teaching indigenous technologies (which is a new topic to teachers and to the science learning area).

All the three teachers claimed that curriculum documents lacked information to deliver to learners. This remark probably portrays teachers' belief in teaching by transmission of knowledge, also known as the banking theory. However, their claim about deficiency of information in the curriculum documents concurred with my analysis of official curriculum documents, in which I observed that the documents and lesson activities lacked clear articulation of the scientific principles of technologies that were being targeted. In terms of strategies for developing learners' knowledge, the suggested learning activities generally over emphasize the importance of finding out information from learners and the community. Pupils are expected to learn from mere use or practice in using the technologies instead of focusing on the science embedded in the indigenous technologies. Lack of focus on specific principles put teachers in a vacuum of ideas about things to think about when organizing lessons, which resultantly affected their teaching performance.

As earlier mentioned, the PCAR science and technology curriculum documents suggested activities that are open to a whole spectrum of technologies, but without specification about the scientific content or specific examples of indigenous technologies. The inclusions of a wide range of technologies chosen for lessons makes it difficult to focus on the scientific principles that need to be covered at a particular level. Furthermore, there is likely to be a difference in complexity of the chosen technologies. Where the teacher relies on the teacher's guide, this might end up with frustration when teachers cannot find or understand the principles involved. Unfortunately, there are no unifying factors on the nature of concepts that must be covered on technologies (that applies to both indigenous and exotic technologies). Hence, implementation of the

science and technology curriculum might give a diverse range of concepts that might be difficult to assess during centralized examinations.

Most of the lesson vignettes indicate so many problems of instruction in regards to lesson organization, assessment of learning, and effectiveness of the instructional pedagogy and use of recourses. In most cases teachers simply walked pupils through a lesson, probably because they were not quite sure about what was expected in the teacher's guides. Part of this problem could be due to knowledge deficiency since all teachers largely complained about lack of information from the curriculum documents.

Therefore, most of the problems teachers faced can be associated with lack of details from the curriculum documents and the heavy reliance on the use of learners' knowledge and unfocused inquiry in the lessons. I am aware that this curriculum design was influenced by the emergence of constructivism, in projects like *Capacity Building Internationale, Germany* (InWent) whose aim is to promote learner-centered approaches. However, while constructivism promotes inquiry, the inquiry ought to be focused on authentic experiences that are well organized. Teachers also need to be familiar with technicalities of inquiry and designing of authentic learning experiences.

It was learned from this study that developing an understanding of scientific principles in technologies is a complex issue. These findings might imply that teachers will need a better backup of extra content knowledge concerning indigenous knowledge to supplement the content outlined in teacher's guides. Since indigenous knowledge is new in the curriculum, this will mean writing books or articles on the indigenous knowledge in Malawi. If we subscribe to place-based education, this recommendation needs to be taken seriously, because different cultures have developed their own technologies depending on their needs, circumstances, and skills. Such artifacts represent the capacity for social reproduction that partly relates with cultural identities.

Teacher's Lack of Scientific Knowledge

Teachers' response to interview questions, concerning description of terms, revealed that teacher's held hazy knowledge about indigenous science and indigenous knowledge. While teachers held limited understanding of these terms, little clarification or help was provided in the teacher's guides. This scenario put teachers at a disadvantage, especially because indigenous science is broad and complex field, which

teachers need to know what is involved in order to successfully engage in meaningful teaching.

Indigenous science is normally considered as local people's ways of knowing, which may involve spirituality and connection to the earth. Findings from this study revealed that teachers viewed indigenous knowledge, indigenous science and technologies only in relation to artifacts (things). As it may have been noticed, teachers held a limited understanding of the topic and therefore were prone to misinterpretation of the content under play. One may ask, "Why were teachers ignorant about such knowledge?" An answer to that question may emerge from Oguniyi's (2007) study in South Africa, which revealed that teachers resisted integrating indigenous knowledge in secondary science because they were schooled in the western sciences and were therefore less familiar with indigenous knowledge system (IKS). Hence, it was not very strange to see these teachers misunderstand indigenous terms because they were not schooled in them. However, we can also say that teachers' lack of understanding was supposed to be expected when the curriculum was being developed since such knowledge was new in the curriculum. Hence, the development of materials for these topics must have factored in extra support for teachers' knowledge to help them handle such work successfully, especially because of their low academic background.

The need for academic knowledge cannot be overemphasized. Ryan and Cooper (2007) have already given us the interplay of content knowledge and pedagogy, which aims at effective teaching and learning. Actually, I consider the link between teacher's lack of academic knowledge and inability to make connections to indigenous knowledge as the overarching finding because of the way teachers demanded information. That demand for information stemmed from their experiences of frustration due to lack of knowledge about the science and indigenous technologies. However, teachers were in need of facts to give (or deliver to pupils), which may not be the kind of knowledge that was required in the topics on indigenous technologies and food taboos and beliefs. This could be the source of the disconnect that created the much talked about problems from their expressed views. At this point I will just talk about the nature of activities and the kind of knowledge that was required, which created problems to teachers in the process of the pilot implementation in standard five.

Technologies are complex and many of them are a combination of various technologies. A western technology might have levers, gears, compression chambers, electronic control systems, a starter, a battery, lights and the list goes on. Each one of these named pieces is itself a form of simple technology. It is important to note that technologies may be difficult to understand, especially when referring to examples like biological control of weeds and pests, and yet others may just be as simple as keeping all the plant refuse in the garden as a technology for keeping the soils fertile. Bearing in mind that technologies include such examples, I would like to say that teachers were far from understanding such dimensions of technologies and yet that is the engagement that the topic on indigenous technologies is asking of them to unpack to learners.

Of course, the examples of technologies listed under indigenous technologies might look simple, but their simplicity will depend on how teachers understand what makes the technologies work. This is where our teachers had problems. They were asked to teach scientific principles from technologies such as catapults, bows and arrows, and cyanide extraction from cassava. If we could take a bow or a catapult, for example, teachers might be expected to understand where the force that propels an arrow (or stone) originates, or how the arrow (or stone) moves. The movement of a stone or an arrow is affected by its interaction with gravity and frictional forces in air. Such forces make the trajectories land at particular positions depending on the speed, time of movement, distance covered, weight of the object, and the force that propels such objects. This is simple to a physics graduate but very complex for someone who has never learned mechanics. And yet scientific principles might be drawn from such parameters. Teachers are, therefore, expected to understand how such technologies function based on such scientific principles. Their capability to help learners improve some technologies can be done if they can manipulate some known principles like those mentioned above.

In case of lesson activities observed in this study, teachers did not dwell on well-defined parameters in technologies because the curriculum did not spell out how to do that. Focusing on well-defined parameters (like those mentioned above) would have been the most reasonable approach for students to follow as they engaged in improving some indigenous technologies.

Since primary school teachers in Malawi are not college graduates, their understanding of scientific principles involved in these simple technologies were out of reach. No wonder, they superficially covered what they did. This is why I argue that the curriculum documents were not articulate enough to guide teachers on what they were supposed to teach. If these were not intended to go to primary school pupils, at standard five, some guidance about the nature of activities to help learners understand the scientific principles need to be specified. Otherwise, the lesson activities would only encourage guesswork, which was how science was taught before the late 1980 curriculum review. The situation could even be more problematic when teachers are used to objective based curriculum, which tend to be more articulate on specifics to teach; as was the case in the outgoing curriculum.

These problems were compounded by the fact that the teachers, participants in this study, were females who were unfamiliar with catapults and bows since bows and arrows belong to masculine chores. Hence, the assumption that all teachers might just figure out how to deal with technologies may be wrong. Female teachers might need a backup of facts or explanations about how such indigenous technologies work. Just as male teachers might need some backup knowledge on technologies that are in the mainstream feminine chores. This is not to emphasize gender stereotypes but meeting face to face with reality, if we would like to help the teachers to smoothly implement a curriculum, which has no explanatory literature and its knowledge was never met in their schooling.

Additionally, scientific knowledge about bows and arrows or related indigenous technologies might better be understood and taught if teachers are academically astute. Since this is not the case for primary school teachers in Malawi, the only recommendation is to find mechanisms of supporting them. This could be through provision of extra literature or in-service training and monitoring how they perform. Pre-service training of teachers on indigenous technologies is the best but majority of teachers are already in the field. Since the current teacher training colleges in Malawi have already started teaching indigenous technologies, it will be interesting to see how lecturers and their students in these colleges can engage in research to upraise knowledge on indigenous technologies and help share such knowledge with teachers in the field.

Furthermore, it will also be better to unveil the entire set of indigenous knowledge that relates with science. This might change the state of knowledge deficiency that affected teachers capability to link indigenous technologies to science.

Exclusive Focus on Indigenous Technologies

The representation of indigenous knowledge in the PCAR curriculum shows partial validation of indigenous knowledge (IK), since it focuses exclusively on indigenous technologies while leaving out the other forms of indigenous knowledge that are relevant to science. A critical analysis of this type of representation of IK might mean that Malawian educators do not fully accept the value of all other forms of indigenous knowledge except technologies or that curriculum developers are not well informed about the value for bringing indigenous knowledge in the science curriculum. I assert that there is such partial validation of knowledge, by curriculum developers, due to the way such knowledge has been reflected in the curriculum. Such representation of indigenous technologies as the only facet linked to indigenous knowledge in science, might be misleading teachers in thinking that indigenous science only involves technologies and if they are unsuccessful in dealing with technologies due to lack in-depth knowledge about technologies, some teachers be put off.

Newton and Newton (2007) contend, “New teachers and teachers with limited knowledge of technology may show a tendency to avoid or neglect cause and purpose in their technology lessons.” This contention came up as Newton and Newton (2007) explored how analysis of technology textbooks might help teachers with low background knowledge in technologies bring some flexibility in their thinking. Newton and Newton (2007) found that technologies are difficult to understand, even when textbooks for learners are actually present. Hence, the question raised from this study’s findings might be: what is the impact of introducing numerous technologies under circumstances where teachers only depend on the teacher’s guide like in Malawi?

The term *understanding* itself involves so many issues. Wiggins and McTighe (2005) assert that understanding involves,

Knowing the meanings of facts, the theory that provides coherence to meaning to those facts, understanding why it is, and what makes it knowledge and also as to when to and when not to use what I know (Wiggins & McTighe, 2005, p. 38).

Therefore, expecting a student to understand technologies and the principles that are involved in their function must be a challenge to teachers, especially to Malawi primary school teachers because of their low academic qualifications. This is more of a reason why they will, by all means, need extra resources to unpack the indigenous technology curriculum. But while pondering about provision of extra readings about indigenous technologies begs another question, “Are the books available for explaining indigenous technologies?” This question raises the need for the teacher’s guides and learners’ books to be well detailed to provide the much-needed information to teachers who are obviously short of knowledge.

Science and The Vernacular

While the literature suggests that using indigenous knowledge helps learners celebrate their identity and also helps in easing learning among indigenous learners (Klos, 2006), this claim may have another catch. The teachers need to have sound academic content knowledge and good pedagogical knowledge that bridges content knowledge and pedagogy (Ryan & Cooper, 2007). Ryan and Cooper (2007) state,

Pedagogical content knowledge represents the blending of content and pedagogy into an understanding of how particular topics, problems or issues are organized, represented, and adapted to the diverse interests and abilities of the learners, and presented for instruction (p. 165).

Such blend of knowledge is not readily available among our primary school teachers in Malawi and teachers also have to deal with language and large class sizes beside deficiency of essential knowledge.

Having mentioned the issue of languages, let me point out that many research study results, in Malawi and Africa as a whole, have indicated that learners do better in lessons if they use vernacular language (Chumbow, 2003; Komarek, 2003). However, in case of Malawi, most of local studies on language have been conducted in lower classes that did not offer science. In this study, teachers in standard five taught science and technology according to the language policy in Malawi, that is, allowing teachers to use local languages in lower classes. However, standard five is treated as a transitional class in which teachers are supposed to start teaching in English and as they slowly relinquish use of Chichewa for instruction.

Results from this study seem to indicate that the success of using local language might depend on the clarity of facts that a teacher has on science and technology content. Some teachers failed to give explanations not only from one language to the other, but in both languages. Interestingly, the meanings of words in both English and Chichewa were the same. This implies that a teacher's wrong conceptual understanding of science matters more than the language used. There were also situations whereby the teachers used inappropriate words in both Chichewa and English leading to loss of scientific meanings. For example, in referring to the elasticity of the rubbers in catapults (slings), one teacher used the word "tougher" or "kulimba" in Chichewa, which distorts the concept alluded to in rubbers. And yet the Chichewa vocabulary (word) that bear direct meaning with the scientific concept of elasticity is "kutamuka." This scenario gave me the impression that teacher's failure in identifying appropriate words may be the main hindrance to instructional clarity than the languages themselves. Connecting scientific concepts and vocabulary with vernacular languages is also a challenge for curriculum developers. This point agrees with issues pointed out by some researchers ascribing to indigenous science, such as McKinley (2005).

In terms of pupils' participation in class, pupils also expressed themselves much more freely in local languages rather than in English. However, a good question might be, "Were pupils learning science in those expressions or distortions of scientific understandings?" The key to this puzzle might be the teacher, who is supposed to monitor pupils' expressions and give them prompt feedback.

This is where another problem begins, since the teachers tended to teach in the official language (may be due to my presence). It was noted that when teachers used English for asking questions, learners' responses dwindled. This might mean that 'teacher talk' never conveyed the meanings to those learners. To make matters worse, teachers tended to avoid asking pupils to answer questions, as a way of assessing them, when they suspected learners would miss the answers to avoid indicating that they did not follow the lesson. Teachers seemed to view pupils' failure as reflecting their pedagogical weaknesses.

Negative Bias Against Indigenous Knowledge

As indicated earlier, the curriculum does not reflect advantages of any food taboos, which are associated with indigenous peoples' ways of knowing. Instead, food taboos are totally discouraged on grounds that they deprive people of nutritional ingredients. Results from this study seem to indicate that educators lacked alternative knowledge about realities of food taboos probably, which probably barred curriculum developers from seeing the value of making a balanced coverage in the lessons. Teacher's aversion of taboos could also be due to the process of enculturation in school knowledge, which embraces a singular western account of meanings and worldviews (Aikenhead & Jegede, 1999). Such misrepresentation of knowledge about food taboos does not ultimately represent all facts about their effects and reasons for their institution, as defined by western scientists. I feel that Western scientists misunderstood or misinterpreted the reasons for institution of some food taboos and beliefs. In the long run, all science learners have labeled food taboos and beliefs solely from negative point of view, as influenced by western scientists interpretations. Science students, from indigenous communities have, resultantly discarded local ways of knowing, and attached themselves to the singular western science account, which they believe to the letter. Hence, their departure from local values of knowledge may be equated with crossing of borders and being assimilated, which Aikenhead & Jegede (1999) would say has disrupted local people's worldview, due to the divorce of cultural ideas.

Such a disconnect from cultural background meanings, regarding food taboos and beliefs, might have deterred educators and curriculum developers from making much scientific sense from local people's observations and the reasoning behind taboos as they designed a curriculum reflecting cultural elements. This could also be a result of inability to critically look at things. Critical analysis of issues like these could help deconstruct the mainstream ideas, as post-colonialists and post-structuralists tend to analyze issues in order to avoid being swamped by exotic knowledge.

Although taboos and beliefs are not listed as indigenous science, their presence in the curriculum illuminated the value of such knowledge to both curriculum developers and teachers. All teachers taught taboos primarily to discourage them. Their perception of taboos provided no room to accommodate positive elements. This is not surprising,

given the fact that the curriculum also portrays the same image of taboos. However, this is a typical example of representations that must be deconstructed. Lim and Calabrese Barton (2007) recognized the validation of cultural practices that were once understood as different from school knowledge and this helped to change the elementary science curriculum for urban students. In their study of urban students, Lim and Calabrese Barton's (2006) found issues that may bear correlation with the issue of taboos in Malawi as the predominant negative representations may change when people learn more about the root causes of taboos.

What teachers mentioned as the importance of technologies to learners reflected the values that the society holds about technologies. On the other hand, taboos are looked down upon, because that is how they are portrayed in science. However, I would like to point out that both taboos and indigenous technologies come from the same stalk of knowledge. School curriculum must therefore give a balanced account of such knowledge to help graduates from those schools to bear balanced understandings and not only negative aspects of some forms of knowledge. A predominant negative representation of a culture kills the soul that identifies with it. Teachers will, therefore, need to have a balanced approach when teaching issues on indigenous knowledge because the role of education is partly to uphold culture.

Furthermore, teachers, all educators, and curriculum specialists need to be enlightened and freed from the scientific stereotypes that curtail chances to realize alternative ways of knowing. Let me point out that most of the taboos arose from some intriguing observations about food by groups of people who may have been affected or speculated being affected due to ingestion of the food that later became a taboo. Hence, to reduce teachers' ignorance of origins of food taboos, teachers must survey and seek hidden meanings that led to institution of food taboos in their local areas in order to relay balanced knowledge to science learners from various locales of the world. Since teachers tend to be so busy with everyday duties, the responsibility to gather information may be shared by other stakeholders in the education systems that might engage in research about taboos in particular localities.

Lastly, teacher's biased view of taboos made them miss teachable moments because they were not paying much attention to the issues that involved taboos. If

indigenous knowledge will have a broader view, such attitudes towards indigenous knowledge will be detrimental to the indigenizing movement. Therefore, I would recommend that curriculum developers must present a balanced view of taboos in curriculum guides and this can be possible if research could be done to find out helpful taboos as well.

Teacher's Use of Resources

This study revealed that all teachers were aware of Teaching and Learning Using Locally available Resources (TALULAR). However, their attitudes towards resources differed. Two teachers thought that it is easy to teach using TALULAR but one felt it was not that easy because pupils did not participate in the provision of materials for making such resources. Such differences of opinion may be common among the teachers. However, my take at this time is to indicate that such attitudes may deter teachers from trying to look for resources. The teaching of indigenous technologies is likely to be resource hungry because the most helpful way of teaching how technologies work will involve manipulating real technologies or good models that represent how the indigenous technologies work. If such resources will not be available, teachers will fail to effectively help learners understand the way the suggested technologies work.

Hence, I would recommend that teachers must be encouraged to utilize the artifacts of technologies from their communities and also invite elders to participate in provision of information, which teachers may be lacking. Gonzales, Moll and Amanti (2005), refer to use of elders' knowledge as using *funds of knowledge*. This approach is said to improve connectivity between the school and the communities, where the expertise for indigenous knowledge or technologies come from. Through such contacts, the teachers can gain knowledge that is almost slipping by because of disengagement from community knowledge systems.

Indigenizing the Science Curriculum

As for inclusion of indigenous knowledge in the curriculum, I was aware that my knowledge was not up to date when I participated in some early stages of PCAR materials development. Consultants from South Africa, Kenya, and Zambia, who had revised their curricula on similar lines, influenced Malawi's recent curriculum revision. Due to this reason most of the Malawian curriculum developers (including me) were less

familiar with the background of some of the ideas pertaining to indigenizing the curriculum. Curriculum developers were also not very familiar with the issues to pay attention to since this indigenizing movement was new and, in fact, I personally did not know that there is a world wide network on indigenizing science. The problems observed in the design of the curriculum could, therefore, be a result of lack of in-depth background to reasons why curricula are being indigenized in some parts of the world.

To majority of curriculum developers, the most appealing thing about indigenization was validation of elders' knowledge, which majority of Malawians still value despite being oriented to Western science. Many educated people still participate in traditional healing and other practices developed by ancestors for over thousands of years. So, revising the curriculum by including cultural knowledge seemed attractive, especially at a time when there had been many emergent technological insights from local people.

Generally, curricula are revised based on many factors, some of which would be for historical, political, and socio-economic reasons. For South Africa (the key influence for indigenizing curriculum in Malawi), indigenizing was fostered by a reaction to political and historical experiences besides other reasons (Oguniyi, 2007, p. 963): hence, politically this move was probably viewed as redemptive, as some multi-culturalists would assert, in an atmosphere of liberty from Apartheid oppression. Historically, that is how Malawi might have identified with South Africa since she was once under the British colony. However, since Malawi has been free from colonization for more than forty years, her current experiences about the colonization pressures may not be the same as those of South Africa.

Hence, at the outset of the curriculum revisions, the majority of curriculum developers may not have had the same feelings as South Africans and probably less informed about the move to integrate indigenous knowledge in science. Therefore, curriculum developers' choices about the kind of indigenous knowledge were probably limited because of the described scenario. As a result, what is described as indigenous in science curriculum only reflects technologies.

However, I would also speculate that the choice of indigenous technologies in Malawi was influenced by the emergence of the need to become a producing country, as

noted by the emergence of the Ministry of science and technology. The political pressure to foster productivity in order to improve the socio-economic status of Malawians must have also influenced the desire to include indigenous technologies in the curriculum. In the same vane, the subject name changed from “Science” to “Science and Technology.” Therefore, I contend that the development of this curriculum must have been fostered by the optimism that it will help in economic development and not necessarily the need to indigenize, as is usually the case among indigenous people. To verify this notion, I made a follow up inquiry from the Malawi Institute of Education (MIE) to establish the drive to indigenize science.

Upon inquiry from MIE curriculum specialists, I learned that the MIE specialists only towed the line of consultants’ suggestions on science curriculum improvement and did not purposefully pursue the ideas as purported by the indigenous movements. However, ideas about contextualizing the teaching of science were buzzing around both among local curriculum developers and from consultants. There was no special study or paper to influence the need to indigenize and the focus of indigenous knowledge aspects was not predetermined during the time curriculum materials were being developed. This might be the source of problems noted in this study about the curriculum. However, as reported in similar studies in South Africa and other countries, the problems associated with integration of indigenous knowledge in the science curriculum may not be unique to Malawi (Oguniyi, 2007). Oguniyi (2007) found out that indigenous teachers tend to lack knowledge about indigenous science or knowledge because they were not educated following the indigenous knowledge curriculum. Therefore, although one would expect such knowledge to be readily available to indigenous teachers, this does not seem to be the case.

Culturally Responsive Science Curriculum

On the positive side and despite the narrow representation of indigenous knowledge, Malawi has committed herself to see the teaching of science in a new light, since the curriculum documents have endorsed using indigenous technologies. Despite all the weaknesses that might be there, I feel this move (indigenization of science) is a milestone in the debate between indigenous knowledge and science because it attunes to making science curriculum culturally responsive as propagated by Stephens (2001).

However, as mentioned earlier about the reasons that influenced decisions about the kind of indigenous items to be included and curriculum developers' background to such knowledge, the Malawi science and technology curriculum failed to meet all characteristics of a culturally responsive curriculum as Stephens (2001) suggests below:

Characteristics for a culturally responsive curriculum:

- It begins with topics of cultural significance and involves local experts.
- It links science instruction to locally identified topics and to science standards.
- It provides substantial blocks of time and provides ample opportunity to students to develop deeper understanding of culturally significant knowledge linked to science.
- It incorporates teaching practices that are both compatible with cultural context, and focus on student understanding and use of knowledge and skills.
- It engages in ongoing authentic assessment that subtly guides instruction and taps cultural and scientific understanding, reasoning and skill development tied to standards.

According to Stephens (2001), culturally responsive curriculum bears the following strengths:

- It recognizes and validates what children know and builds upon that knowledge towards a more disciplined and sophisticated understanding from both indigenous and western perspectives.
- It taps the often-unrecognized expertise of local people and links their contemporary observation to vast historical database gained from living on land.
- It provides for rich inquiry into different knowledge systems and fosters collaboration, mutual understanding and respect.
- It creates a strong connection between what the students experience in school and their lives out of school.
- It creates content standards from multiple disciplines.

This array of ideas were not in my mind when I participated in the PCAR curriculum development and I believe my colleagues did not have such a clear guidance when proposing items to be included in the science and technology curriculum.

Obviously, the selective use of technologies alone misses out on the first point on characteristics of a culturally responsive curriculum as suggested by Stephen (2001), because technologies are not the only that are culturally significant. Additionally, the curriculum process may also have missed using the unrecognized (local) experts in thinking about technologies.

As indicated in the rationale, curriculum developers in Malawi were concerned with helping the learners solve everyday life problems. However, the lack of clarity on how the scientific principles are connected to indigenous knowledge was the pitfall in that pursuit. While other countries may have other reasons for including indigenous knowledge in science, in Malawi, the indigenization was probably intended to co-exploit both western and local ideas, an arrangement which pertains to hybridization of knowledge (Dei, 2000; Michie, 2000; Shumba, 1999).

Multicultural View of Content

Posner (2004) points out that content is the heart of any curriculum. However, instead of merely looking at content as that which we teach in a curriculum, Posner (2004) concurs with Galton (1998) that there are many meanings about curriculum and content. Posner (2004) describes content from three viewpoints: a behavioral psychological view, a pedagogical view, and a multicultural view. Behavioral psychological view considers content in terms of objectives, from different domains (cognitive, psychomotor, and affective), which lead to the substance that we teach. A pedagogical view looks at the embodiments of concepts and representations, in form of analogies, illustrations, examples of explanation and demonstrations. Of interest to us is the third view, content as a multicultural view. Posner (2004) states, “From the perspectives of multiculturalists the purpose of education is to accommodate the diversity of the student population” (p. 86). This makes a lot of sense where you have distinct mixtures of cultures due to migration, as is the case in the US. However, I wonder if the curriculum indigenization process, in Malawi, considered migration and ethnic differences as significant elements in decision-making. It is through such wonderments that I suspect the decisions on indigenization, during curriculum development, may have lacked the framework for justifying the choice of content on indigenous technologies. Therefore, it may be speculated that there were no psychological, pedagogical or even

multicultural tenets, which could drive decisions the nature of indigenous science content to include in each class.

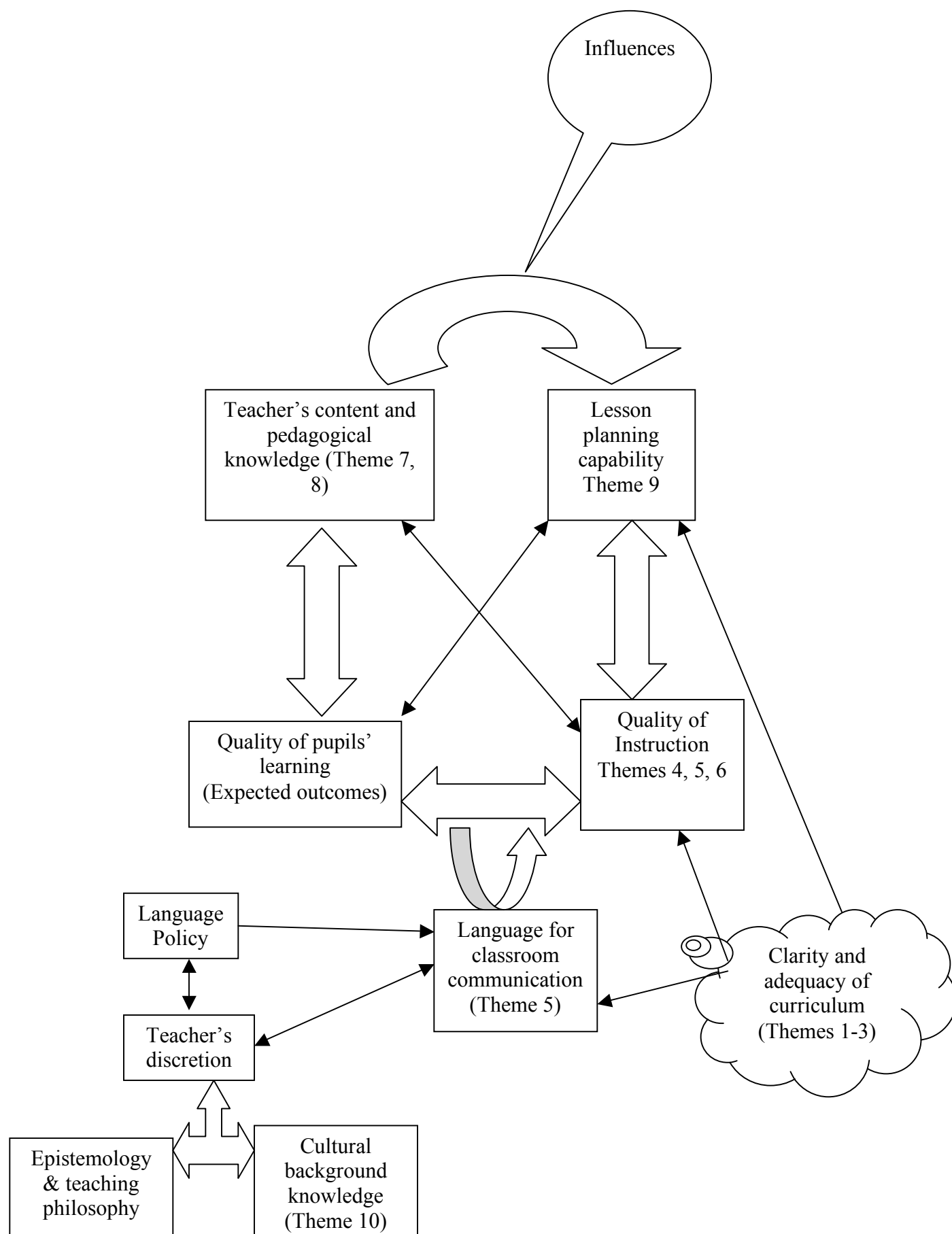
No wonder, the decisions on nature of content still bore the colonial legacy about what was deemed as appropriate knowledge. Taboos and beliefs could therefore only be represented as negative, as was the case during colonial days. The contenders of indigenization of science claim that some colonial forms of representation of knowledge work against learners' and a people's identity to the extent of eroding such knowledge from their minds. Therefore, as Malawi embraces the indigenization of curriculum, it may be necessary to review latent negative representations of some science content in the forthcoming curriculum revisions. Actually Ninnes (2000), in a study entitled *Representation of indigenous knowledges in secondary school science textbooks in Australia and Canada*, actually cautioned that even some examples of artifacts or words that are written in books that try to represent indigenous or minority groups may end up perpetuating cultural imperialism since they present examples which are of low value. Such examples, in texts, fail to compete with the comparable value of regular scientific influence, and thereby maintain the status of power leaning to western science.

Hence, representation of only negative parts of cultural practices, as done in science curriculum in Malawi, is tantamount to perpetuating subjugation of indigenous knowledge, despite putting indigenous knowledge (or technologies) forward as a way of uplifting or recognizing cultural diversity. This implies that the curriculum developers need to be very alert about possible portrayals, which may seem like there is a move in the positive direction while the opposite is also true.

Synergy of Themes in The Implementation Process

To wrap up these findings, let me say that this study sought to learn how indigenous knowledge is featured in the standard five PCAR science and technology curriculum and also teachers' experiences while implementing this new curriculum. This groundbreaking study revealed various problems that need to be addressed. Since it was a small-scale study, the study only opened the eyes about the issues to be followed up. However, the findings are persuasive enough and indeed draw our attention to important pointers to what should be done by the curriculum developers, teachers, and probably teacher trainers as they play their roles in implementation of this curriculum.

Figure 2: Factors Affecting Achievement of Curriculum Goals



This far, I would like to say that among the ten themes that came up, each one has a part to play in the whole process of pedagogy and unpacking of the PCAR science and technology curriculum, focused on indigenous knowledge. As my mind spun around these themes, I started seeing how the themes interacted in the processes of teaching. Hence, I hereby present a conceptual diagram (Figure 1) that ties some of the themes together and builds my thesis on how the themes play out in the teaching processes; especially those to ensure achievement of the goals involving the indigenous knowledge in science and technology curriculum.

Fig. 1 displays subsets of constructs that played out in this study which I think will still play out in the process of implementing indigenous knowledge in science and technologies. Curriculum issues portrayed in themes 1-3 (located in the right side of the figure - in the bubble) seem to affect all processes that involve lesson planning (reflected in theme 9) as well as actual teaching or instruction (highlighted in themes 4, 5, 6). Hence, the quality of curriculum guides affected the choice of instructional language and concepts (theme 5), design of learning experiences, execution of plans and the outcomes of teaching. A teacher's pedagogical content knowledge of science and technology (Theme 7, 8) seemed to propel the whole process of instruction, which resultantly affected the results at all levels. However, language use (theme 5) seemed connected to many factors because of its pivotal role in instruction. Teaching tends to involve careful selection of words because meanings are generated from those words. As teachers embarked on teaching indigenous technologies, some of the words came from knowledge (theme 8), others came from the curriculum (themes 1-3), and yet others came from teachers' professional development which initially starts from teacher training education. Beyond all such sources of knowledge, the teaching of indigenous technologies demanded an understanding of some cultural or local knowledge about technologies prevalent in various local places. A combination of knowledge from local places and curriculum requirements were determinants of teachers' evaluation of the role of recently introduced content on indigenous technologies as portrayed in (theme 10).

It is for that reason that place-based education comes under play. In this paper, we came across scenarios where learners were given tasks such as using knowledge to improve machines. We also heard teachers asking for more scientific and cultural

knowledge to improve the curriculum. I too, advocate the improvement of the curriculum so that it suits the learners' knowledge spaces. It was from such facets and quest for improvements that I wrote my double haiku (Japanese poem) to express my contemplation.

If something is working poorly
It needs someone to improve its performance
Improvement demands someone with knowledge
What kind of knowledge matters?
Situation determines the best type of knowledge
Place-based knowledge is a must.

Since there are many issues to think about improving (teacher's knowledge, cultural backgrounds, organization of effective learning experiences, e.t.c.), I hereby make a proposal on how practical work can be done to meet the PCAR's desire to improve learners' achievement of outcomes, since teachers seemed to face lots of problems on this issue. The suggested proposal will come last because it addresses many issues that came out of this study. Since one of the most important observations was poor organization of teaching practice on indigenous technologies, as depicted through lesson vignettes, I suggest how teachers can work collaboratively on development of a unit that can clarify some of the issues that I think could reduce the problems of instructions observed from this study. However, the suggested approach resonates with constructivism and learner centered learning. Therefore, the proposal can apply beyond borders of science and technology. Prior to giving that detailed proposal on how to organize practical work, I will give implications for further research.

Implications for Further Research

To help improve the curriculum and how content is represented, I would recommend the commissioning of research studies on the type of indigenous knowledge that Malawians feel could boost the image of local people and bridge learners' classroom science experiences with experiences at home. In absence of such research, curriculum developers can only resort to guesswork or intuitive thinking about what they consider as valuable technologies to feature in the curriculum.

To gather more information in this new area, a team of researchers might engage in a survey of the nature of indigenous knowledge and/or technologies that bear scientific relevance from various parts of Malawi. Accumulation of such information might give curriculum developers a wide range of choices and probably create a hierarchy of technologies or indigenous technologies, which would provide a choice of the most prevalent and essential ideas to be represented in the curriculum.

As this curriculum rolls out, it might be necessary to let teachers compile data that show their problems and successes in the teaching of indigenous knowledge which might reveal issues to be dealt with during the revision of the curriculum. From curriculum analysis, this study revealed that taboos are exclusively represented in the negative sense. Hence, budding off from such finding, another study might explore both positive and negative food taboos from the communities. Each food taboo and beliefs could also be analyzed to check the meanings behind its origin. A compilation of such knowledge will increase access to such information by teachers.

Currently, Malawian primary school teachers largely depend on a prescription of approaches to teaching as depicted by highly structured programs, whereby; exact content to be covered is prescribed in teacher's guides. This arrangement leaves very little room for their adjustment of the science curriculum, which almost makes teachers believe that ideas suggested in the teacher's guides are unchangeable truths. This view conflicts with the nature of science, which stipulates that new evidence is likely to change some of the facts that we accept at the moment, the tentative nature of knowledge (AAAS, 1990). Teachers' belief in absolute scientific facts tends to make them refuse to take ideas that children might think about as they are learning science. This scenario could be said to present science as dogma, which naturally conflicts with the true nature of science.

In view of the above stated background, I feel that science learning in primary schools can be improved if teachers would be engaged in classroom research, whose findings could be shared, tried out by others, and probably improved in this process. In the long run, such ideas or practices could be documented for the consumption of all teachers. I also feel that when teachers notice the benefits of researching, their desire to conduct more research will increase and thereby improve their teaching as well. The Ministry of education could encourage research in the classroom by attaching some

incentives. For example, a policy might be developed to encourage research among teachers in their classroom practice, of course with clearly stipulated incentives. This approach would enlighten teachers on how to deal with difficult areas or even new ones in science such as indigenous science.

Indigenous science has just been introduced in the curriculum. There are many issues that teachers are still not sure about how to approach the teaching about indigenous knowledge because they probably do not know the origin of such ideas. To clear misunderstandings, I recommend that teachers must make a deliberate effort to explore reliable types of indigenous ideas from their community. They could also try to find out reasons why their students respond to the indigenous-knowledge-related content in the way they observe it happen. Research would thereby illuminate both false and helpful ideas from the indigenous knowledge pool. If all teachers in the country would share their notes on such issues through a science teachers' magazine, which the Ministry would organize, probably under the Department of Teacher Education and Development (DTED), teacher's values and beliefs about indigenous ideas may likely change according to such findings. Teachers may therefore need no persuasion or showing on which ideas to use or discard. Furthermore, they would avoid naive explanations about indigenous ideas that they are ignorant about. If previous research has not already indicated issues at stake, teachers may embark on fresh research to unravel ideas behind the unknown areas. In this way they might be involved in development of clear frameworks about indigenous science in a more constructivist approach. Being involved in research is likely to equip teachers with the skills that would be passed on to learners. Hence, they might develop some insights on how to engage pupils in inquiry, which is one of the major tenets of constructivism according to Llewellyn (2005). This can only happen if teachers would have easy access to literature and also when they are convinced about the benefits for research. I hereby turn to a list of possible research areas and possible research questions that might extend ideas from this study.

Possible Research Areas and Questions

1. Research in the use of indigenous technologies in communities which might focus on the following areas:
 - a. How many Malawians rely on indigenous technologies?

- b. Which categories of Malawian communities are likely to use indigenous technologies in the next ten years?
- c. How have indigenous technologies changed in the past four to five decades (in the life time of the current generation of adults), or century.
- d. What forms of indigenous knowledge bear scientific relevance from the communities?
- e. What range of indigenous knowledge would be relevant to include in the teaching of science and technology.
- f. How do parents value the teaching of indigenous knowledge in school science and technology?

2. Research in the schools:

- a. What kinds of concepts are easy to teach under indigenous technologies and vice versa?
- b. What are people's preferences on use of indigenous technologies in different communities?
- c. What aspects of science could be associated with indigenous technologies (this could be a survey targeting a wide range of people in the community and the education systems at all levels).
- d. How do learners perceive as the value for learning indigenous technologies?
- e. What kinds of technologies are feasible to use at different class levels in the primary school science and technology.
- f. Which kind of problems do teachers often meet while teaching indigenous technologies?
- g. How much time does it take for learners to understand some principles on some named indigenous technologies?

Improving Teacher Practice Through the Practical Work of Science

This is a proposal on use of practical work in science to demonstrate unification of topics in the teaching of science and technology, with a focus on integrating topics bearing indigenous technologies. I propose this approach to practical work in a bid to create more time and meaningful use of teaching time using authentic examples of learning

experiences that would ensure learner's understanding of ideas leading to the application of such ideas in everyday life. This would also help to pool together teacher's knowledge and upgrade development of the PCAR curriculum.

Value of Practical Work in Science

The value for practical work in science cannot be overemphasized. It is common knowledge that learning by "doing" enhances understanding of scientific concepts just like all practical skills are developed through practice. Many educators will agree that practical work is a valuable activity in school science because by nature, it is a practical subject. This is the reason why most school science in many countries is done practically and the more hands-on work is done, the better the teaching of science. More practical work in science teaching is therefore considered as progress. However, it is not uncommon to hear that practical work is unproductive in the process of science teaching and learning. This is often a result of poor organization of practical work, especially when it is taken as humdrum and routine, rather than engaging or inspiring. In a strong critique of current practices, Hodson (1991) wrote:

As practiced in many schools, practical work is ill conceived, confused and unproductive. For many children, what goes on in the laboratory contributes little to their learning of science or to their learning about science and its methods. Nor does it engage them in doing science in any meaningful sense. At the root of the problem is the unthinking use of laboratory work.

Such criticisms arise because practical work is often carried out rapidly, or with unreliable equipment, or with little time to enable pupils to practice the use of equipment before making measurements - and these are often taken with insufficient attention to care and precision. Resultantly pupils may fail to observe or realize the phenomena they are supposed to observe, let alone be helped to appreciate patterns, trends or explanations. Conclusions that seem obvious to the teacher may appear less so to the student, even when they do make measurements or observations the teacher intended. Hence, simplistic and routine treatment of practical work fouls up the purpose of such work and resultantly yields negative effects. However other scholars consider practical work as, "*The missing link between science and technology education and development*" (Zesaguli, 1999). Therefore, turning practical work into a productive tool for science

teaching, demands special knowledge, organization, appropriate resources, and providing reasonable amount of time to accord learners a chance to make the most from practical work.

Trends of Practical Science Teaching in Malawi

The teaching of science in primary schools is currently below standard and this status has necessitated establishments of interventions such as Malawi Teacher Training Activity (MTTA) and Capacity Building International, Germany (InWent) activities that target teacher educators as a way of having the ripple effect of learner-centered teaching approaches in Malawi. Teacher training colleges are targeted because of the obvious ripple effect when teachers qualify and go out into the schools. These two interventions target knowledge transformation of teacher educators, who in turn pass this information down to pre-service teachers who eventually go into the schools. It is hoped that the newly trained teachers will change their approach to teaching science, being better equipped with pedagogical understanding, and in turn influence other teachers in the field to teach like them.

Previously, Malawi Integrated In-service Teacher Education program (MIITEP) program infused TALULAR as an intervention to help teachers conduct practical work due to lack of supplies of science teaching and learning resources. But unfortunately since the introduction of TALULAR ideas during MIITEP, practical work still remains scanty and disorganized in the primary schools. The output of MTTA and InWent interventions are slowly emerging but the amount of work on the ground is still enormous. The two new interventions target pedagogical practices. Of much interest is the encouragement of learner participation in science lessons, as propagated in constructivism. InWent's intervention, in fostering learner-centered approaches, was propelled by constructivist perspectives. This means that the active learning approaches that are being advocated are well complimented by the previous move to foster practical teaching by using TALULAR. Let me point out that TALULAR ideas are now online. Thanks to Andy Byers for starting the development of a wiki on google for interested parties to pick ideas from or even contribute at no extra cost. You can visit google "etalular" to see what is up and contribute to upgrade the undeveloped segments or improve the developed ones as well.

Connections to PCAR Curriculum

In my current study on teacher's perception of some topics in the PCAR curriculum, there are so many indicators that teachers are still failing to generate adequate and appropriate teaching and learning resources. Their teaching quality still manifests low quality (which emphasizes theoretical coverage of science and poorly organized practical activities) and heavy dependence on prescribed ideas in the teacher's guides and pupils' books. The curriculum also presents so many concepts (some broad), which mostly come as independent entities. During planning for teaching, it was noted that teachers usually copy the ideas given in the curriculum guides without processing connections between the numerous concepts given in the curriculum. In practical terms, this means a lot of work, which is to be covered in many separate lessons.

Having so many lessons has several implications on the teaching practice. Teachers often hurry through their work in order to cover enough information, which to the best of their understanding is better done didactically. Theoretical coverage of work (as designed and presented by primary school teacher's in this study) was erroneously deemed superior to practical work because teachers consider provision of theoretical presentation of work as a ideal because it provides learners with direct facts that they can reproduce when asked. Quick theoretical coverage of scientific concepts negatively affects learners' understanding because they have very little time to process information and develop long lasting understandings. This is compounded by the fact that science is a living subject that demands active processing of knowledge, which includes questioning things and generating solutions to new experiences.

Therefore, not all what should come from science is pre-packaged, as the primary school teachers seem to believe. Children need to spend reasonable time exploring how things happen or what causes natural phenomena in a systematic manner and with clear intentions. Children need to develop their own understanding of natural phenomena and how materials work. This does not just come in a single moment. Quick theoretical coverage of scientific activities is, therefore, detrimental to development of young scientists who are supposed to learn how to deal with authentic issues in the world. Solving practical problems is pivotal to improvement of a people's socio-economic status, which obviously applies to Malawi as well.

Recommendations for Fostering Practical Science Teaching

It is therefore imperative to find ways of helping the teachers to improve their organization of content in order to give them room for engaging learners in meaningful scientific experiences in schools. Through the experiences learned from my current study which endeavored to find out issues that teachers are likely to grapple with during the implementation of grade five science topics on indigenous science topics, I have a couple of recommendations on what should be done to foster practical teaching of science.

Unlike mere involvement of learners in group work, there is need to help teachers learn effective ways of organizing content such that learners have to spend adequate time processing scientific ideas while learning various concepts from the designed activities.

The main goal of this work is to illustrate how content prescribed in the syllabus and teacher's guides could be integrated in a few units that would carry all the desired scientific concepts intended for a particular level in primary school. Reducing the activities and knowing the types of concepts associated with the main activity would help learners to spend more time on scientific work, reduce theoretical loading of learning experiences, improve teachers understanding of the connection of scientific activities, and learning the best ways to plan for many other related concepts.

To enhance practical science teaching, I suggest a couple of strategies to immerse teachers and practicing teachers (both of whom are pivotal in the implementation of the new curriculum) in the rigors of practical science teaching. First, I intend to design an integrated unit from the content outlined in the PCAR curriculum. This unit intends to show teacher trainers, student teachers, and practicing teachers about how to weave the concepts in a few authentic activities that would be done for a reasonable length of time and allow learners to seriously engage their thoughts in the processes that open up opportunities to generate scientific concepts in a more realistic manner. A 5Es model of lesson development, which complies with constructivist approaches, will accompany this unit.

Secondly, besides showing the unified scientific concepts, I would like to illustrate ways of encouraging pre-service and practicing teachers to develop their own resources and probably make materials development an on going activity while in the field. These two products (a unified unit and processes of encouraging generation of

teaching resources from locally available resources) are expected to foster practical teaching of science, which is likely to reverse teacher's resort to theoretical teaching. The need to have teachers develop their own resources is heightened by the introduction of indigenous technologies, which will depend on the teacher's choice of indigenous technologies that are relevant in their local environments.

Finally, I will give a detailed description of constructivism and how it can help foster practical teaching among teachers when they embrace this teaching and learning model. The paradigm shift may be challenging and is not a panacea to all teaching problems but it is a powerful teaching and learning model that could show teachers the value of active engagement of learners and how to engage learners in the learning process. One of the key goals of constructivism is to foster lifelong learning, which may also be linked to technical and vocational education. I will briefly show the link between constructivism, science practical work, and technical and vocational work.

Model of a Unit in Science that Encourages Practical Work

The unit that I am describing here is developed based on the principles stipulated in Outcome-based Education (OBE) and extracted from work developed in the standard five curriculum materials. I hereby illustrate how the teachers would realize authentic scientific activities from a single unifying activity in agriculture. The intention is to develop an integrated unit, which allows for realization of various *success criteria* within grade five Science and Technology and also across subjects. It is also designed to foster continuity of learning and utility of school ideas in life after school, which the PCAR curriculum calls the *world of work*. The description of activities brings to light the practical activities that learners would always do and from which they would develop scientific concepts over a period of time but in a more natural way and in realistic activities. The main goals of this unit would be to:

- Provide learners with scientific skills in conducting investigations
- Develop holistic scientific knowledge and skills applied in agriculture and associated consumer activities.
- Illustrate the thinking processes that teachers would engage in integration of a wide range of learning experiences covered under one umbrella activity.

- Show a wide range of lessons that would emerge from this activity while following the same syllabus and teacher's guide in grade five.

Panning

Teachers who are used to following prescribed curriculum usually follow all what is suggested to the letter. They fail to create their own framework of activities that would generate the desired curriculum goals. To them, fulfillment of prescribed activities, as suggested in curriculum books, is the only conceivable way of teaching. Unfortunately, multiples of suggestions given in the syllabus and teacher's guides, if treated separately, become too numerous for the teacher to fit in the teaching calendar. In a bid to cover as much work as possible, the teacher rushes through such work. To avoid hurried coverage of such work, I propose a long activity from which several lessons would be developed but in such a manner that sufficient time would be spent on each activity in order to help learners grasp the concepts reasonably. This approach also provides opportunities for the teacher to assess learners' performance and provide remedial activities to ensure successful understanding of key concepts.

I am cognizant of the fact that our teachers lack planning skills. This piece of work attempts to put the teacher in the picture of possible things that would go together and done practically, in various forms of practical activities that foster development of scientific concepts. The skills involved in the process of planning are also listed and illustrated in the example.

Although teachers are taught how to plan their schemes and lesson plans, there are still lots of gaps in their understanding of helpful planning. In many cases, this is due to lack of scientific principles that are supposed to guide teachers' planning procedures. Let us imagine that the teacher would like to teach science with the intention to help learners develop scientific skills that would continue to serve pupils in life after school, the teacher needs to be aware of what activities are important in life after school. Such activities could also have the potential to open up opportunities for modification and application in a wide range of life activities. In a nutshell, such activities need to be authentic (Harlen, 2001).

Learning Experiences

A practical learning unit ought to help pupil to observe, reason, engage, evaluate situations, and make decisions. Pupils need learning experiences from which to draw concepts. The teacher needs to have clear indicators for development of concepts. In the process of teaching, the teacher needs to monitor the development of concepts. Hence, a good unit should have provisions for assessment through built in activities. Having practical work also serves to provide assessment of physical and mental skills. Fully developed pupils need to have both physical and mental skills. Both types of skills impact a person's participation in everyday life activities, but also avail opportunities for a healthy preparation for continued learning. Success in developing such a unit may call for rigorous thinking, which I feel may work better if done collaboratively. Due to this, I feel that successful planning may require team planning among teachers who teach similar levels of classes. It may also demand having teachers who cover various disciplines to share possible concepts that could fit in suggested learning experiences. In this way, one can be very sure of a rich focus on important concepts emerging from the planned learning experiences. Any teacher's deficiency in knowledge would be masked and in fact knowledge would be upgraded in the course of the collaborated thinking in the process of planning of the units.

Description Of A Unit

A unit is a set of lessons that would best come under one umbrella. The choice of issues to be covered together may depend on the nature of instructional strategy to be used. For example, constructivism is a strategy where a teacher plays the role of a guide while the learners actively search for meanings through inquiry, interdisciplinary interaction of knowledge, or indeed mere transmission of information. Since, I am dealing with practical work, my focus will illustrate the kinds of ideas that foster practical learning. Therefore, development of a unit is determined by specific choices such as the desire to develop in depth understanding, opening up the horizon of ideas to the pupils, or linking knowledge from related learning areas. A teacher may decide to have five lessons from a unit or have more. Specific activities to be conducted are spelled out and these may portray whether the unit involves practical learning or theoretical learning. To

ensure achievement of goals of the unit, plans for assessing each lesson need to be provided and progression of knowledge development must be easy to visualize.

Examples of Practical Lessons on Indigenous Technologies

These are numerous possible types of activities that would be practically done by learners under the indigenous technologies. In this section, I only give examples that would serve as a starting point. College lecturers can come up with more examples to add to the following activities.

Conducting Researching On Indigenous technologies

This would start with exploring the meanings of indigenous technology, after dealing with technologies in general and giving an example of indigenous technology. To engage pupils in this knowledge, teachers would ask pupils to read or ask people (including searching on the web) about indigenous technologies. Each child would be asked to come with a report on probably one indigenous technology that he can discover from books, people, or experience. Each child could explain how he/she came across that technology, people who were using it, and how it was used. This information may reveal cultural or historical aspects of the user (linking social studies with science).

Success of this activity will depend on learners' capability to identify correct indigenous technologies, talking about their use, the users and probably providing evidence of the time for acquisition of such knowledge. The teacher may learn the diversity of learners' background knowledge in connection with this topic. Some students will be computer literate, others will depend on parents, and yet others may use other strategies. Such information may give the teacher an opportunity to assess students' prior knowledge from which to move forward in this study.

Understanding How Indigenous Technologies Work

To develop learner's understanding of the way indigenous technologies work, another lesson would put students in groups, probably based on similarity of areas of interested and ask them to explain how they think their indigenous technology works. This task would help pupils to make predictions and hypotheses, which they can test in subsequent lessons. Therefore, this activity might help pupils follow scientific processes for acquiring knowledge, done in a practical manner. If one follows the constructivist approach, learners would therefore be put at the centre of knowledge construction in a

systematic and progressive manner. The teacher's role would be to clarify scientific principles involved and help learners think about possible things to be done. Things to be done are usually not obvious, but the teacher needs to be ready with examples, pictures, and resources to help learners realize some principles that explain how indigenous technologies work. In the following section, I describe how a lesson on making soda would be carried out.

Making Local Soda. Helping children to understand the making of soda avails scientific principles such as solubility of substances, separation of mixtures (soluble and insoluble substances). Using various filtration designs or mechanisms, learners may discover differences in the clarity of filtrates from different filtration mechanisms. Such knowledge would eventually help them realize the differences of filtrates and probably start wondering about properties of filtration mechanisms that contribute to the difference of products noted.

To make decisions about which is a better filtrate, learners may consider using their filtered soda and compare palatability of foodstuffs that could be prepared from such filtrates. The teacher may also help pupils investigate vegetative materials (parts of plants) that are normally used for making soda and identify similarities of such materials. This activity brings in opportunities to teach cooking methods, history of cooking, cultural values of food and its taste, current understanding of preservation, and levels of vitamins in cooked green vegetables. Students would be called upon to think about food preparation values or habits and associated food taboos and beliefs. For example some cultures prohibit women who are menstruating from applying salt in foodstuffs. Such food preparation taboos can be linked with hygiene, but additionally, they would learn about hygiene rules set by local people.

Hence, instead of looking at this lesson as a mere filtration process, learners would realize that this is an indigenous technology similar to western technology that lead to making of soda.

Student would then think about prevalent needs for ash water and compare it with soda on utility, cost, palatability that go into marketing. Marketing ash water may open up exploration of a study on the supply and demand for ash water in homesteads. Students would then conduct surveys, assess the packaging that people would desire,

based on knowledge from other packaged foods. They would make decisions about the economical ways of marketing their ash product. Marketing of ash may open up an opportunity to teach mathematics dealing with cash accounts; profits, proportions, percentages and this would be built in the ash filtration lesson.

Five E's Learning Cycle Model

Learning Cycle

To foster practical teaching, all teachers need to become familiar with scientific inquiry processes but also following the 5Es learning cycle design of lessons that support constructivist approaches to teaching and learning. The 5E's lessons are characterized by the following:

Engaging learners in the concepts to be learned by challenging the learner's minds. This involves capturing students' attention, assesses students' prior knowledge, and identifies appropriate activities to engage learners and make an impact on their understanding of impending concepts.

Exploration of ideas, done by students, rather than spoon-feeding them through mere exposition of knowledge. The teacher acts as a guide in the interaction with materials or ideas, also sets up appropriate inquiry activities that direct concrete experiences of the concepts that students learn.

Explanation of what is being learned in which teachers and students work together in the process of analyzing information, where the teacher clarifies ideas being developed by pupils. Students typically work together in groups and with the teacher to analyze information from exploration and the key role of the teacher is to clarify scientific principles involved in the activity.

Extension/Expansion/Elaboration of concepts. This phase of instruction deepens learners' understanding of concepts as they apply in the real world. This is an active learning endeavor where learners take responsibility to see application of ideas in real life.

Evaluation is the last stage in the five E model whereby appropriate formal and informal evaluations are identified throughout the lesson.

All active lessons, bearing the 5Es, are conducive to effective development of scientific understandings and all aspects have something practical to be done or assessed which complies with enhancing practical work in science lessons.

Application Of 5Es On Soda Making

As it may be noted, lessons focusing on practical work would span across days and not end in one day. It may lead to clear direction of goals of each activity that a teacher would easily assess and all the work gives room for practical activities. Being an indigenous technology, all teaching resources can be obtained from the local environment depending on what is available. Therefore, teachers undergoing training or those in the field only need to know what to do in order to get the resources, some of which can be brought to school by pupils. Through this simple “Soda Making” activity, the concept of filtration, refining of filtrates, uses of filtrates, solubility, application of mixtures in everyday life, business mathematical computations, opportunities for computing simple proportion, profits and interest come under play. Pupils may also learn practical ways of analyzing substances and make appropriate decisions for human health, based on tangible evidence from both literature and practical findings.

The teacher may have less talking while learners do the searching for information from books, adults, and even from the web. These activities would also naturally bring in cultural understandings that determine choices of food and the history for such food habits and type of technologies used. The value for such technologies would naturally come to light. From such practical activities, learners would obtain scientific skills as well as learn cultural issues involved in the food-processing endeavor. The involvement of parents from the public would foster collaborative social construction of knowledge, as advocated by social constructivists like Vygotsky. The wide range of activities would cater for different types of intelligences as stipulated by Howard Gardner.

Covering different sections of the curriculum using such clustering of ideas would hopefully allow more time spent on activities and make teachers realize various ways of organizing the concepts in science and ensure practical presentation of scientific activities that engage the mind and the hands. Once this becomes easy to visualize, after collaborative planning, teachers may start modifying such plans as it pleases them, especially when they get used to this approach to teaching. One crucial step is to open

teacher's minds to possibilities. If learning would proceed in the suggested manner, pupils would already be on sound footing to excel in examinations, pursue career opportunities, solve problems in everyday life, and probably actively contribute to national development. Hence the desired OBE in PCAR would bear the fruits.

However, I realize that developing an integrated unit, as described above, may be demanding but it avails a natural and realistic way of teaching and learning knowledge. In most cases knowledge is not packaged in compartments and therefore opening up linkages between knowledge is valuable. Having it packaged in practical activities ensures development of multiple skills in learners and puts them on the path to functional life in the society. The teachers need to simply have clear unifying authentic activities, goals for their units, and clear choices for the activities that would clarify what to do and achieve at a particular level. Such knowledge will clarify the development of the steps to follow in developing such units.

Since this approach to teaching is not common, teachers would need to be exposed to this approach and learn related teaching and learning theories like constructivism and specifics of inquiry approaches that would enhance student understandings. Teachers would also be facilitators in helping guide students in making authentic scientific connections to their everyday lives within the context of Malawian culture.

General Conclusion

The range of issues that emerged from this study included poor clarity of the curriculum, limited scope of content in the curriculum, predominant focus on indigenous technologies and inexistence of other forms of indigenous science, poor organization of learning experiences (both from curriculum documents and by teachers), lack of literature resources to supplement what is given in teacher's guides, and communications problems. As a result, teachers faced so many problems in teaching the new content on indigenous technologies in the new school curriculum.

While conceptualizing this study, charged by constructivist ideas, I had the impression that engagement of indigenous knowledge in the teaching of science presents an opportunity to teach science successfully since indigenous knowledge would serve as prior knowledge. Indeed, literature supports the fact that learners do better when they

start learning using familiar knowledge. However, it turned out that the teaching of indigenous technologies was not that smooth. Teachers complained that curriculum documents had inadequate information, especially about scientific principles that are embedded in indigenous technologies. Hence, teachers struggled to guide learners towards development of the desired scientific principles anticipated by curriculum specialists (from the indigenous technologies). To make matters worse, they could not figure out the science principles from the indigenous technologies. This resulted into superficial coverage of content since teachers did not clearly know what to do. In general, teachers faced many problems.

Problems noticed in relation to the teaching of indigenous technologies as well as food taboos and beliefs could be multi-pronged. First, the curriculum design lacked a theoretical foundation, which could guide the specification of desired principles in curriculum documents. Hence curriculum designers lacked fine details of knowledge and hoped that teachers would find such details. In absence of literature to back up ideas under indigenous technologies, teachers could hardly tell the nature of ideas that come under play in connection with the listed indigenous technologies. Lack of details in the curriculum aggravated teachers' insights on the design of lessons. Secondly, teachers lacked knowledge about how indigenous technologies function, especially when dealing with technologies that do not belong to their gender roles. When it came to teaching scientific terms, words were hard to come by because teachers were not trained to handle such concepts. Hence, applying Vygotsky's principles of constructivism, teachers lost the role of an expert elder in teaching indigenous technologies. The content on indigenous technologies placed teachers as well as pupils in a state of dissonance and in the process, that dissonance disabled teachers from providing scaffolds to learners.

Teachers' beliefs in dishing out facts did not work well because most of the ideas were expected to be processed from engagement with using technologies. This is where it would be recommended that all teachers be trained on constructivist approaches so that they can help learners to reason as they create meanings from learning experiences. To facilitate this, I would recommend that the science and technology curriculum must focus more on a few authentic learning experiences, so that learners can spend adequate time on processing information by both manipulation and reasoning. As it was noted in this

study, the science was not obvious from indigenous technologies. A better clarification of tasks in the curriculum might help teachers in developing the kind of ideas they could help learners achieve. Otherwise, the way things were noted, the scientific principles were elusive from the indigenous technologies. Teachers failed to see them because of low scientific academic background but even for those who may have such background, it would be hard to decide how far to go where there are many principles associated with a single technology.

Teachers' lack of knowledge about indigenous knowledge is a common scenario as pointed out in literature (Michie, 2002; Oguniyi, 2007; Shumba, 1999). This issue implies that the teaching of indigenous technologies will need to call upon knowledge from elders or experts in indigenous knowledge. This notion concurs with Gonzales, Moll and Amanti (2005), who consider community elders as bearers of funds of knowledge. However, as Stephen (2000) described factors that could result in provision of a culturally responsive curriculum, the elders or experts of cultural knowledge traditionally lack the power to influence what is taught in school classrooms.

As Malawi embraces and pursues the indigenization agenda, there will be need to connect with elders and draw from them the knowledge that could soon disappear due to forces of globalization (Katz, 2004). Maintaining cultural knowledge is one of the principal tasks of education. However, Malawi has several micro-cultures that have origins in different tribes. Therefore, successful implementation of indigenous science will require a systematic way of documenting cultural knowledge. To do that, there will be need to set up a database as well as identify data collectors and the custodians of data. Availability of a wide database of knowledge from the community will open up a space for ordering, grouping, and clarifying forms of knowledge that come from the communities.

Stories, artifacts and local knowledge can be mapped from all parts of Malawi from which common elements and differences would be discovered. Future curriculum revisions would benefit from such data, just as all teacher educators would also do. A clear purpose for using indigenous knowledge might then come up since a commitment to setting up a database would stem from clear determination to validate indigenous knowledge. The oral nature of knowledge would change since the academy would start

processing it. This step would also inform other scientists about the nature of indigenous knowledge. Availability of such information might not only help local curriculum developers, but also shift the dialogue about what counts as science (Stewart, 2006).

Setting up a database would also avail the much-needed information that all the teachers demanded. Maintenance of worthwhile knowledge would require accumulation and refining of indigenous knowledge from research studies. Since, indigenous knowledge in science is new in the academy, there are few people who could be ready to combine both scientific and local knowledge. To extend the indigenous movement project, I would recommend identification of a dedicated team of scientists who would collaborate on responding to issues emanating from the science classes, such as extending the ideas on indigenization, establishing policies to shape the direction of the indigenous agenda, and probably liaise with owners of sites that hold valuable indigenous knowledge worthy sustaining. In the long run, all issues surrounding realization of outcomes from indigenous knowledge may show out better than seemed to be the case at the first leg of its implementation.

Opportunities emanating from engaging in indigenizing the science curriculum might include (a) addressing issues of diversity across cultures in Malawi (thereby providing scientific programs that are relevant to both culture and science), (b) teaching science by using locally available resources from various places in Malawi (which is less expensive), (c) training primary school teachers and teacher-educators to validate and document their self created knowledge which complies of the science agenda, and also (e) boosting self concept, identity, and self determination among both teachers and learners. Above all, science and technology would open windows for co-construction of knowledge between schoolteachers and community elders, which would better address place-based learning. In the long run, teachers would then ably function as expert elders in the social construction of knowledge in science and technology classrooms, after interaction with elders.

Finally, let me point out that it is high time the indigenous movement turned to the application of theoretical ideas expressed in recent literature. While it is true that there are post-colonial factors that are affecting people's perceptions about worthwhile knowledge and living habits, there is high likelihood that indigenous people will continue

using both western scientific ideas and their traditional viable scientific ideas in hybrid forms (Carter, 2006). The issues to grapple with should, therefore, shift from mere debate about whether one is science or not, to exploring more about such claims in order to confirm or disconfirm the claims put forward in the theoretical debates about the role of indigenous science. However, it appears engaging indigenous science curricula seem to be plausible only among indigenous people and not the Western societies. I, personally, have no problems if doing so helps sustain indigenous people (like Malawians) in survival and participation in the global issues or even influence decisions. Hence, I advocate hybridization of knowledge and prefer to open borders between cultures because there is low likelihood of separation of knowledge systems in the current world; especially today, since people are inter-civilized, inter-socialized, and their existence is interdependent.

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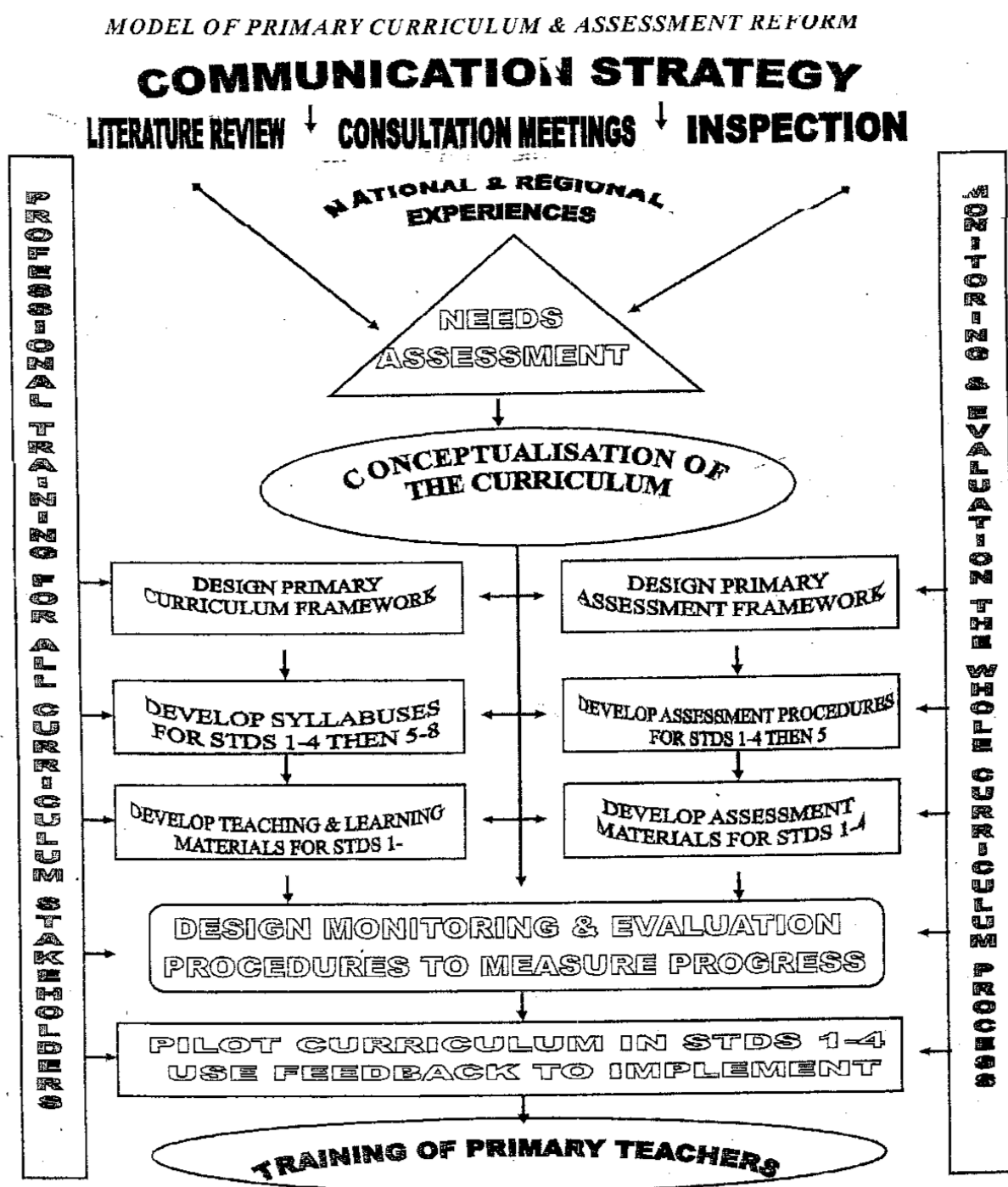
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Appendices

Appendix A

Figure 3: Model Of PCAR Processes



Appendix B

Table 6: Learning areas in the reformed Malawi primary school system

8 Years	6 LEARNING AREAS (P-4) BREAK INTO 8 SUBJECTS (5-8)						
INFANT PHASE							
P CLASS	LITERACY & LANGUAGE	NUMERACY & MATH	EXPRESSIVE ARTS				
STD 1	LITERACY & LANGUAGE	NUMERACY & MATH	EXPRESSIVE ARTS	LIFE SKILLS			
STD 2	LITERACY & LANGUAGE	NUMERACY & MATH	EXPRESSIVE ARTS	LIFE SKILLS	SOCIAL & ENV SC		
JUNIOR PHASE							
STD 3	LITERACY & LANGUAGE	NUMERACY & MATH	EXPRESSIVE ARTS	LIFE SKILLS	SOCIAL & ENV SC	AGRIC, SC & TECH	
STD 4	LITERACY & LANGUAGE	NUMERACY & MATH	EXPRESSIVE ARTS	LIFE SKILLS	SOCIAL & ENV SC	AGRIC, SC & TECH	
SENIOR PHASE							
STD 5	ENGLISH	CHICHEWA	MATHS	EXPRESSIVE ARTS	LIFE SKILLS	SOCIAL & ENV SC	SCIENCE & TECH
STD 6	ENGLISH	CHICHEWA	MATHS	EXPRESSIVE ARTS	LIFE SKILLS	SOCIAL & ENV SC	SCIENCE & TECH
STD 7	ENGLISH	CHICHEWA	MATHS	EXPRESSIVE ARTS	LIFE SKILLS	SOCIAL & ENV SC	SCIENCE & TECH

From PCAR documents (Kaambankadzanja, 2005)

Appendix C

From: Absalom D. K. Phiri, Department of Teacher Education and Development, P/B 215, Lilongwe.

To: The Director, Malawi Institute of Education, P. O. Box 50, Domasi.

Date: May 27, 2007

Subject: Request for Standard Five New PCAR syllabus and Teacher's Guides.

Dear Sir,

I am a doctoral student at Virginia Tech and currently, I am back home for research. I formerly worked at DTED before going for study leave. As hinted in the above subject, I would like to request for three standard five PCAR syllabi and three Teacher's Guides to be used for my Doctoral research. I verbally talked to the Deputy Director about my intention to conduct a pilot study on some topics, which cover *indigenous science* in grade five. Indigenous science *application challenges* is the area that my research focuses. Since Malawi just introduced elements of indigenous science in the new curriculum, my interest is to learn how teachers cope with such type of science, which they have never seriously considered as important all along and never got trained on issues involved when employing multicultural science.

I intend to have three case studies (three teachers and their classes) in three different schools, hence the need for three syllabi and teacher's guides. I assume that Teachers guides have already been produced along with the syllabus for science and Technology. I will be very grateful if I could access the requested materials as soon as possible so that I can make use of teachers and their classes before the term winds up. If all goes well, I have to squeeze all my observations between June and July. Hence, time is quite tight. If this request is acceptable, you may inform me through my phones (09233243, 01418715) or email <aphiri@vt.edu> so that I can find a way of collecting them as soon as possible. Hoping to hear from you soon.

Yours faithfully,

Absalom D. K. Phiri.

Ph D. doctoral student (Curriculum and Instruction)

Virginia Tech and State University, USA.

Appendix D

Verbal Consent for Teachers

Investigator: Absalom Phiri, Doctoral Student (Science Education). School of Education
(Department of Teaching and Learning)

This statement will be read to the teacher participant and audio-recorded. Teachers will have an opportunity to agree or not to participate in the study.

I am conducting a study to learn how indigenous science topics will be taught in the new PCAR curriculum during its implementation in Malawi. I would like to observe you teach and also interview you after you have taught all the work that you will plan from the new curriculum, to learn how you teach about indigenous technologies and food taboos and beliefs that are included in the new curriculum. I would also like to read your planned work and your personal evaluations, after teaching your lessons, on the two topics, after using the new learning materials (i.e. Syllabus, teacher's guide and learners' book).

The interview, to be conducted at the very end of your teaching will last about 35 minutes and classroom observations will be video recorded. The images on the video of teachers and children may be shown at professional meetings for educational purposes. I may also use the information collected to publish the reports in professional journals.

You will have an opportunity to review any papers from this research project before they are submitted for publication. I will not identify you by your actual name in papers or videotapes of your teaching, unless you request that I do.

This research will help me understand the issues that are likely to emerge when teaching about indigenous technologies and food beliefs and taboos (encrusted in indigenous science) in the newly reformed curriculum in Malawi. You may choose to participate in this study by agreeing to the following statements:

Do you agree to participate in the study?

What is your name?

What is the date?

Would you prefer to use you real name in published reports or in videotapes of your teaching?

You may choose not to participate in this study at anytime by notifying your principal.

Name of Participant: _____

Researcher Signature: _____

Witness Signature: _____

Date: _____

Appendix E

Interview Questions For Teachers

Although qualitative research questions may not be pre-determined, the following will be examples of questions:

1. What is your understanding of the following terms:
 - a. Indigenous?
 - b. Technology?
 - c. Indigenous science?
2. When did you first come across knowledge about
 - a. indigenous technologies?
 - b. food taboos and beliefs?
3. What did you experience as you taught topics on:
 - a. Indigenous technologies?
 - b. Innovations of indigenous technologies?
 - c. Food taboos and beliefs?
4. How do you think pupils coped with content under
 - a. Indigenous technologies?
 - b. Food taboos and beliefs?
5. What would you like to be changed in order to improve your teaching and also learners' performance under
 - a. indigenous technologies?
 - b. food taboos?
6. How helpful were the Teacher's guides and Learners' books in your teaching?
7. What do you think could be done to improve the units on
 - a. Indigenous technologies?
 - b. Food taboos?
8. What challenges did you face when planning for teaching the topics under
 - a. Indigenous technologies?
 - b. Food taboos?
9. How much time do you think would be suitable for the work allocated under
 - a. Indigenous technologies?

b. Food taboos?

10. How helpful to learners is the content under indigenous technologies and food taboos and beliefs?

Appendix F

Final Interview Notification Memo

From: Absalom D. K. Phiri, Ph D student in curriculum and instruction, School of Education, Virginia Tech, USA.

To: Grade five teachers who have participated in my study on “Exploring the Integration of indigenous science in primary school science curriculum.”

Date: July 23, 2007.

Subject: Notification and scheduling for interviews.

Dear participant:

This is to notify you that I will be conducting interviews with you after going through all classroom observations. This is in line with your earlier agreement (in June, 2007) to participate in this study as stipulated in the verbal consent, which included acceptance to be interviewed. I am ready to conduct the interview with you beginning from July 28, 2007 to August 3, 2007. Feel free to choose a date for the interview and time within the range of days that I have indicated. When you are decided, indicate the date and time that you feel will be convenient for the interview and indicate your name and signature in the space provided below:

Date: _____ Time: _____

Name: _____ Signature: _____

Appendix G

Institutional Review Board Continuation Approval



Office of Research Compliance
 Institutional Review Board
 1880 Pratt Drive (0497)
 Blacksburg, Virginia 24061
 540/231-4991 Fax: 540/231-0959
 E-mail: moored@vt.edu
 www.irb.vt.edu

FWA000005721 expires 1/20/2010
 IRB # is IRB000000057

DATE: April 18, 2007

MEMORANDUM

TO: George E. Glasson
 Absalom Phiri
 Ndalapa Mhango

Approval date: 5/15/2007
 Continuing Review Due Date: 4/30/2008
 Expiration Date: 5/14/2008

FROM: David M. Moore 

SUBJECT: **IRB Expedited Continuation 1:** "Ecological Sustainability, Indigenous Science, and Education in Malawi", IRB # 06-309

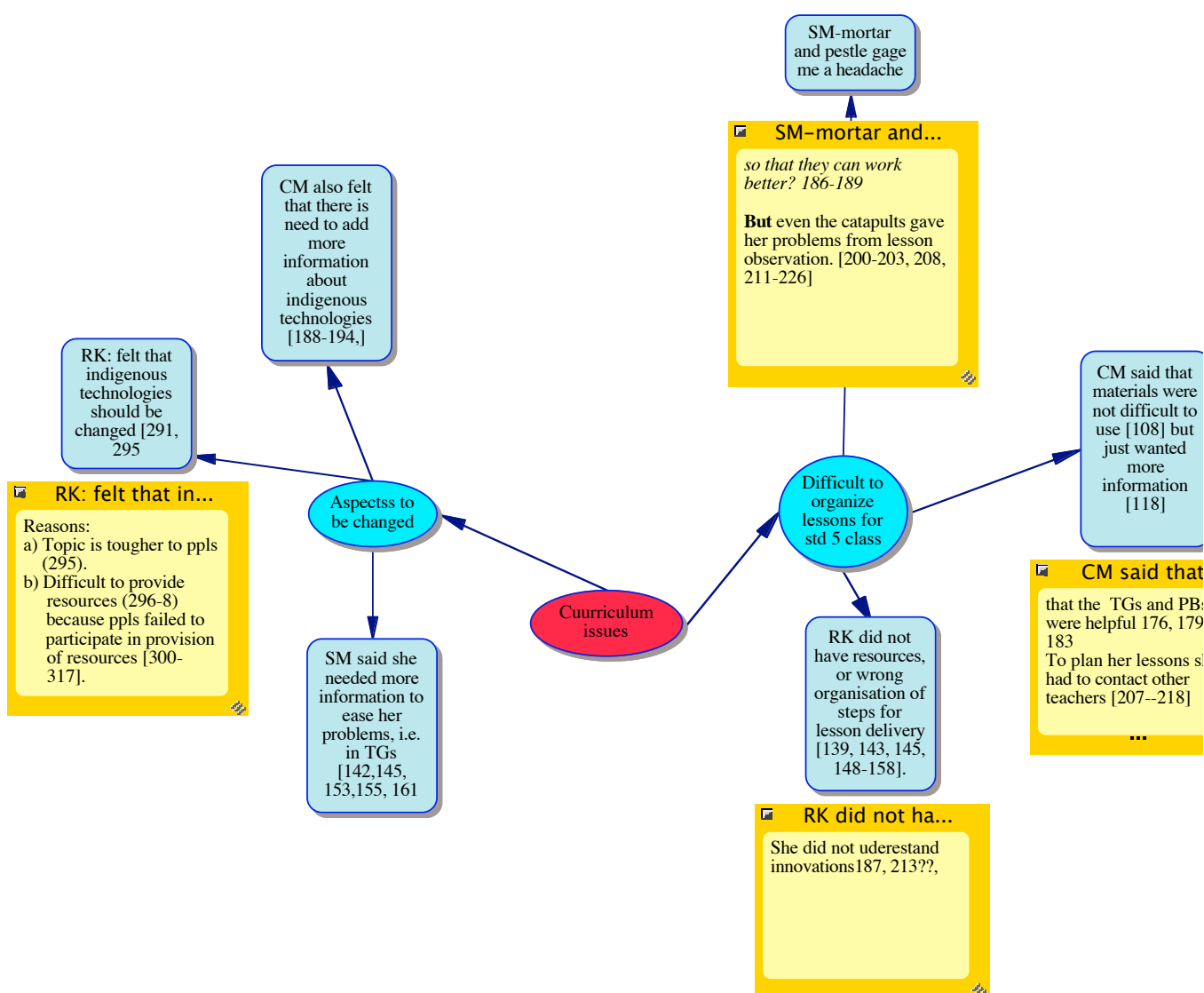
This memo is regarding the above referenced protocol which was previously granted expedited approval by the IRB. The proposed research is eligible for expedited review according to the specifications authorized by 45 CFR 46.110 and 21 CFR 56.110. Pursuant to your request, as Chair of the Virginia Tech Institutional Review Board, I have granted approval for extension of the study for a period of 12 months, effective as of May 15, 2007.

Approval of your research by the IRB provides the appropriate review as required by federal and state laws regarding human subject research. As an investigator of human subjects, your responsibilities include the following:

1. Report promptly proposed changes in previously approved human subject research activities to the IRB, including changes to your study forms, procedures and investigators, regardless of how minor. The proposed changes must not be initiated without IRB review and approval, except where necessary to eliminate apparent immediate hazards to the subjects.
2. Report promptly to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.
3. Report promptly to the IRB of the study's closing (i.e., data collecting and data analysis complete at Virginia Tech). If the study is to continue past the expiration date (listed above), investigators must submit a request for continuing review prior to the continuing review due date (listed above). It is the researcher's responsibility to obtain re-approval from the IRB before the study's expiration date.
4. If re-approval is not obtained (unless the study has been reported to the IRB as closed) prior to the expiration date, all activities involving human subjects and data analysis must cease immediately, except where necessary to eliminate apparent immediate hazards to the subjects.

Appendix H

Figure 4: Example Of A Concept Map Used for Data Analysis



Appendix I

Table 7: Curriculum Organization: Extract for indigenous technologies

Assessment standards	Success criteria	Theme/ Topic	Suggested teaching and learning activities	Suggested teaching, learning, and assessment methods
<p>We will know this when the learners are able to:</p> <ul style="list-style-type: none"> demonstrate an understanding of indigenous technologies 	<p>Learners must be able to:</p> <ol style="list-style-type: none"> explain scientific principles applied in some of the indigenous technologies 	<p>Indigenous technologies</p>	<ul style="list-style-type: none"> Discussing the indigenous technologies such as those used in: <ul style="list-style-type: none"> -food preservation -separation of mixtures -corn flower production -water purification -chidulo production -removal of cyanide from cassava. Discussing scientific principles applied in indigenous technologies. Collecting samples of indigenous technologies. Practicing some of the indigenous technologies 	<ul style="list-style-type: none"> questioning and answer peer assessment teacher observation practical demonstration project investigation discussion self assessment field visits oral and written questions oral and written report