ANTI-COLONIAL EDUCATIONAL PERSPECTIVES FOR TRANSFORMATIVE CHANGE

African Indigenous Knowledge and the Sciences

Journeys into the Past and Present

Gloria Emeagwali and Edward Shizha (Eds.)

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ANTI-COLONIAL EDUCATIONAL PERSPECTIVES FOR TRANSFORMATIVE CHANGE

Volume 4

Scope

Informed by an anti-colonial spirit of resistance to injustices, this book series examines the ways and the degree to which the legacy of colonialism continues to influence the content of school curriculum, shape teachers' teaching practices, and impact the outcome of the academic success of students, including students of color. Further, books published in this series illuminate the manner in which the legacy of colonialism remains one of the root causes of educational and socio-economic inequalities. This series also analyzes the ways and the extent to which such legacy has been responsible for many forms of classism that are race- and language-based. By so doing, this series illuminates the manner in which race intersects with class and language affecting the psychological, educational, cultural, and socio-economic conditions of historically and racially disenfranchised communities. All in all, this series highlights the ways and the degree to which the legacy of colonialism along with race-, language-, class- and gender-based discrimination continue to affect the existence of people, particularly people of color.

African Indigenous Knowledge and the Sciences

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EDWARD SHIZHA AND GLORIA EMEAGWALI

INTRODUCTION

The aim of this text is not only to disseminate a historical background of African indigenous sciences, but also to dislocate and disrupt the notion that African indigenous knowledge is confined exclusively to the supernatural. What counts most is not simply discovering the origin of Africa's various forms of science, but unearthing the characteristics of what may rightly be called African science to compensate for centuries of marginalization and devaluation. The goal is also to understand the social and economic implications of impressive cultural innovations. Often, when discussing science in the context of Africa, an exclusively diffusionist hypothesis is projected in most literature with the tendency to perceive Africa as a passive recipient of foreign science without its own unique contributions. There is often a reluctance to consider or acknowledge that diffusionist hypotheses may well be irrelevant, questionable and false; paradoxically, most of the diffusionist theses proposed centuries ago by colonial anthropologists and pseudo historians, have never been in any way confirmed. Furthermore, there is, perhaps, cultural or political resistance to accepting the evidence that Africa has evolved its own explanatory framework and system of ideas as portrayed in the content and context of its indigenous knowledge systems.

Diffusionist theses have been fabricated to a wide range of fields, including iron production. The same can be said of several other endogenous achievements within Africa. However, within the last ten years much research on metallurgy and other technologies has been documented, in Africa and elsewhere in the world, and many diffusionist theories have crumbled under the weight of the evidence (Hughes, 2012). The publications that have emerged to rupture the diffusionism theory clearly attest to advanced indigenous expertise in African metallurgy and related technologies in general (Bocoum, 2004).

Explanations of worldly phenomena come and go, but acceptance of any explanation claiming to be "scientific" is constrained by the widespread belief that it should fit smoothly into the worldview prevailing in science at the time it is proposed (Callahan & Leeson, 2006, p. 2). However, the assumption of "a worldview prevailing in science at the time" is misleading as it connotes that there is one worldview that proffers scientific explanations. While we agree that science is not static, we disavow the notion that science has its explanations from a particular regional and eurocentric worldview. Definitions of any concept depend on the cultural worldview of the people who use the concept for their everyday practices. Any form of science is dependent on cultural practices (whether indigenous or western) and relies on direct observation, experience, experimentation, and interpretation.

Discounting and underrating scientific epistemologies and ontologies that are associated with indigenous societies has been a major tendency by Eurocentric observers. Building technologies, physics and mathematical principles used in constructing indigenous structures such as Great Zimbabwe are dismissed as non-scientific. In addition, ethno-medicinal treatment of illness and diseases as well as the application of spiritual healing from holistic geoscience and human interactions are viewed with suspicion. Rather than working within carefully constructed boundaries and methodologies established by cultural theories, they broadly generalize entire fields of academic expertise and dismiss many of them. Eurocentric scientism reduces science to a monolithic interpretation of the social reality using reductionist views, thus, restricting human inquiry.

African indigenous knowledge fulfills the expectations about science; although Africans do not consider themselves as "masters and possessors of nature," but respect nature as a resource that comes with sustainability considerations attached to it. Whether it is physics, geoscience or medicinal knowledge, African indigenous knowledge has existed for centuries and generations and has been sustainably utilized to serve African communities and societies. Indigenous knowledge has gained attention and acknowledgement as another form of science that can be used to explain phenomena and socio-cultural realities of diverse African societies. The authors in this book have taken the indigenous Africanist perspective to illustrate how indigenous knowledge reveals itself as a science. In the seventeen chapters that make up this text, authors point out, through historical narratives and illustrative data, that science in its different forms existed in African societies.

We shall now focus on some of the issues highlighted by the various contributing authors of this text, which is divided into five segments. In his discussion of pedagogical principles in technology teaching, Mishack Gumbo reminds us of the disservice to students from diverse cultural background of teaching strategies that fail to recognize the diversity of students. Place-based pedagogies synonymous with African indigenous ways of knowing and learning, which are relevant to the background, learning styles and student centered priorities of students, are necessary to make up for this pedagogical deficiency. His argument and point are endorsed by Yovita Gwekwerere who independently focuses on the Eurocentric bias of science education in Africa and seeks to narrow the gap between the teaching of physics, the curriculum and the experiences of children. Students should be given contextualized local examples with meaningful examples and illustrations from their cultural background, argues Gwekwerere, and she proceeds to give specific alternative models applying indigenous perspectives for achieving this end. Edward Shizha concludes the segment on epistemological and pedagogical issues with a focus on the diversity within Africa. He provides more examples of the appropriate technology that emerged from within Africa and expands on some of the issues discussed in this opening chapter.

Our intellectual journey then shifts to African perspectives on time through the scholarly discourse of Vongai Mpofu; Francis Muchenje, Ruth Gora and Ngoni Makuvaza; and Mathias Sithole, in three separate chapters. How do Africans perceive time? What distinguishes the rectilinear models of time from some of those that evolved within Africa? How do worldviews such as *Unhu*/*Ubuntu* intersect with African concepts of time? What about African management of periods of leisure and rest within a specific time frame? How do ideas about materials, circular motion, levers, centers of gravity, buoyancy, tension, friction, resonance, sound waves, energy and force manifest themselves in the African context. How best can we convey these principles to students of physics? These are some of the issues of concern to these authors. The segment on physics and cosmology concludes with discourses by Atah Pine on Tiv divination and Peter Alcock on South African indigenous knowledge about the stars.

We then move on to a slightly different area of discourse with a focus on West African enclosures and structures of various kinds by David A. Aremu, Aribidesi Usman and Patrick Darling in independent chapters. Gloria Emeagwali, looking at African traditional medicine, discusses some of the phytochemical reports that underlie many of the herbal resources frequently prescribed by medical practitioners. This segment on medicine and health is enriched by illuminating discussions on ethnomusicology and healing by Charles Aluede and Vincent Aiwuyo, and concludes with Evadne Ngazimbi's insightful chapter on indigenous narrative therapy. *African Indigenous Knowledge and the Sciences: Journeys into the Past and Present* concludes with a focus on metallurgy by two veteran archeologists, Jay Spaulding and Richard Darling who discuss ironmaking in East and West Africa, respectively.

We invite readers to embark on a stimulating intellectual journey with us as we illuminate the various dimensions of African indigenous knowledge systems and the sciences.

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PART 1

EPISTEMOLOGICAL AND PEDAGOGICAL ISSUES

GLORIA EMEAGWALI AND EDWARD SHIZHA

1. INTERCONNECTING HISTORY, AFRICAN INDIGENOUS KNOWLEDGE SYSTEMS AND SCIENCE

In this chapter we discuss the genesis of science in Africa with reference, first of all, to the South African Cape region, about one hundred thousand years ago (Jacobs, Duller, Henshilwood & Wintle, 2006). We then reflect on aspects of science as it evolved in ancient northeast Africa with some reference to ancient Nubia, Ethiopia and Egypt, highlighting aspects of the contributions made in ceramics, building technology, medicine and metallurgy. Brief references are also made to Southern Africa, in this case the Kingdom of Mapungubwe, precursor to Great Zimbabwe (Duffey, 2012). We reflect on some of the conceptual underpinnings of African Indigenous Knowledge (AIK) as science, and conclude with specific reference to the individual authors/chapters of this text and their contributions to this discourse on AIK and the sciences.

As pointed out in an earlier work (Emeagwali & Dei, 2014), evidence found at Wonderwerk Cave in 2012, in South Africa, point to the earliest use of fire-making in the world, going back a million years. Berna et al. (2012) discuss the dating of evidence from the site such as burnt bone and the ashes from plant remains. The scientific world also discovered, with amazement, that ancient Africans developed the capacity to mix paint in containers in the form of abalone shells, and coat their ornaments with iron oxide pigment as early as 100,000 years ago, thus creating a world record, yet to be superseded in the annals of ancient science and technology. Assumptions and conjectures were made and so, too, long-term projections, in the assemblage of hammer-stones, grindstones, ochre, animal fat, iron oxide powder, and charcoal, to make the paint in the mini containers. These discoveries of Henshilwood (2007) and Henshilwood et al. (2001, 2011) have not only cast new light on the African genesis of chemistry but they have also confirmed the fact that Africa was indeed a birthplace of science as we know it, and that indigenous knowledge capabilities to cope with the environment and create value have a long history in the continent. We also know that as early as one hundred thousand years ago, there were the beginnings of written symbolic language in the form of triangles and horizontal lines, also in ancient South Africa, based on the geometrical engravings that have been found. The discoveries of Blombos in the South African Cape, point to the earliest evolution of abstract design, creativity and symbolism in the world and marks some of the earliest documentation of African Indigenous Knowledge to date

G. Emeagwali & E. Shizha (Eds.), African Indigenous Knowledge and the Sciences, 3–11.

(Henshilwood et al., 2001; Tribolo et al., 2006). What is clear from these discoveries is that the knowledge evolving within the continent from this early period was aimed at problem solving, and involved specific trial and error experimentation and goals.

By 9000 BC, some of the earliest ceramics emerged in Nubia, predating those of ancient Egypt and Ethiopia, which may have lagged behind in this sphere, relatively speaking (Ehret, 2002), granted that Malian pots, dated 11,400 years ago, are older (Huysecom et al., 2009). By the Aksumite era of Ethiopian history, however, we have a wide range of ceramic products in the form of shallow thin-walled bowls, deep bowls with rims, basins, pots, jars, jugs, storage pots, braziers, legged vessels, beakers, semi-globular round-bottomed bowls, cooking pots, pedestal vessels and bird-shaped vessels, the product of indigenous innovation and skill (Phillipson, 2000, p. 303). Fast-forward to the early and late Aksumite era, between 1000 BCE and 1000 AD, and we have close to two hundred stelae obelisks, one of the largest being 33 metres (110 ft.) weighing 750 tons and representing a building, thirteen storeys high, the largest single block of stone ever quarried, sculptured and erected in the ancient world (Connah, 2001). Likewise, archeologists have found in this region, evidence of numerous multi-storied residences, elite houses and mansions, some of which may have been palaces. One of the present authors had the opportunity to view one of these elite structures dated about 1000 BC in Yeha, about two hundred kilometers from the town of Axum, where the former occupant of the building bitterly criticized the modus operandi of the German archeologists in charge of the excavation, complaining about the inadequate compensation given for the legacy of her ancestors that was reluctantly sold to the team conducting the excavation. The structure in question had more than twenty rooms and yielded pots dating back to about twenty seven hundred years. Other ancient structures in present day Aksum, Gondar and Lalibela include:

- Dams and Rainwater Cisterns
- Terraces
- Several subterranean multi-chambered tombs for the elite
- Complexes of courtyards and towers
- Stone castles, the nucleus of the court and capitals
- Stone altars
- Murals, many of which are in monasteries and ancient temples, painted with local pigment that seems to outlast synthetic paint.
- Sculptured churches and temples, sculpted between the 5th and 16th century in the highlands and Tigre Province. About forty-four temples at Gondar and a totality of more than 300 temples at Matara, Haoulti and Mantara. We may estimate about five hundred of these structures, bearing in mind that the discovery of ancient Ethiopian structures is an ongoing process.

We shall now make a few comments on ancient Egypt, whose mastery of medicine is celebrated in a variety of scrolls, named, unfortunately, after adventurers, merchants and others, rather than the ancient Egyptians themselves. In the so-called

Edwin Smith papyri, are careful discussions of injuries to the top of the head; injuries to the face; injuries to the jaw, neck, thorax, spine and arm; the names of human body parts and anatomy; neurological symptoms; the earliest known description of the brain; the first description of the meninges and brain pulsations; and a clear familiarity with the nervous system, blood circulation and the cardio-vascular system. But even so, Egyptian medicine was holistic and reflected a preoccupation with the supernatural, the divine and ancestral forces, in a manner that is quite familiar to scholars of African Indigenous Knowledge Systems. Invocations and prayers accompanied medication and were believed to be vital and indispensable for the medication to work effectively (Finch, 1998; Nunn, 1997; Sauneron, 2000).

Before the disruption of African technological advancement by slavery and colonialism, Africa witnessed the *in situ* genesis of an ironmaking industry that contributed to the technological heritage of humanity. The metallurgic know-how was a broad spectrum of expertise and included the making of steel in ancient Tanzania, as discussed in great detail by Schmidt (1997, p. 127):

> The Haya smelt had many distinctive features, including the preheating of the blast air, the efficient recovery of iron, the carbon boil, the formation of cast iron, and the formation of phosphorus rich cast iron. It is simply easier to believe that these many interlocking features arose from an incremental process of experimentation than to believe that they were learned as an ensemble by imitation. Moreover, reflecting on these innovations, one comes to realize that they are all, one way or another, adaptations to the chemistry peculiar to local materials: the limonite ores, the Mucwezi charcoal, the swamp reeds and the refractory tuyere clay.

Such technologies were also confirmed by Okafor (2004) in regard to the size and use of furnaces and the treatment and production of fuel, and de Maret (2004), who writes not only of technical diversity, but also of the importance of the cultural and symbolic diversity of African iron metallurgy. We should also note that in the case of ancient Nubia, in northeast Africa; Ghana, Mali and Songhay in West Africa; and Mapungubwe and Great Zimbabwe in Southern Africa, effective gold mining technologies emerged over time. Not only was ancient Nubia a major source of gold for Egypt, but it was also a major innovator and designer of jewelry. Markowitz and Doxey point out that "nothing exceeds Nubian jewelry and other items of personal adornment in terms of technical mastery, elegance of design, innovation and sheer beauty" (2014, p. 9). Nubian material artifacts speak a million words and are even more important than written documents, in our understanding of ancient technological wizardry. We stare in wonder at the delicately fashioned gold rosettes; hinged collars made of gold and silver; gold pectorals of Auset (Isis); the golden mask of Queen Malakaye of the Napata era; and numerous necklaces, ear studs, earrings, fly pendants, arm bands of gold and gilded beads. Some date as early as 2500 BC and the Nubian kingdom of Kerma. They reflect precision and detailed asymmetrical measurement, the product of standardized equipment and the weights and measures of precision found in excavations and "diamond shapes stamped from gold sheets" were applied to flat surfaces and wires hammered from thin pieces of gold (Markowitz & Doxey, 2004, p. 89).

As we shift to Southern Africa's Kingdom of Mapungubwe, variations of this technique appear in a wide range of exquisite gold objects, including the famous Golden Rhino, golden scepters, gold foil fragments with chevron patterns, gold beads and nails, necklaces, armlets, bangles and bracelets of all shapes and dimensions. As pointed out by Duffey, Tiley-Nel, de Kamper and Ernst (2008), many of Mapungubwe's objects are "rare and unique in the world" (p. 26), yet they continue to be Southern Africa's best well-kept secret, totally ignored in numerous textbooks, and relatively unknown by the very descendants of these sophisticated metallurgists. Unfortunately, post-apartheid South African authorities continue to keep some of their most cherished historical artifacts within remote game parks, inaccessible to many of its citizens and frequented mostly by head hunting tourists in search of animal trophies.

It is apparent that had the past indigenous sciences and technologies not been disrupted, they could have helped Africa to compete in the present technological advancement. In line with this argument, the dominance of western, Eurocentric scientism is challenged by Hutchinson (2011) who offers an insightful metaphor for the current controversies over science:

> The health of science is in fact jeopardized by scientism, not promoted by it. At the very least, scientism provokes a defensive, immunological, aggressive response from other intellectual communities, in return for its own arrogance and intellectual bullyism. It taints science itself by association. (p. 143)

The bullish dominance of western science had a negative and destructive effect on the development of other technologies by undervaluing the creativity of other cultures and societies.

Scientific knowledge, in whatever form, definition and cultural context it may exist, is found in all societies. Each society has its own way of categorizing and labelling types of knowledge. However in African indigenous communities, knowledge is often treated as a holistic body of knowledge. African indigenous knowledge systems, which are based on the natural environment and human practices for human sustainable development, are intricately interrelated. As noted by Adyanga (2014), these science practices are generational and synergistic with other disciplines such as history, geography, trade and commerce. African indigenous science is embedded within the larger body of knowledge constructs that constitute African indigenous knowledge systems. While most research and publications have focused on social science theories and paradigms (Emeagwali & Dei, 2014), less has been written with regards to the so-called 'natural sciences'. This book seeks to fill the gap and address some of the misconceptions about the African indigenous knowledge. Of particular interest in this book is how physics, geoscience and other sciences were developed and utilized in African societies.

African civilization and societies are replete with cultural knowledge that is deeply rooted in local cultures and everyday lived experiences. African indigenous societies have, for centuries, developed their own sets of lived experiences and explanations relating to the environments they live in (Kimwaga, 2010). Our argument in this book is that indigenous sciences have always existed in African societies. This is due to the fact that the way knowledge is produced and utilized and how people actually learn it and transmit it is culturally specific. Different cultures have different ways of experiencing social reality and, hence, different ways of categorizing knowledge (Shizha, 2015). This is influenced by their worldview and belief systems as well as perceptions about the natural environment, including the socio-economic and ecological context of their livelihoods (Shizha, 2014). In fact, the history of Africa's indigenous ways of knowing and knowledge production did not begin with the coming of Western knowledge systems, and neither should their future depend exclusively on Western and other worldviews (Kaya, 2014). Unfortunately, rather than western science acknowledging the multiple, collaborative and accumulative dimensions of knowledge, western scholars and scientists attempted to either dismiss, devalue or negate indigenous knowledge as being not worthy of scholarly engagement (Emeagwali & Dei, 2014; Shizha, 2015). In the same vein, there are also African scholars who have been 'miseducated' in western paradigms and perspectives of what is perceived as scientific knowledge who tend to mythicize and devalue indigenous science. Many African scholars went through a western education system that indoctrinated them to view African indigenous knowledge and its scientific epistemologies and ontologies as irrelevant to 'modernization', and hence invalidated and irrelevant. However, as various authors reveal in this book, African scientific knowledge has a role to play in human development as it is widely practised in African communities and used to solve problems that affect communities and their members as they encounter challenges from their ecosystems and cosmic environment.

While science, from a western, theoretical and methodological perspective, is judged from a positivist approach, indigenous science is defined from its holistic and utility perspective. Indigenous science is better understood as practical, personal and contextual units which cannot be detached from an individual, their community or the environment (both physical and spiritual). African knowledge, and its method of acquisition, has a practical, collective and social or interpersonal slant (Owusu-Ansah, 2013). Before the advent of Western methods of scientific inquiry, African knowledge and methods had successfully guided people in all spheres of life, including the spiritual, social, educational, agricultural, political and economic (Tanyanyiwa & Chikwanha, 2011). Knowledge of science empowers members of society with the abilities and capabilities to deploy and employ practical techniques and skills to manage their natural environment and to find ways to solve human problems. This is the central theme is this book. Different authors have examined different ways in which African indigenous sciences were utilized by African people to advance knowledge and to develop skills and abilities to make sense of their natural world and to improve their livelihoods. Indigenous African science encompasses a sophisticated array of information, understanding and interpretation that guides interactions with the natural milieu: in agriculture and animal husbandry, hunting, fishing, natural resource management, conflict transformation, health, the naming and explanation of natural phenomena, and strategies to cope with fluctuating environments (Semali & Kincheloe, 1999; Kante, 2004; Horsthemke, 2004).

Indigenous knowledge systems constitute the core of community-development processes in agriculture, the preservation of food, collection and storage of water, animal husbandry and ethnic veterinary medicine. It also forms the basis of indigenous interpretation of meteorological and climatic phenomena, orientation and navigation on land and sea, as well as in the management of natural resources. Indigenous knowledge is also very useful in local primary health care, preventive medicine and psychosocial care as well as the role of procreation (Abah, Mashebe, & Denuga, 2015). Indigenous people possess an immense knowledge of their environments, based on centuries of living close to nature. By living in and from complex ecosystems, they have an understanding of the properties of plants and animals, the functioning of ecosystems and the techniques for using and managing them, a system that is particular and often detailed and transmitted to the younger generation through traditional songs, stories, narratives, epics, legends, dreams and practices (Abah et al., 2015; Chikaire et al., 2012).

Technical knowledge or science is always adaptable and malleable. It is knowledge that evolves and adapts to the changing circumstances in which members of the communities find themselves. In fact, indigenous knowledge has not remained static, neither has it been confined to the shores of the African continent. Like all knowledge systems, such knowledges have diffused and interacted with other ways of knowing from other communities (Emeagwali & Dei, 2014). Its adaptability enables local African communities to better understand the differences and interactions between their science and other knowledge systems in order to reconstruct their own knowledge systems and to make better-informed decisions about which knowledge (internal or external) is appropriate for their sustainable future (Seleti, 2010). It is heartwarming that development practitioners are starting to realize the importance of recognizing and working with indigenous knowledge sciences, which builds on generations of experience, to best support the adaptive capacity and strategies of rural communities. There is increasing acknowledgement that indigenous forecasting methods are locally relevant and needs-driven, focus on the locality and timing of rains, and are communicated in local languages and by local experts known and trusted by the people themselves (Kaya, 2014; Chikaire et al., 2012).

Science and its methods of investigation and ways of interpreting social and natural realities cannot be divorced from a people's history, cultural context and worldview. Worldview shapes consciousness and forms the theoretical framework within which knowledge is sought, critiqued and or understood (Sarpong, 2002 cited in Owusu-Ansah & Mji, 2013). Almost all knowledge has cultural relevance and must be examined for its particular focus without universalizing it in the manner that western scientific thought and methodologies seek to do. According to Asante (1987, p. 168), the hallowed concepts and methods within western thought are inadequate to explain all of the ways of knowing because "universality can only be dreamed about when we have 'slept' on truth based on specific cultural experiences." While we should be careful not to universalize western science as *the* relevant and valid knowledge, we should also be careful not to universalize African indigenous science as homogenous and universal to all African societies. Indigenous African science is unique to each African society, although there may be commonalities within these bodies of knowledge. We should acknowledge that even in African societies themselves, there are different forms of scientific knowledge since each society may have its own way of viewing social reality, and its own way of interacting with the natural world. African indigenous science is place-oriented and often orally transmitted partly because it is people-centered. Indigenous science is primarily concerned with the utility, accessibility and practicability of knowledge.

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MISHACK T. GUMBO

2. PEDAGOGICAL PRINCIPLES IN TECHNOLOGY EDUCATION

An Indigenous Perspective

INTRODUCTION

In this chapter, the author proposes principles that should be considered when teaching technology in indigenous contexts. The chapter is not about educational technology, computer integrated teaching or information and communication technology. The chapter is about *Technology Education,* which is a school subject taught to students. Around the world, many teachers teach in indigenous or multicultural contexts, yet they are poorly prepared to do so. They simply turn a blind eye to integrating pedagogical perspectives that recognize indigenous learners during their teaching. Passive learning seems to be a predominant outcome (Lavonen, Autio & Meisalo, 2004) because students are turned off by the pedagogical strategies that do not consider students' diverse cultures. This problem is compounded by curricula devoid of content from indigenous places, as well as teaching and learning materials that neglect such content. There is a great need to utilize the wealth of local indigenous knowledge systems and to incorporate them into mainstream formal education (Msila, 2007).

Literature abounds with accounts of the marginalization of indigenous learners or diasporans when it comes to the teaching of technology (Apple, 1986; Eggleston, 1996; Zuga, 1997; O'Riley, 2001). The universalist and industrial approaches (Fleer, 2015) monopolize the content and pedagogy of technology education. But inclusive pedagogy concerning indigenous students is an under-researched phenomenon. In this chapter are suggested principles that could transform the teaching of technology to the benefit of indigenous students. These principles are sourced from the literature and they are anchored on collectiveness, holism, co-creative orientation, cooperative approach to problem solving, experiential knowledge, orality, ubuntu, spirituality, values and complexity (Gumbo, 2014; Ngara, 2007; Masango, 2006; Emeagwali, 2003), these principles relate very closely to the life principles of indigenous communities.

In order to arrive at these principles, there is a need to define technology and technology education, curriculum and pedagogy, and argue that technology teaching needs to change, as well as to briefly discuss frameworks that support the suggested principles. The approach in the chapter is explorative and is not focused on one country only.

G. Emeagwali & E. Shizha (Eds.), African Indigenous Knowledge and the Sciences, 13–32.

DEFINITIONS OF TECHNOLOGY AND TECHNOLOGY EDUCATION

Technology

Technology is about engaging complex processes that involve knowledge, skills and resources available in various environmental contexts, to produce solutions to societal problems or to meet needs and/or wants. The Department of National Education in South Africa, now the Department of Basic Education (DBE), defines Technology as, "the use of knowledge, skills, values and resources to meet people's needs and wants by developing practical solutions to problems, taking social and environmental factors into consideration" (2011, p. 8). According to *Indiana Technology Education Curriculum Standards* (2006, p. 3),

> Technology is a body of knowledge and action, used by people, to apply resources in developing, producing, using and assessing products, structures and systems in order to control and modify the natural and human-made (modified) environment.

Through the help of other scholars, Williams (1996) defines technology through its characteristics. According to Williams (1996, p. 3), therefore, technology:

- extends human potential through action;
- addresses human needs and wants;
- is a human creation and is thus implemented and used by people;
- is mostly and practically implemented through the use of tools, machines, techniques, systems and technical ways;
- exists in, affects and is affected by society and culture;
- is evident in every culture irrespective of its level of sophistication or stage of development;
- enables people to exert control over the natural environment;
- is important for the people to survive; and
- is future orientated.

Since this chapter is written from an indigenous knowledge systems angle, it is important to consult literature about the indigenous definitions of technology. According to Senabayake (2006), indigenous knowledge is unique and closely related to a particular culture or society and can thus be referred to as local/traditional knowledge, folk knowledge, people's knowledge, traditional wisdom or traditional science. The fact that indigenous knowledge is mostly evident in practical activities such as agriculture, food preparation and conservation, health care and education (Senanayake, 2006), qualifies it to be referred to as indigenous technology (Battiste, 2002; Robyn, 2002; Kimbell, 2008).

Culture harbours both the material and non-material expressions of a people (Ogungbure, 2011). Alternatively, material and non-material expressions can be termed tangible or intangible devices, formulations and techniques which fulfil some need or provide some service for humankind in a given environment (Moalosi, Popovic, Kumar, & Hudson, 2005; Obikeze, 2011). These expressions are technologies because they are meant to address people's problems, needs and/or wants. Three categories of these technologies include:

a. Material (physical) technology such as bows and arrows, ploughs, looms, laboratories, machines, electronic devices, knives, fishing nets, explosives, etc. The material side of technology provides its visible and tangible nature. For example, one can see, feel and touch a bow and possibly know its function.
b. Social technology such as methodologies, techniques, organizational and management skills, bookkeeping and accounting procedures, negotiating and counselling techniques and social institutions like patriarchy and matriarchy; songs, jokes, ideas, skills, etc. This dimension of technology accounts for the process nature of technology between the input and output.
c. Communication technology is inclusive of language, signs and symbols, drumming, and the internet, etc. This last dimension of technology markets technology in different forms, for example, a symbol that represents a certain technological device posted on a particular website may arouse interest in those who become aware of it; they may begin to contact the designer or manufacturer.

These cultural products (technologies) are in turn organized in terms of goods and services. Thus, they are further sub-divided into:

i. Material goods such as soap, food items such as maize, ornaments, television sets, houses and aeroplanes, etc. The material goods are mostly a result of the function of the material technologies above. For example, a crushing stone with its base or processing machinery used to process maize into maize-meal.
ii. Social goods/services such as values, norms, customs, motherhood, priesthood and friendship; social goods/services like concerts and plays, football games, health and healing systems and belief systems, etc. From a cultural point of view these social goods shape the technologies in certain cultural settings. For example, the belief system for a particular culture may affect the type of medical technology that can be applied in that cultural setting, and hence, decisions and application of technology in such setting should consider differences of this nature.
iii. Intellectual goods such as ideas, abstract concepts, names, terminologies, cognitive knowledge and idioms, etc. These goods are brought about by how people are informed by their cultural systems. The ideas that I am expressing in this chapter, for example, are informed by my thinking about technology as conceived from an indigenous cultural perspective. Seemann (2000) contends that cognitive activity and cultural milieu are inseparable and that a society educates its young by passing down its socio-cultural attributes that guide what a child learns and becomes.

These categories of technology informed by culture have serious implications about how technology should be taught, especially in indigenous contexts or to a student group that includes students with indigenous backgrounds. Technology teachers cannot afford to design teaching strategies which do not help them (students) learn meaningfully.

Technology Education

Technology education as a school subject has been referred to as Industrial Arts, Craft and Design, Textiles and Work, Industrial Education and Technology Education (Dugger, 2008, p. 1) in different contexts. In the previous versions of the curriculum in South Africa, it was referred to as Technology Learning Area. In the new Curriculum and Assessment Policy Statement (CAPS) (Department of Basic Education [DBE], 2009) it is referred to as Technology. The dominant international terms by which it is known are Technology Education and Design and Technology Education. I prefer to use the term Technology Education in this chapter. I find it logical to adopt this term because after defining Technology one needs to know what Technology Education is, then.

Technology Education is a subject with its own content and methods, the intention of which is to prepare students to participate in the technological or engineering (job) environments. Technology Education is a unique theory-practice subject that presents opportunities for teachers to engage students in the learning activities that are informed by their (students') thinking, which is in turn shaped by their (students') environments or cultural backgrounds. The design concept—which drives the teaching of the subject (referred to as the backbone of Technology Education) through a problem-solving approach to investigate, design, make, evaluate and communicate, not followed linearly—should allow students room to express their design ideas from their cultural contexts. However, as expressed in the introduction, while teaching technology has always suggested inclusive strategies, research has been almost silent on making the teaching of technology relevant to indigenous contexts. This silence is obviously informed by a western Eurocentric approach to education in general, which perpetrates the exclusion of indigenous knowledge and overemphasizes a "modern" industrial concept of technology to the detriment of indigenous forms of technology.

Pudi (2007, pp. 37–38) discussing technology education in the school science curriculum provides the following definition:

> Technology Education can be seen as a comprehensive experience-based educational programme that allows learners to investigate and experience the means by which people meet their needs and wants, solve problems and extend their capabilities. It is concerned with the knowledge and skills necessary to develop, produce and use products or services, and how to assess the impact of these activities on humanity and the environment (ethical considerations).

Technology Education refers to educating children to employ the hardware and software of technology according to the technological categories explained under the definition of Technology above, that is, the tangible and intangible sides of technology. It includes the education theory and practice of a range of material processes for metal, wood, plastics, textile, leather and food materials. All these have a component of learning theory but the greater and more important is that of gaining practical experience (Kumar, 2002, p. 125).

In Technology Education students learn about designs of artifacts, materials that they use, and the processes involved. The knowledge dimensions can come from different fields of technology such as Food Technology, Textile Technology, Transport Technology, Mining Technology, and so forth, which are tangible in nature, or intangible technologies which have been explained earlier in this chapter. There are a range of skills that students learn alongside knowledge in Technology Education: designing, decision making, evaluation, communication, time management, collaboration, problem-solving, and a whole lot more skills.

DEFINING CURRICULUM AND PEDAGOGY

The crux of this chapter is teaching. This creates a need to define pedagogy. But teaching is an aspect of curriculum. Therefore, a related need is to define curriculum as well. According to Perso (2012, p. 31), "curriculum is a broad concept that includes knowledge and content, delivery and teaching, assessment and even reporting to parents." Perso's (2012, p. 31) working definition befits the context of the current discussion in this chapter; particularly that curriculum is the "intended and planned learning proposed by the system, school and classroom teacher." This definition is appropriate because it does not limit the design and implementation of curriculum to the school, but includes the teacher as well. In fact, the teacher is the important role-player because we see practically, the enactment of curriculum through teachers. The teacher is the main implied actor in this chapter because teachers are the ones who teach. With this in mind, then, pedagogy is the enactment of the curriculum (Perso, 2012, p. 31). Enactment implies the methods and delivery styles that the teacher uses to bring about the desired learning. Perso (2012, p. 31) states further that "student behaviour in the classroom is largely determined by the pedagogies used by the classroom teacher and the way that each student experiences the enacted curriculum." According to Perso, curriculum, pedagogy and behaviour are closely connected and interdependent. The big question is then, "What is the teacher doing with the curriculum in relation to the student?" Teaching heavily depends on teachers' reading and interpretation of the intended curriculum and their preparedness to attend to the needs of their students (Perso, 2012, p. 44). Place-based pedagogies, that is, pedagogies which are relevant to the student's milieu, are a need in indigenous context in order to connect between the lived experiences and aspirations of indigenous students and their communities and schooling and work (Perso, 2012, p. 44). Fogarty (2010) is of the view that a pedagogic framework is needed to ensure the accommodation of indigenous perspectives in the teaching context. The academic performances of indigenous students have been found to improve when schools promote their language and culture in curricula (Demmert, 2001).

Teaching is based on oral and written instruction, symbols, stories, proverbs, singing, dramatizing, observing, repeating, imitating, memorizing and participating. In indigenous African education, observation and memory take precedence as pedagogical styles—names of animals and plants, size and type/shape of horns of animals (Elleni, 1995). What this boils down to is that the teacher should be conversant with pedagogical styles that can spice up the conventional ones for the sake of making the subject matter relevant to indigenous students as well. Table 1 shows strategies that are prevalent in indigenous ways of teaching in Aboriginal settings (many indigenous communities could identify with these strategies) compared to those which dominate conventional mainstream teaching.

Table 1. Learning styles in aboriginal and mainstream pedagogies compared

Traditional aboriginal learning styles (If students are from traditional indigenous backgrounds it is likely they have a preference for…)	*Mainstream learning styles*
Observation and imitation	Verbal and oral instruction
Personal trial/ and error, and feedback	Verbal instruction accompanied by demonstration
Real-life performance/learning from life experiences	Practice in contrived/artificial settings
Mastering context specific skills	Abstract context-free principles that can be applied in new, previously inexperienced situations
Person-oriented (focus on people and relationships)	Information-oriented
Spontaneous learning	Structured learning
Holistic learning	Sequential and linear learning

Source: Hughes and More, 1997

It should be noted that the fact that verbal and oral instruction is classified under the mainstream learning style column in Table 1 does not imply that it is absent in indigenous teaching. In fact, it is very evident in indigenous education (Elleni, 1995) and that is why it is mentioned as one of the pedagogical principles. The understanding that should be created here is that in mainstream learning, oral and verbal presentations dominate teaching in a confined learning environment such as the classroom. In open, traditionally authentic settings, oral and verbal teaching is balanced with observation and imitation.

TECHNOLOGY TEACHING NEEDS TO CHANGE

Tension mounts nationally and internationally about whether schools should teach indigenous cultural content (Perso, 2012). It is high time that this tension transitions to a discourse about teaching this content and how that should be done. The dominant cultural values are those of the majority of teachers—white, middle class—which downplays the strengths of students from different cultures. This forms a blockade for teachers not to appreciate what their students have to offer in classroom discourses. In the teaching of technology this is very unfortunate considering the opportunity that the subject offers for students to showcase their thinking through the projects that they complete. Gribble (2002) argues that while emphasis is placed on children's learning styles and their socio-cultural context, the curriculum fails to empower them. Gribble (2002) blames this on the teachers' inability to define or determine the valued knowledge to teach from different social and cultural contexts.

The teachers' failure to rightly accommodate indigenous students in their teaching is informed by the forces that have conceptualized and perpetrated the curriculum of Technology Education, and the teaching thereof, from a purely western perspective. In England and Wales, for example, the Technology Education curriculum is accused of being biased towards black students. Eggleston (1992, p. 59) argues that the authorities' declaration: "Technology Education should be taught to *all* children, black or white" might not be achieved until the sources of the powerful social pressures that have for generations differentiated technological achievement by race are understood. Eggleston (1992, p. 64) cites the Final Report of "The Design and Technology Working Group" that states:

> Cultural diversity has always been a feature of British life…[providing] a richer learning environment for all…the teaching of design and technology will require perceptiveness and sensitivity from teachers' [to take account of] different beliefs and practices, especially when food, materials and environmental designs are involved…there are rich opportunities here to demonstrate that no one culture has the monopoly of achievements in design and technology.

However, Eggleston (1992) explains his disappointment that the recommendations of "The Design and Technology Working Group" have not been heeded. According to Eggleston (1992), indigenous cultures which, because of certain realities in this world, have come from elsewhere into England and Wales, are being denied formal platform in the school curriculum to have their perspective of life represented. Layton (1993) declares that learners should be exposed to the fact that artifacts, systems or environments from other cultures, have identifiable characteristics and styles and draw upon this knowledge in design and technological activities. Design and Technology could and should then provide not only equal but enhanced opportunities for young people who have, so far, not found it easy to make it in the more traditional areas of the curriculum (Eggleston, 1992). According to Eggleston (1992. p. 65), the curriculum should present opportunities for young black people to compete on more equal terms with white children in the subject.

As indicated above, this racial orientation within the Technology Education curriculum informs the biased teaching approach of teachers. They hold certain connotations about students from non-English and Welsh cultures. In *Teaching Design and Technology*, Eggleston (1992) captures the racially motivated assumptions that white teachers hold about black students regarding their work: they do a messy job; they cannot be given access to the examination because they lack motivation; they will be handicapped by language; they lack the appropriate cultural background; they fail to understand the system; they will not know how to work hard; they will have behavioural problems and be disruptive. These students are perceived this way because they struggle to come to terms with curriculum and teaching that fail to accommodate their worldview.

The second example is from the American context. Educational literature is silent on teaching African-American students (Ladson-Billings, 2000). Much of educational research has focused on generic models of pedagogy (Shulman, 1987). Shulman (1987) proposes a framework for a teacher's pedagogical content knowledge. Knowledge of students and their characteristics, educational contexts and values form part of the framework (Shulman, 1987). But the transformation framework of Shulman and others are yet to thrive against the opposing models. One such model is the 19th century Americanization model. This model was designed to merge all students regardless of their ethnic or cultural origins into one ideal model (Ladson-Billings, 2000). A model such as this could be supported if equity and equality were uncompromised standards. But the intentions of the model were utterly biased. Ladson-Billings (2000, p. 207) exposes this intention as follows:

> Of course, this Americanization process considered only those immigrant and cultural groups from Europe. Indigenous peoples and people of African descent were not thought educable and therefore not a part of the mainstream educational discourse.

For many years the education of African-American students was left to be the responsibility of African-American communities but through state-supported segregated schooling systems (Ladson-Billings, 2000). Although the ideal was to have integrated schooling of students, African American teachers felt more comfortable teaching African-American students in the schools, in African American community settings, as they would feel the freedom to adopt a critical stance to the curriculum and pedagogy (Foster, 1990). Due to white supremacist assertions which claim that African-Americans are genetically inferior and not fully human, the expectation for educating them has been low (Allen cited in Ladson-Billings, 2000).