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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).

Zuga (1997) is aware of the existence of the biased treatment of students in the American school system based on their ethnic backgrounds, expressed in terms of students' attitudes towards the Technology Education curriculum. Zuga (1997) notes the long-time omission of ethnic differences in this research area, which could inform technology teachers about curriculum. For instance, African-American and Native-American students could have value conflicts with the western approaches to Technology Education. This omission disregards the realities of the multicultural nature of the American society and can therefore be attributed to a tendency to view Technology Education hegemonically (Zuga, 1997). The third example relates to the struggles of Aborigines in Australia. Most indigenous parents do not want their children to lose out on their indigenous worldview even though they are not opposed to the national standards curriculum (Perso, 2012). Perso (2012), in concurrence with Forgaty (2010), quotes from a Select Committee on Aboriginal Education appointed in 1985 by the House of Representatives, which among others identified two key needs for indigenous education:

- Desire to gain English literacy and numeracy; and
- Desire to preserve Aboriginal identity and to have education as far as possible provided in their local communities so that children could remain in communities to be raised as Aboriginals.

This seems a balanced situation between the mainstream curriculum and indigenous perspectives. Tripcony (2010, p. 5) is of the view that while children should be able to confidently communicate with and work within mainstream organizations, they should maintain "their own unique identities and connections with their families, communities and cultures." Fogarty (2010) observes a transition in the Australian Northern Territory indigenous community caused by the evolving culture, suggesting the complimentarity and interaction between the western and indigenous knowledges that should be brought upon by the learning and schooling programs. Fogarty (2010), on the contrary, observes what seems to be a constant rejection by indigenous people in remote regions, of some form of the mainstream employment such as mining, rather choosing the options that make them stay connected to their communities to fulfil kinship and customary obligations.

The above examples suggest that teachers should re-examine their pedagogical approaches and strategies. They should show an interest in the culture of their students and be prepared to learn along with them. Culture is deeper than just understanding someone's ethnicity, race and faith; it includes broad notions of similarity and differences as well as students' multiple social identities and ways of knowing and of being in the world (Ontario Capacity Building Series, 2013). Effective instruction includes:

- Approaching curriculum in a flexible manner to tease out informal and subtle information, and adaptation of the curriculum to the students' lived experiences;

- Inquiry-based learning to ensure self-directed learning in students;
- Use of a variety of resources, which include community partners to facilitate learning;
- Knowing and building on students' prior knowledge, interests, strengths and learning styles;
- Engaging a broad range of students to draw from varied students' perspectives and varying instruction by employing different methods and opportunities; and
- Developing the socio-cultural consciousness of students through curriculum approaches.

(Montgomery, 2001, pp. 4–8; Ontario Capacity Building Series, 2013, pp. 6–7)

These effective strategies are informed by frameworks that are opposed to teacher dominance and linear pedagogical approaches. A few of these frameworks are presented in the next section.

FRAMEWORKS FOR ENSURING THE INCORPORATION OF STUDENTS' KNOWLEDGE IN TEACHING

Alternative theories and models such as the southern theory, the culturally relevant teaching model, the sociocultural constructivist model, the community of practice, the blended model, participatory modelling, and personal mental models (Wenger, 1998; Ladson-Billings, 1994, 2000; Yishak & Gumbo, 2012; Wahyudi, 2014; Fleer, 2015; Yishak & Gumbo, 2015) should be considered. The southern theory promotes multi-centred social science perspectives, social science critiques, social sciences that produce many forms of knowledge, and social science that is relevant to democracy (Wahyudi, 2014).

Culturally relevant teaching (Ladson-Billings, 1994, 2000), which other scholars term culturally responsive teaching or culturally responsive pedagogy (Gay, 2000, 2002; Montgomery, 2001; Villegas & Lucas, 2002; Grant, 2010), is about teaching that integrates a student's background knowledge and prior home and community experiences into the curriculum and the teaching and learning experiences that take place in the classroom. All students learn differently and that is informed by their background, language, family structure and social or cultural identity. Scholars allude to the three tenets of culturally responsive pedagogy: institutional, personal and instructional (Ontario Capacity Building Series, 2013). Instructional implies in this case, "knowing students well and considering the classroom practices which lead to a culturally responsive classroom" (Ontario Capacity Building Series, 2013, p. 2).

Vygotsky's theory of constructivism promotes instructional approaches that support student-focused learning environments (Subban, 2006). Social constructivism is about building onto students' varied lived experiences to enliven the curriculum, enhance the value of locally situated learning, and develop inquiry-based learning to ask questions and create knowledge (Ontario Capacity Building Series, 2013). Social constructivism promotes collaborative learning where students appreciate varied expressions of

knowledge in their activities. Vygotsky's theory raises the need on the part of the teacher to cater to the students' diverse learning styles in a sociocultural context (Subban, 2006). Students who engage in collaborative learning conditions experience more constructive learning processes (Zhu, 2012). According to Shackelford and Maxwell (2012), constructivism ensures cognitive, social and teaching presence. Cognitive presence is about students' ability to construct meaning through sustained communication in the learning community context (Shackelford & Maxwell, 2012). Cognitive presence showcases the exploration, construction, resolution and confirmation of students' understanding of the content (Garrison cited in Shackelford & Maxwell, 2012). Social presence implies the ability of students to project themselves socially and emotionally through communication (Shackelford & Maxwell, 2012).

Lave and Wenger (1991) coined the concept of 'community of practice' as they explored apprenticeship as a representation of situated learning. What this theory tries to communicate is that learning is a communal event in a social sense. A community of practice encapsulates the ideals of a social theory. According to Wenger (1998, p. 5), the four core units of the social theory of learning involve:

- *Meaning* – an avenue to express a non-static competence personally and communally, in order to know existence and humanity as significant.
- *Practice* – an opportunity to share the past and communal resources capable of sustaining communal engagement.
- *Community* – an environment that encourages discourse about communal set-ups where human endeavours are made clear as worth trailing and involvements are identifiable as proficiency.
- *Identity* – path taken to discuss how learning transforms human personalities by creating individual chronologies that lead to *becoming* within the confines of the environment.

Yishak and Gumbo (2015) have considered a few models that could be considered for teaching indigenous students, that is, standalone, restructured or blended models. These authors recommended a blended model without compromising the fundamentals of a standalone model. The blended model integrates both the indigenous knowledge systems and western or mainstream knowledge systems.

There are also other models such as participatory modelling (Standa-Gunda, Mutimukuru, Nyirenda, Prabhu, & Haggith, 2003). Models in varied forms such as personal mental models, mathematical equations and physical models, represent people's understanding of the world (Standa-Gunda et al., 2003). Models are useful in decision making, exploration of new possibilities and to facilitate understanding (Standa-Gunda et al., 2003). "The combination of modelling and participation can create a productive environment conducive for social learning, but this is only achieved with good facilitation" (Standa-Gunda et al., 2003, p. 315). The deliberations in this chapter thus far suggest the transformation of pedagogical principles about teaching technology by integrating indigenous perspectives.

TECHNOLOGY EDUCATION AND THE PEDAGOGICAL PRINCIPLES THAT INTEGRATE INDIGENOUS PERSPECTIVES

Promoting a Collective Approach to Learning and Design Projects

A person can find their true meaning by viewing themselves through the community they are members of—the membership of which is by cultural ties and values. No doubt, collectiveness has characterized indigenous societies over centuries. The communal orientation of indigenous societies versus individualism that informs capitalism in western societies is reason to invest in the collective learning approach in Technology Education. Those who are committed to culturally responsive pedagogy (Ontario Capacity Building Series, 2013) are in turn "committed to collective, not just merely individual empowerment" (Ladson-Billings, 1995, p. 160). From a socio-cultural perspective:

> Social learning is a collective process for accumulating new knowledge essential for problem solving, decision making and community development. Social learning can be a powerful force for change, through collective interaction at the community level. It involves critical thinking about the underlying assumptions concerning stakeholder action, values and claims to knowledge. (Standa-Gunda et al., 2003, pp. 315–316)

The collective engagement of students is fostered when they think about and participate in design projects. The teacher should encourage teamwork or the use of a collective approach in design tasks; for example, when conceptualizing solutions to technological problems. It should not merely be a group work approach.

Inculcating a Holistic View to Knowledge and Phenomena

True understanding of nature is achieved through viewing it as an integrated whole, that is, through an eco-systemic view. Thus, knowledge is not linear, nor is it the logical compartmentalization of things as science classifies it; rather, it is integrated and inter-disciplinary. Watson and Chambers (1989) write that a western society is economics- and competition-driven, which culminates into knowledge that is characterized more by measurement and comparison, whereas an indigenous society gives primacy to a genealogical kinship. This means that the technology teacher should adopt a holistic approach to teaching and learning. He or she should be open to alternative forms of knowledge that students can incorporate in their learning. This is where indigenous students will contribute integrated knowledge systems (for example, their beliefs, values and spirituality) into their design ideas, like suggesting a shape that is attuned to their cultural milieu or a particular value system in the design of an artifact.

Adopting a Co-Creative Orientation Towards Knowledge

Knowledge is co-created and community-owned rather than individualized; with elders being the libraries of such knowledge they possess the richness of indigenous

knowledge. The creation of knowledge by indigenous students does not begin and end in the classroom. Elders in their communities share important knowledge that includes technological knowledge, knowledge which could be referred to as "tech knowledge" due to its practical nature. The co-creation of knowledge happens as students consult and interact with each other in a learning situation, but that extends beyond the borders of school into consulting their community members. Thus, "teachers need to design work units and tasks with knowledge of their students and their needs in mind, particularly the ways in which they learn and the ways they communicate" (Perso, 2012, p. 32). Curriculum should as well focus on the local community context and empower students such that they can create their own jobs and become entrepreneurs to uplift their communities (Perso, 2012). This would mean that the technology teacher should nurture design projects that have relevance to the students' environment. They should help identify the technological needs and/or wants in the societies that students are members of so that students always design from their milieu. Schools should therefore help students realise the relevance of what they are learning in the classroom so that those who do not wish to leave their communities in search of jobs elsewhere can stay and benefit their communities (Perso, 2012).

Encouraging a Cooperative and Negotiated Approach Towards Problem Solving

Frameworks such as those discussed above can be used in problem-solving activities. A Lekgotla model applied in many indigenous societies to address problems can be considered. The Lekgotla model originates from the "tribal" meeting where village issues are addressed. Men of the village would sit in an arranged place to discuss the issues of the village. Protocol would be observed, that is, the most senior person would speak first followed by the next down to the least. This is still happening in the family environments, for example, during the lobola (dowry) negotiations. A delegation consisting of uncles and aunts of the groom-to-be will be requested by the groom-to-be's parents to request a meeting with the similar delegation on the bride-to-be's side to negotiate lobola. These groups are honoured with this important role and are responsible to advise and facilitate the marriage between the bride and the groom. A modified version of this model can be used in Technology Education to ensure all students' participation in their groups when they engage in problem-solving activities. Sub-groups can be delegates who will think about solutions to the problem and meet to negotiate solutions. They can role-play Lekgotla when they negotiate solutions to the identified problems in their learning activities.

Standa-Gunda et al. (2003) used the participatory model and social learning to engage twenty-eight broom grass harvesters (who made brooms from grass to sell) in Zimbabwe in developing solutions to the depletion and possible extinction of the grass. The end users preferred the brooms made from the grass that was harvested with its roots because the brooms were long- lasting compared to the brooms made

from the grass without roots. While this was a preference for the end users it created the grass depletion problem. The participants were thus involved in a discussion to arrive at a decision on how to sustain the grass. The group generated solutions for possible actions such as harvesting the grass at the right season, planting the seeds, stopping the harvesting of the grass with its roots and so forth. It can be realised that participation driven by collective engagements and a common goal is important in problem-solving situations—an ideal model for problem-solving activities in Technology Education.

Collaboration is central in these models and/or the theories discussed above. Lavonen et al. (2004) state that in Technology Education, collaboration features prominently as a pedagogical strategy. Collaboration is social interaction within a group or team. In such a dynamic, students work together for a common outcome. They establish joint goals and referents, arrive at joint decisions, solve emerging problems, construct and modify solutions and evaluate the outcomes through dialogue and action (Lavonen et al., 2004). Students actively communicate and work together to produce an outcome, and evaluate their outcome through dialogue and action.

Enriching Learning with Experiential Knowledge of the Elders

The young are mostly taught through observation by keeping them close to elders engaged in activities of the day. Thus, education mostly happens through experience, demonstration and observation. During Kimbell's (2008) touring of Zambia he observed the construction of a dhow at a beach site, which is a 25 feet long traditional Red Sea/Indian Ocean sailing craft. Raw materials (typically branches or trunks of teak) were shaped and fixed by hand without a single drawing. Kimbell (2008) claims that the builders knew about the strength of the timber and how to shape and fix it. Kimbell reflected on tacit knowledge (knowledge that is difficult to transfer to another person by means of writing it down or verbalising it), which he thought was involved as he observed new members of the building group being progressively inducted by participating in what he referred to as the mysteries of the trade of building the sailing craft. What this suggests is that the technology teacher should consider inviting elders who possess this expert knowledge to come and demonstrate how they do problem solving in their environment. Alternatively, educational tours should not only concentrate on industry in urban environments, but should also be spread to indigenous environments to tour indigenous factories or manufacturing sites such as dhow building. The role that indigenous community members can play in education should not be undermined. Consideration of tacit knowledge means that the teaching of technology should not follow the blueprint of the design process always, that is, investigate, design, make, evaluate and communicate.

Including Orality as an Alternative Form for Reporting or Communicating about Projects

Knowledge is mostly shared or transmitted through oral communication. Oral communication plays a huge role in indigenous societies, for example, in reporting, teaching about proverbs, idioms and riddles, telling stories. Elders who possess this rich knowledge have been perceived as living or walking libraries as a result. Since technology students are required to report and market their design projects, orality should be valued as a learning style (see my comments on Table 1 above), rather than overemphasising written reporting or marketing.

Building a Learning Community through Ubuntu

Knowledge about core cultural values is essential. The young are taught respect, responsibility, unity and so forth. The fundamental belief is that *motho ke motho ka batho ba bangwe (Tswana)* (Mokgoro, 1997); *umuntu ngumuntu ngabantu (Zulu)* (Mokgoro, 1997; Nyaumwe & Mkabela, 2007); *munhu munhu ngevamwe (Shona)* (Nyaumwe & Mkabela, 2007), which, literally translated, means a person can only be a person through others (Mokgoro, 1997; Nyaumwe & Mkabela, 2007). In most indigenous societies, young ones are taught Ubuntu institutionally, such as, in initiation schools. In this kind of existence, one person's personhood and identity is fulfilled and complemented by the other person's personhood. Each person *is* because the other person *is*. Each person *exists* because the other person *exists* (Muwanga-Zake, 2009). In his groundbreaking work *Let Africa Lead,* Khoza (2005, p. 269) defines *Ubuntu* as "an African value system that means humanness or being human, a worldview characterized by such values as caring, sharing, compassion, communalism, communocracy and related predispositions." Khoza (2005) adds that although *Ubuntu* is an African term, its philosophy can have a universal application, especially in indigenous societies as it can be seen with its Aboriginal conception related above. In 2010, during the author's scholarly visit at the University of Waikato, in New Zealand, the author toured the Maori Cultural Village, during which he observed the values that relate to *Ubuntu*: singing, unity, respect, communality, etcetera. The principles of *Ubuntu* can benefit teaching in Technology Education where students are called upon to exercise responsibility over their learning activities, such as cleaning their work spaces. The principles of *Ubuntu* can also be used as the basis for collectiveness and collaboration. That way they will learn to value each other's contribution and celebrate their achievement as a collective.

Accommodating Learners' Design Ideas That Could Be Informed by Spirituality

Part of indigenous knowledge is held as sacred as it is believed to be divinely revealed by the Creator. Knowledge about nature cannot be divorced from the Creator

and this facilitates the perpetration of a moral responsibility over nature which is taught even to the young through expressions, idioms or riddles. According to Harris (1990), (Aboriginal) indigenous world views are informed by spiritual and religious beliefs, while western cultures are informed by science. As indicated earlier on, designs and artifacts in indigenous environments are mostly influenced by the belief systems prevalent in such environments. In the open indigenous markets one notices human face sculptures and masks as well as animals and birds. These relate very closely to the designer's and end user's belief world, for instance, animals as totems. This also ties well with holism in the sense that indigenous designers mostly make artifacts that reflect nature. Hence, technology teachers should be aware of what informs design ideas of indigenous students in order to devise strategies to accommodate them appropriately. For example, a young Zimbabwean inventor, Sangulani Chikumbutso, exhibited his technological prototypes on 20 July, 2015, reported on the website: http://thisisafrica.me/zimbabwean-inventor-sangulani-chikumbutso-unveils-amazing-new-prototypes/ (This is Africa, 2015). These prototypes, among others, include:

- a hybrid engine-powered helicopter, which runs on six different fuels without any need to make adjustments on the engine, a unique innovation element which will help to draw market interest;
- an electric car, which runs on a renewable micro-sonic energy device with zero emission, another innovation element which brings the aspect of environmental friendliness to the design;
- a magnetic converter;
- a green power generator, which promises to revolutionise the energy sector as it is also powered by a micro-sonic energy device, and it generates electrical power by converting radio frequency energy directly into electricity;
- a special drone; and
- a SD-HDMI transmitter and receiver for mobile surveillance, which can transmit and receive the wireless high definition video and audio signals from SAITH-HDMI transmitters with high receiving sensitivity.

The prototypes promise to bring to the fore unique inventions that will benefit his country and the world. According to TechZim (This is Africa, 2015), Sangulani had already begun to experiment with electrical technology when he was at primary school. But then his father's influence as a mechanic aroused his interest to become a mechanic. Today Sangulani owns a company called SAITH Technologies. SAITH is a Biblical word from a phrase *Thus saith the Lord.* Sangulani's story is that his designs are God revealed, hence he decided to name his company SAITH Technologies. As a technology teacher, imagine having a learner like Sangulani in your class. What would be your response to his design ideas? He claims that his design ideas were spiritually discerned as well as inspired by the experiential knowledge endowed in his father as an elder.

Using Values as a Tool to Cultivate a Deeper Understanding of Technology in Terms of Its Biases and Impact

Knowledge, and therefore science, is not value-free as it cannot be divorced from the cultural and value systems of indigenous societies. An attempt should be made to make the school and home experiences of diverse students more congruent (Ladson-Billings, 2000). Indigenous people everywhere would like to know about their culture and history, which suggests a collaboration between parents and teachers to raise kids (Perso, 2012). Knowing about the value system of indigenous students can help in positioning the technology teacher appropriately to teach about values (religion, beliefs, culture, education, etc.), which is an integral part in the learning of technology.

Accommodating the Complex Dimensions of Knowledge for Meaningful Learning

Indigenous knowledge's rich complexity is found in ceremonies and rituals, for instance, dance, music, storytelling, folktales, epic, poetry, recitation, demonstration, (word) games, sport, praise, riddles, reasoning, puzzles, tongue-twisters. What is desired, then, is teachers who are capable of interrogating the curriculum from a culturally responsive perspective as they attempt to determine their strengths and weaknesses (Perso, 2012). Their interrogation should target things such as accuracy, purpose, significance, authenticity of narrative texts, visual illustrations, learning activities and authorial sources (Perso, 2012). At the same time, they should expose and confront racism, stereotyping, distortions and overemphasis on factual information (Perso, 2012). This list, juxtaposed to Table 1, provides a repertoire of strategies that can be considered in technology teaching.

CONCLUSION

The teaching of technology needs to transform to include indigenous perspectives. The literature surveyed and presented in this chapter attests to this need. I addressed the purpose of the chapter by defining the terms Technology, Technology Education, Curriculum and Pedagogy; highlighted the need to transform the teaching of technology; presented the frameworks that support the integration of indigenous perspectives in technology teaching; and presented the ten principles about teaching technology from an indigenous perspective.

Schools and teachers should re-examine their teaching strategies and make sure that they do not alienate indigenous students in their classes. They should ensure that they integrate indigenous knowledge systems in the Technology Education curriculum.

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