Integrating Culturally-mediated Tools as Instructional Models in Science Classrooms

by

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Abstract

This study explored the possibilities of using beads and beadwork (cultural artifacts) to create instructional models of simple and complex organic compounds for teaching and learning of life sciences concepts in South African science classrooms. The objective was to find ways of integrating African indigenous knowledge (AIK) through cultural artifacts into westernized science teaching to enhance better learners' understanding of and performance in sciences. I became interested in using materials available in learners' (students') lived-world to spur their interests in learning sciences when I taught high schools life sciences in Iyin-Ekiti, Ekiti State, Nigeria. Classroom resources were very scarce and those manufactured by textbook companies were boring to indigenous learners. They tended to memorize and regurgitate to pass exams and often could not explain the concepts in their own words. Therefore, I had to improvise. I asked learners to bring resources from home that we then use to create paper mache of science concepts as instructional models thereby concretizing abstract life sciences concepts. This hands-on, minds-on, culturally related, approach sparked learners' interests in science that resulted in high performance in science and spurred me to carry on this study. This study has therefore solidified my view that materials found in the learners' lived-world (cultural artifacts) can be used by teachers to enhance the teaching, learning and understanding of westernized science and help improve science performances (the learners ability to produce and reproduce the knowledge of simple and complex organic compounds) and literacy of indigenous learners.

Enhancing indigenous learners' understanding of westernized science concepts by using culturally relevant materials that are significant in learners' lived-world became imperative in South African context. The South African National Curriculum Statements stated categorically that teaching of sciences must "values indigenous knowledge systems and acknowledges the rich history and heritage of the country" (NCS, 2005. p. 5) and the Curriculum and Assessment Policy Statements (CAPS, 2011. p. 2), as policy documents, mandated that "children acquire and apply knowledge and skills in ways that are meaningful to their own lives". In addition, CAPS also instructed teachers to "construct models of simple and more complex molecules using beads" (CAPS, 2011. p. 19). Surprisingly, the teachers, who participated in this study, were unaware of this provision in the CAPS document and it may not be wrong to assume that most science teachers are equally not aware of this provision. More critical is that the curriculum did

not state how these models of simple and complex organic molecules would be constructed with beads; and the schools and/or teachers were not provided with beads, resources, and neither were they trained on how to do this. Without these provisions, the outcomes envisaged by CAPS will continue to be hidden in the curriculum without actualizing them.

This study takes a qualitative approach using a case study paradigm and video-recorded (teachers professional development workshop, teachers interview and teachers and learners classroom interactions) and conversation analyses with the use of questionnaire to collect data on "how" beads and beadwork could be used to create instructional models for teaching and learning of simple and complex organic compounds and more. The study was conducted in two peri-urban (township) schools near a metropolitan city in South Africa. Four (4) grade 10 life sciences teachers and their learners (forty learners on an average) as participants were involved in the study. The four life sciences teachers were interviewed after the professional development and training workshop. In the professional development and training workshop, all sciences teachers indicated their interest to participate and this was not denied, however, only the experiences of four life sciences learners were captured during the interview. In essence, there were four interviews (20 minutes each) with the life sciences teachers. The focus groups were conducted for 20 minutes also. The study was carried out in three phases. In phase one, I as the researcher taught myself how to create simple and complex organic compounds in order to teach the processes to science teachers. In phase two, I engaged science teachers from two schools in a professional development and training workshop where I worked with the teachers on how to create simple and complex organic compounds as instructional models using beads and beadwork. The third phase was where teachers taught learners how to create such instructional models by themselves, which were later used to teach the organic molecules Participants included four teachers and their learners. I also engaged a professional bead maker to help me gain a better understanding of the knowledge of beads and beadwork and the learning processes that are involved in bead making.

Research findings indicated that the aesthetic properties of beads and beadwork and interests of learners in the aesthetic properties endeared the learners to the hands-on, minds-on activities and enhanced their sustained engagement, interests and interactions among learners, learners and their teachers, and both learners and teachers with the culturally-related materials (beads and

beadwork). These materials became tools for generating culturally related instructional models (CRIM), as the beads and beadwork became cognitized for teaching and learning of life sciences in the classroom. The professional development and training workshops with the teachers became forum for teachers' heightened awareness of and interests in the use of not only beads and beadworks but other cultural artifacts in concretizing abstract science concepts. Teachers demonstrated the conviction that the use of the cultural artifacts integration model (CAIM) could be a pedagogical approach to aligning the two worldviews, indigenous knowledge (IK) and westernized science (WS) in indigenous science classrooms. Other areas of indigenous knowledge integration with westernized science in the African sciences classroom/contexts; and how they can be integrated using the CAIM present areas for further research.

Keywords: Culturally Responsive Pedagogy, Culturally Related Pedagogical Resources, Indigenous Knowledge Systems, Nature of Science, Culturally Responsive Resources, Cultural Artifacts Integration Model

Declaration

I declare that this thesis is my own unaided work. It is being submitted for the Degree of Doctor of Philosophy at the University of the Witwatersrand, Johannesburg, South Africa. It has not been submitted before for any degree or examination in any other University.

Sina Joshua Fakoyede
___01 day of Nov --2018

Dedication

This academic piece was enabled by God's grace. He is the almighty enabler. I dedicate this thesis to:

My Father, Dad, the late Reverend. Canon, Samuel Ajayi Fakoyede, of recent memory, who believed in my dreams of becoming a Doctor. Dad, I did it through your believing in me. Though Dad's body was buried yet he lives in and through me. I love you dad!

My mom has been the best woman any child can ever have. Mother, Esther Fakoyede, has been my rock. You will live to reap the fruits of your labor and the fruits dad did not live to reap.

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Abbreviations

CRPR	Culturally Related Pedagogical Resources
CAIM	Cultural Artifacts Integration Model
CRIM	Culturally Related Instructional Models
NOWS	Nature of Westernized Science
IKS	Indigenous Knowledge Systems
SOIK	Stock of Indigenous Knowledge
DBE	Department of Basic Education

Academic Output

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Chapter One

Learning Moments

Introduction

Humans become who they are by their interconnectivity and interrelationships with other beings in the social web (Tobin, 2005). This research journey started years ago before I decided to add to the body of knowledge in science education; it began in a subconscious way. The journey encompasses many moments, which when I recall made me feel that it was thoughtful to have embarked upon such journeys or episodes. My heightened awareness now affords me the opportunity to tell my story in episodes. In weaving these episodes together, I employed Tobin's (2005) bricklaying concept. To bricolage according to Tobin (2005) is to utilize different tools where needed in crafting a research tapestry, a story or a meaningful and useful crafting item, an object or a thing of value.

The first episode started in my life sciences class in a rural community of Iyin Ekiti, Ekiti State, in Nigeria, when I first started teaching. It was my first time in a rural school as a science teacher. It seemed now as if it is a long time ago, but it is not. It was a challenging start to a professional life, at first. However, as things began to happen later on, my research studies would not have started implicitly without those early wobbly beginnings. I had to make a huge adjustment because the usual buzz of city life was not there in the rural village I was posted to start my teaching career. I felt jolted as there were no basic infrastructure, no mobile networks and such communication and accommodation luxuries I was used to; and none of the city buzzing was present. On another hand, one could feel the serenity settings and the ambience that characterize a rural setting. From the mud houses to the bicycles parked across the street, the village buzz was my new life. The sight of people greeting each other in their local dialect and dressed in their traditional garbs were everywhere. The sight of the rising sun and setting of it seemed spectacular to me; I had never paid much attention to such phenomena. The sight of moonlight at night was a reminder of lack of electricity**.** However, this is my new life and I needed to adjust to it. I began to enjoy the beautiful sounds of the wind, sometimes howling, sighing and soughing as it was blowing over the trees and making waves in the tall grasses further authenticates the calmness one finds in a rural area. At early evenings, the chirping sounds of the crickets in the side bush, the croaking sounds of frogs and toads inform one that the night is approaching. Birds start to roost as well as domestic animals, such as goats and sheep, come back to their fenced home (kraal) to prepare for the night.

Community members soon started to acknowledge my presence in their community and would stop bye to greet me. People of the town seemed to know each other as everyone greets everyone on the streets and literally everywhere, whatever they are doing, there is a greeting for it. I had to learn how to slow down as greeting everyone one meets as this relational ontology is not the same the "every man for himself", urbanized city life that I grew up in. People share things with each other; fresh vegetables and fruits were given to me for free. This communal life style made me wonder what world we lived in as I experienced the dichotomy of urban and city lives.

Days after starting my teaching career, in the school where I was posted, I noticed that most learners do not often come to school punctually. Some do not come at all, especially when there are works on the family farm to complete. In addition, some learners leave early to go and help on the family farm; some began to take advantage of that to skip school and to go play with friends because they claim to find the school boring. Before I knew the reasons for their absences from school or for coming late to school or leaving early, I thought to myself "Perhaps they were not just interested in schooling". "What could be the problem?" One way to find out, I thought, was to become friendlier to them (learners) as well as interact with them to know what the challenges they face were. Years after this decision, I got to know that the interactions with the learners I sought for was a form of social capital. I also sought to know more about their welfare, parents, the learners' interests in subjects and why the learners seem to come late or not even come to school at all. This phenomenon did not just happen to me but also to other teachers; while I wanted to, I was inquisitive wanting to know why other teachers do not seem to be interested. I became more inquisitive because my learners seem not interested in learning life sciences at all and I wanted to know why.

There was this negative attitude towards science; hence, few performed well in their life sciences examinations and tests. ''It was too wide and such an abstract subject'', some learners complained. Others said, "I forget what I read immediately after I have read it, especially life science. This notion was buttressed by Rogers and Ford (1997) who opined that some students have developed negative stereotypes of science and scientists, whom they view as "nerds" or "mad scientists." Others describe scientists as "hard", "old", "frightening", and "colorless". All of these are metaphors for a boring, abstract subject. I thought of ways to get the learners interested. Earlier, I decided to become their friend and mentor ("a frientor"), according to Otulaja (2016) (personal communication 2/15/2016) instead of just their teacher. I also switched between the learners mother-tongue and English language (the authorized language in the school) as I taught them in the classroom. Their performances in life sciences were below average and this challenged me to employ whatever resources I could to get the learners interested in life science concepts. "My students needed to understand life sciences better", I told myself. I was to teach them the nutrient cycles (nitrogen, carbon, water, oxygen). I decided to teach with charts and models because it seemed to me like a more abstract topic. The laboratories had few charts related to the topic with only improvised specimens such as preserved frogs, snakes, chameleons and some more animals. I was not surprised, all these animals were found around the learners and since there seemed to be no standard laboratory in government owned rural schools, the previous teachers tried to improvise on specimens that could be found in the environment (place-based materials). So, I informed my learners to bring materials from home, such as, rough papers, starch, and coloring ink to the classroom, using the classroom as a field of social and cognitive engagement.

I informed them we were to use the materials to create models of the nutrient cycles. They gladly brought them and I subsequently taught them how to create these models to demonstrate their own understanding of the concepts. I put the learners into groups and allowed them to interact with each other. I allowed this because they were informed that they would create these models on their own. However, and despite my explanation, I still felt some may not understand me. So, the few that understood could peer-tutor others through peer interactions. The concepts they were to create were those of water, carbon, nitrogen and oxygen cycles. I moved from group to group to further elucidate the ideas. I realized soon afterwards that they were becoming more interested in what they were doing. They were interacting, smiling, teaching and correcting as the learners were seen interrogating each other. The emotional energy level in the classroom spiked as learning the subject matter became fun. Some, through their artistic talents, created models that represented the cycles given them in their group as others either commented or demanded to be part of the "doing process" as they did not just want to be idle. It became a sort of division of labor. At the end of the term examinations, results showed significant improvement in pass rate. As success begat success (Tobin, 2005), students began to demonstrate increased interests in life sciences perhaps because of the lived-experience (habitus) they encountered. I encouraged them present their models in the science exhibitions and they became proud of themselves and formed identities that denote their success in life science. Other members of the school knew them as the alpha of life science. They would voluntarily tell me afterwards in other lessons what in their lived-world they can allude to in enhancing their learning in the classroom. Even in topics that I felt were too abstract to be represented by a model, the learners will have a material that they can use to represent the concepts. They were willing to create something. According to Gay (2002), the employment of cultural characteristics, experiences, and perspectives of students becomes a conduit for effective teaching**.**

Looking Back

Looking back to the activities in my life sciences classroom years after, I argue that the groups I formed in my life sciences classroom was what Wenger (1998) called community of practice (CoP) and Bourdieu (1978) called social field. The learners had gained cultural capital, which became symbolic when they presented it in the science exhibition week. This (cultural capital) I accessed by allowing the learners to self-regulate their own learning and it enabled them negotiate their route from the known to the unknown. I also alluded to the potency of learners' social capital as enabled by their social interaction to enhance their understanding of life science concepts. Bringing some materials from home to school was like bringing home culture into the school culture and aligning them (Aikenhead, 2001). It was also a form of placed-based learning because the materials the learners brought were found in the learners' environment. It gave them a sense of ownership and belonging as does the school culture. This transfer of home materials to the school setting, I supposed, avoided continued disconnection with their homes (Adams, Luitel, Afonso, & Taylor, 2008). Perhaps I had reproduced the society in the school by helping the learners to transfer their habitus from home to school (place-based learning). This habitus accumulated and became obvious by the excitement and the marks they got afterwards which translated into a form of identity of success (symbolic capital). In the communities of practice, learners were generated opportunity to learn together communally, share experiences as well as common interests. The learners also shared a common passion (Collins, 2004) and a successful interaction afterwards. I ended up being a more knowledgeable other (Vygotsky, 1978) rather than a traditional teacher as I had to balance the power dynamics in more productive ways. Rupturing the power dominance as a teacher brought a sense of what I call "working together" (relational pedagogy) rather than "I-know-it-all". I could supervise the learners much more readily, guide them so that they could adapt intellectually as Vygotsky argued. To transform the way they learn, improvised models helps made my pedagogical practice more effective.

Furthermore, each model became a sort of symbol, and in a way, a sort of identity for each group. Other teachers and learners came to see them, asked who created the models and subsequently reproduced the idea in their own classes. Is this cultural learning? This model gradually evolved into a method other teachers used in their teaching. My life science learners became school representative afterwards and won numerous prizes. It was a defining moment in the learners' lived-world and experience. Again, I did not just become a hero to these learners spontaneously. My father started it. He was a teacher. I can explain my home schooling as an "all-in-one", inclusive education. I was home-schooled very early in an unwittingly, holistic and wholesome context by my father and siblings. I was very inquisitive and was immersed in what I learned such that when I started school at the age of five, I was assessed and admitted into class one. To my surprise, after a week in first grade, I was moved to the second grade. Unknowing to me, the teacher had assessed me, saw I was far ahead of my classmates and the school decided to promote me to the next grade in just a week. It ended up being that I had learned so much at home, without being conscious of it. I commended the education I got from my parents and siblings outside the walls of the classroom; hence, I describe it as wholesome, holistic and collective (Sarpong, 1991) and practical.

Further on the wholesomeness of indigenous knowledge, my early home schooling was not compartmentalized into so many subjects like mathematics, English, basic science, which were compulsory in national examinations. I was taught the subjects in the context of human interactions and using contextually-available instructional tools. For example, I learnt mathematics with soft drink bottle caps and pebbles (small stones) until I mastered basic calculation skills. These were hands-on activities, which seem not practiced in schools today as learning of science remains abstract to indigenous learners. Equipment for experiments in the laboratory was either not available or outdated (Wilson, 2009) in my primary school days. My father's innovative approach sought for teaching aides that could readily be found in his surrounding, which also helped him simplify the complex concepts (Seel, 2003). I could not forget what I was taught because they became epistemic objects that helped me remember what I was taught. Looking back now, I could say perhaps because my father was a teacher, his habitus helped him teach me even before being admitted into primary school. This same habitus (Bourdieu, 1986) earned him a social class, which was respected by the public that anything relates to upbringing of the child in the society was directed to him for professional advice. His class had a ripple effects on me as I attended what the society saw as the best school in the community we leaved in. It affected my thought processes as we were always told that children of teachers must perform better than other children in the school.

This experience enabled my understanding of science through my university days when we were introduced gradually to the school of thought that models enhance learning. Our education classes comprised of educational technology where we had to improvise models of different concepts in our various fields. Upon graduation, I had already had the teachers' education experience (TEE) as a pre-service teacher; and immediately after graduation, I also continued enhancing and valuating my teaching experience. My credentials as a professional teacher (a sort of institutionalized cultural capital as Bourdieu (1978) argued, allowed me the opportunity to be employed by the government and afterwards posted to the high school where my moment began as reported in this chapter. So, the classroom activity was not just serendipitous. It was because of the capital I have acquired over the years, which afforded me the required experiences to navigate my way through the new social environment (field) I found myself. My proxemics of interaction was enabled by the habitus what was culturally developed and reproduced in the learners (Bourdieu, 1986). Dewey (1938) linked the house and school together in forming a wholesome experience for the child. Clandinin (1986) further posited that experiences could be experiential; past-experiences are reconstructed to meet the demands of a particular new situation.

My educational experience as a child became a type of stock of knowledge (Sewell, 1992) from which I was able to draw to negotiate my new concept. Also as a child, I watched my father improvise materials for his teaching which included games; fun-filled activities into which I must have immersed into, unconsciously. As humans, we acquired much of the content of our thoughts, which led to knowledge acquisition. I believe the surrounding culture provided me with the affordances –Vygotsky (1998) called this intellectual adaptation. He says the culture of a child teaches the child on what to think and how to think. As we played our games and had fun, I discovered we unknowingly went through series of affordances such as observing, measuring, inferring, predicting and communicating. Observing from dad and my other siblings, as a more knowledgeable other, as well as allowing me to deduce or infer, predict from what was explained; hence, my creative and critical thinking skills were developing. All these are basic scientific processing skills. It was a form of hands-on, minds-on, pedagogy. The materials used became epistemic objects and learning resources. The will to explore more into these resources, which can be used as models for teaching and learning life sciences, led to me exploring the use of beads and beadwork (cultural artifact) as instructional models to be used to teach in the science classroom. .

Creating an Interactive Environment

Creating an interactive environment with cultural artifacts (beads and beadworks) as learning resources seem to afford learners increased learning opportunities as in the case of my life science class and my wholesome learning from my dad. Creating models from culturally related materials (place-based materials) also appears to enable learners understanding of science; as reported in my life sciences class. This actually influenced my decision to probe more into the use of cultural materials that can be adapted to enable learning in the classroom. This could also enhance my evolvement from being teacher-practitioner to a teacher-researcher (Tobin & Kincheloe, 2006, p. 59), teacher as researcher (Tobin, 2005) working with artifacts that can be alluded to teaching science concepts to indigenous learners. Thus, looking for culturally relevant materials to use as models of life science concepts to create activities that might transform classroom education from a place of "banking education" (Freire, 1990, p. 58-66) to a culturally enabling responsive learning environment. A field where teachers should no longer be gatekeepers of knowledge but facilitators of learning experiences (Freire, 1990). Again unknowingly, as I proceeded to unpack the "what and how" of this research work, my supervisor and I found that the CAPS document had stated " construct models of simple and more complex molecules using beads or plasticine" (p. 23). As we found out in chapter four, the teachers who participated in the professional development and training seminar reported they were not aware of the curriculum stance on the use of beads to teach simple and complex organic structures in the classroom.

The practicality in learning that I experienced in my childhood enabled my pedagogical practice years later in the life sciences classroom and created an image or identity of an innovative teacher in the school. It was long lasting and I sought for ways to keep reproducing this experience (Vygotsky, 1978) in different situations especially with the use of materials (cultural artifacts) that are indigenous and place-based. From the use of beads for abacus in the mathematical field to life science classroom, I met with my supervisor who facilitated the conceptualization of the possibilities of beads and beadworks being used as instructional materials in the life science classroom. This process went further; it gave me a further impetus to carry the research out as well as more credibility to the research work. I became more conscious of the need to carry the research out when all teachers that participated in the professional development and training seminar confessed to being unaware of the instruction on the use of beads and beadwork (cultural artifacts) to create simple and complex organic molecule in the classroom. There was also no supply of beads by whoever was responsible. In the resource section in the CAPS document, beads were not even stipulated to be provided in the classroom for these exercises. Hence an added reason to why this research works was worth conducting. This was another AH…AH moment in the research journey.

The Goals of the Dissertation

In this dissertation, my goal is to explore the possibility of creating instructional models from materials that indigenous learners are familiar with such as beads and beadworks. The aim is to use beads and beadworks to create models as instructional tools for teaching and learning Life Sciences. The goal also is to demonstrate cultural learning with the use of beads and beadwork to indigenous learners and make concrete the abstract nature of simple and complex organic compounds being taught in Grade Ten (10) multi-culturally-diverse science classrooms.

Beads come in different colors, shapes and sizes which could be appropriated in learning. Using beads and beadwork to create models may generate opportunities to enhance culturally-responsive teaching (CRT) as argued by Ladson Billings (1992). I assume that there is pressing dare need for the use of more hands–on, minds–on activity as it is commonly said, you are what you repeatedly do. Models to be used to develop basic learning skills aids teaching and learning of biological concepts in the classroom can be created by learners with materials seemingly familiar to the learners. I explore the use of beads and beadwork (cultural artifacts) as instructional models in the teaching and learning of life sciences in the classroom. Will this enhance learning? Can these artifacts improve classroom interactions among indigenous learners and serve as a vehicle for improving participation in science and students' participation in science.

Problem Statement

Creating a culturally responsive classroom seems to be insufficient without an interactive, pragmatic, hands-on, mind-on, with culturally related instructional models (CRIM) in the science classroom. Indigenous learners seem to be disinterested in science year after year (Aikenhead, 2017). They seem to see the teachers' classes as boring (Gay, 2010) while they also see science subjects as difficult to understand as they memorize them; hence they seem to give up before they start learning. More importantly, the learner tends to feel less familiar with science subjects and its application to their lived-world (Ogunniyi, 2017). They tend to see science as alien to their everyday life. The disinterest in science appears to detach them from being able to solve their societal challenges thereby over relying on westernized knowledge to solve the numerous societal problems. The root cause seems to be the learners' disinterest in science. Using materials found in the learners' lived-world seem to be able to create and sustain learners' interest in learning science concepts thereby enabling the increase in the relevance of science to their lived-world.

Significance of the Study

This study anticipates the possibilities of minimizing the process of memorization, improving indigenous learners' collaborative and cognitive skills, as well as maintaining the learners' attention span. The idea behind the use of beads is that these materials can be found in the indigenous learners' environment as cultural artifacts worn for various cultural and aesthetic reasons could be used to create models of concepts in Life Sciences thereby generating hands-on, minds-on activities. It aims to complement the drive for a culturally responsive classroom with the use of culturally related instructional models of abstract life sciences concepts.

Rationale of the Study

Learners are known to be familiar with their lived-world especially indigenous learners whose way of knowing encompasses relational ontology (Chilisa, 2012). In the westernized classroom, learners' beliefs and experiences seem to lean towards learners not seeing themselves in science or seeing science in their lived-world; hence, they tend to struggle to learn science. The learning context, learning approach, learning outcomes seem to suggest this as the context is individualistic, approach is teacher-centered and the outcomes suggest indigenous learners continued disinterest in science (Tobin, 2005). Can the use of artifacts as instructional models enable and sustain learners' interest in science? This study explores the possibilities of using beads and beadwork (cultural artifacts) as instructional models in the teaching and learning of life sciences. This study tends to add to the body of knowledge on the actualization of a culturally responsive pedagogy that enhances a classroom responsive science classroom.

Research Questions

This study is asking the following research questions to help me unpack my findings:

- How would the knowledge of beads and beadwork be used to create models of Life Sciences concepts as instructional tools for learning in the science classroom?
- What would teachers learn from the use of beads and beadwork (cultural artifacts) in creating models of Life Sciences concepts as teaching and learning (instructional) tools in the science classroom?
- How would models of life science created from beads and beadwork affect indigenous learner's performance in the Life Sciences classroom?

Answering these questions, with all purposeful intentions, will help generate new knowledge into non-Western cultures' quests to use culturally-mediated tools and approaches to probe and illuminate pathways to improving science teaching and learning for teachers and learners in contexts where indigeneity of science has become a clarion call. I approach this study from the point of a teacher who upon reflection on two of my past worlds where one had a lot of hands-on and the other less hands-on activities with different results in both. Also from my experience as a biology teacher in a remote area who has used the locally made materials for models to arouse the interest of my learners in studying life science and encourage class participation. Windeatt (1989) argue that instructional materials have a hidden curriculum that includes attitudes towards knowledge, attitudes towards teaching and learning of roles and relationship of the teacher and learners.

Weaving my way through the tapestry of this study, from what appears to have led me into the need to unravel the possibilities in creating models made of beads and beadwork to learning life science concepts in the classroom; and to the methodology employed in this interpretative ethnographic type of research. Mainly my subjects are humans involving me as a participant observer, the teachers and learners as co-participants. According to Bergold (2007) participatory research can be regarded as a methodology that argues in favor of the possibility, the significance, and the usefulness of involving research partners in the knowledge-production process).Participatory research methods are geared towards planning and conducting the research process *with* those people whose life-world and meaningful actions are under study (Reason & Bradbury, 2008). Consequently, this means that the aim of the inquiry and the research questions develop out of the convergence of two perspectives—that of science and that of practice. A methodological design that can be classified as a participatory design process in the real sense represents an attractive and fruitful knowledge-generating option when it comes to researching the social world in the sense of habitualized practice (Bergold, 2007).

Again, since this interpretative research involves a process of participant observation with the goal of ascertaining what is happening and why from the perspective of the participant. In addition, the possibilities of using beads and beadwork to create life science models to aid teaching and learning is not yet ascertained. Hence, the use of bricolage provided the coupling of different perspectives (polysemic) of looking through the data and making sense of it. According to Wibberly (2012), bricolage is no frequently used approach in research. Therefore, researchers utilizing bricolage as a research design have less exemplary texts to draw on in coming to their own understanding of this approach to research. I am looking beyond the more standard traditions of carrying out qualitative and quantitative study design. Another reason for bricolaging is the employment of multiple theories, its interpretation of phenomena, and the object of its observation that is inseparable from the historical dynamics that have shaped it (Kincheloe, 2006) as culture is enacted within fields. Tobin (2006) asserts that using bricolage to do research requires in-depth knowledge of multiple theories and methodologies, multiple ways to collect, describe, analyze and interpret the object of the research study. According to Kincheloe and Berry (2004), bricolaging provides new knowledge, insights, Ideas, practices and structures that move towards diversity and inclusiveness. The concept 'bricolage' comes from the work of Denzin and Lincoln (2000), who used the term in the spirit of Claude Levi-Strauss (1966) and his lengthy discussion of it in *The Savage Mind*. This text explores parallels between mythical/primitive thought and bricolage.

Conducting Research

Following my experiences in high school where hands-on activities were scarce to the teachers' unawareness of the capital the learners had, compared to my primary /elementary school where we had a lot of activities we did with our hands and our capital valued and acknowledged. I witnessed the efficacy of using models to teach. My encounter with my students when I became a life science teacher was an eye opener. They had the notion that life science is so difficult to pass because they were taught life science as an abstract subject. This was before I was posted to the school as a life science teacher. The outcomes of my telling them to bring some materials from home to make models of the water cycle, nitrogen cycle, carbon cycle was overwhelming and many said they could not forget all they did for the rest of their life. This was actually encouraging and I was energized to find more on the use of cultural materials familiar to the learners. These materials (beads and beadwork) were used to create models of life science concepts, particularly when it appears there were few or no models to represent the simple and complex organic compounds.

Envisaged Outcomes.

The envisaged outcome of conducting this research in eight (8) life sciences classrooms from two different schools in the same district and aimed at the possibilities of using beads and beadwork (cultural artifacts) as instructional models in the teaching and learning of life sciences.

The research also aimed at exploring the possibilities of transforming teachers' pedagogical practice as well as learners' enhanced learning of life science in the classroom. Based on earlier participants' action research studies, some expected outcomes are distributed leadership to increase individual and collective agency, increased participation and interactions in the class amongst learners and between teachers and learners, to increase interests in the learning activity as well as negotiating power dynamics in the classroom. To judge the quality of this research and its outcomes, I adapted the authenticity criteria delineated by Guba and Lincoln (1989) which had been transformed from various conceptions of validity and reliability as paradigms in research shifted (Seale, 1999). From the concepts of validity and reliability came the issues of trustworthiness as Lincoln and Guba (1985) posited. Guba and Lincoln (1985) argued for the exigency for a research study that is credible, transferable, dependable and confirmable.

In extending Guba and Lincoln (1989) work on the four authenticity criteria to the narratives in this study, I employed the ontological, educative, catalytic and tactical authenticities to ensure a rigorous approach in carrying out the research work. According to Tobin (2006), ontological authenticity relates to the extent of change in the participants perspective as a result of their involvement in the action research as I document these changing perspectives as well as ontologies. Ontological authenticity also appraises the changes in the theoretical baseline in this study. Relatively, educational authenticity seen by Tobin (2005) as a support criteria to beneficial changes in their ontological perspectives as making sure all stakeholders understand how to make their experience sense of reality. Catalytic authenticity enables participants' actions to be positively catalyzed to show improvements to what was achieved in the research study. In the same vein, it professes and obligation to educate all participants to enable participants improves themselves in relations to the studies impact. While tactile authenticity affords participants the extent to which their agency has been expanded and additional structures are provided for those individuals for whom the efforts to educate them and catalyze wholesale changes were not sufficient.

In furtherance of adhering to high quality qualitative research, I ensured I had no preconceived ad determined ideas about what benefit to be accrued to the participants; I just allowed the natural process to yield its results and so that templates to confirm priori expectations are not formed (Tobin, 2005). As a result, the data negotiated my trajectory towards answering my research questions. Each of the four criteria is part of a whole: therefore, the ways in which each of the criteria is addressed and accomplished affects the quality of the study.

Research Contexts

This study was carried out in two peri-urban township schools in the city of Johannesburg metropolitan municipality school district. Both schools are classified as public, no fee paying, Quids-up, quantile two and three schools. Quid-up schools are billed to be assisted by the quality improvement and development strategy initiative to improve Science, Mathematics and Technology teaching and learning in secondary schools. The quantile system classifies schools according to the level of poverty in surrounding areas. The community surrounding the school as provided by the Department of Statictics South Africa (2011) habits demography of 54.47% black African, 24.22 % of white, 16.97% of Indian or Asian, 3.29% of colored while 1.04% of other. But both schools had all black learners. On account of languages spoken, 33.14% of the people surrounding the schools speak Sepedi, while 21.67% speaks isiZulu. 13.31% of the people are Xitsonga speakers, 7.00% are isiXhosa speakers while 6.34% of the people speak Sesotho Furthermore, and 3.93 % speaks Setswana while the isiNdebele people are about 3.72 %. 3.51% of the people speak Tshivenda while just 2.11% speaks English and 1.84% speaks SiSwati.

Resources seem impoverished and less equipped, hence, the dominant language spoken in the school area is Sepedi and isiZulu. The classroom demographics could be explained as multicultural hence; the learners spoke more than one language in the science classroom. This was evident in the transcription of the video-taped classroom interactions (in chapter five) as it showed there were more than one language the learners employed in their classroom interactions-a reference to code switching or translanguaging. The schools are also socially, culturally, and academically diverse hence the choice of the schools for the research. The teachers were mainly South African with a few non- South Africans as one of the life-science teachers involved in this research work was a Zimbabwean. In terms of gender each class was made up of between 50%-55 % females and 40%-45 % males. The logical and systematic search for the possibilities in exploring the use of bead and beadwork (cultural artifacts) as instructional models in the teaching and learning of simple and complex molecules led me into lenses employed as frameworks to unpack the hidden constructs was explained below.

Frameworks Employed in Research

The frameworks employed in this research provided lenses to understand and fathom the complexities and possibilities of outcomes from the use of bead and beadworks (cultural artifacts) to create models of life science concepts for learning and teaching in the classroom. By frameworks I mean theoretical and methodological. This research employed both constructs and was viewed through multiple lenses. Through the theoretical lens, this interpretive research reckons who interprets and analyzes while unfolding praxis in the science classroom. It is also an empirical study which is examined along different focal points of the intangible microscope depending on where and when and how the theories employed could interpret the data. In resonance with Tobin's (2005) bricolaging perspectives of weaving theories together as when fits and using the theoretical lenses to see through theories to interpret moments in the research work, Socio cultural theories were also employed to weave through the research tapestry of this research study. Vygotsky (1978) explained the cognitive space as a classroom space similar to social fields with social interactions whose dynamics is regulated by rules, roles and resources-all components of a structure.

Giddens (1981) argues that structures shape peoples practices but also people's practices shape their structures hence, both structures and practices presupposes each other then they are dialectically related. The arrangement of learners' classroom space (seat arrangement, desk position and orientation) influences how teachers and learners interacts (teacher and learners and learners-learners interaction) in the classroom (social field). On the other hand, the use of bead and beadwork (cultural artifacts) to create models of simple and complex organic structures in the science classroom transforms the teacher's pedagogical practices by (i) changing the learners' positions from the linear and longitudinal position to learners sitting in groups of three and four thereby enabling increased learning access to each other (ii) increased teachers distributed attention and leadership to the learners. Structures according to Giddens (1984) are virtual but as evident in this study, structures can be implicit (virtual) and explicit as the sitting arrangement in the classrooms can be explicit structures and mental structures which Bourdieu

(1978) called schemas could be implicit. Rules are also virtual as they can be applied within spaces of interaction. Wacquant (2011) also posited rules as not formalized but tacit in nature. Rules, when generalized could become 'a way' of practice by some individuals; hence likened to culture.

According to Bourdieu (1978), structures can act as rules which can also determine and condition learners' thought and behavior. In the same vein, the use of beads and beadwork (cultural artifacts) to teach simple and complex organic compounds which transformed learners' learning practices determined learners' thoughts and behavior therefore; they (learners) were positively (emotionally) energized during and after the learners' interaction with the models in the science classroom. According to Wacquant (2011), rules need to be internalized by agents in other to express practices and strategies. These rules become a sort of roles of agents when motioned to concretize the abstract nature of rules. Lave and Wenger (1991) also posited the space for social interaction as community of practice with roles for each individual that is mediated by a legitimate peripheral participant or a more knowledgeable other. Bourdieu also uses field to denote social spaces and for this study, likened to the science classroom. To Bourdieu (1978) social spaces are structured by networks of capitals (social, economic and cultural) in the classroom transactions. Likewise, Lave and Wenger (1991) argues the field as a shared domain of human endeavor which correlates to a science classroom (field) with a science classroom (field) with a shared domain of human endeavor (beads and beadwork) cultural artifacts). Furthermore, a group of learners creating models with beads and beadwork (cultural artifacts) share a common concern or passion for something they do and learn how to do it better as they interact regularly. The social interaction between each individual becomes invaluable to the teacher and learners if visualized as a form of social capital (Bourdieu, 1992). Also cognizant to the pedagogical processes in the classroom is the cultural capital (Bourdieu, 1992) which Bourdieu posits as acquisition of all that the individual's culture deposited as a stock of knowledge (Sewell, 1999).

Visualizing the community of practice (Science classroom) as a cognitive space to employ pedagogical processes that values learners social and cultural capital as captured in this research work appears profitable on account of the interwoven constructs expressed by the learners such as peer tutoring, assessment and evaluation, peer identity formation, peer imitation and observation; all expressed through translanguaging - a channel as enabled by the learner's bid to learn simple and complex organic compounds. Bourdieu saw the classroom as a field of practice (agency and structure) with power dynamics where learning takes place by observing and modeling Bandura (1977). Seeing the classroom as a field of practice where learning is mediated through tools and artifacts aligns with Vygotsky's (1978) thought and language as mediated by artifacts. Development of learners' cognitive processes through practice and reflection while being involved in an activity can be a way of applying abstract knowledge to a real world activity as Engeström (1999) posited. Therefore, the process of mediating learning with tools and artifacts found in the learners' lived world seem to depict structures that promotes a shared pedagogical process where the teachers and learners can lay claim to ownership of the learning process as opposed to the traditional teaching process where the teacher is seen as the island of knowledge; hence, the teacher deposits knowledge to the cognitive banks of the learners. In view of these, I employ Freire (1970)'s critical pedagogy to question dominance in the power dynamics and learning in the classroom transactions.

Critical pedagogy also tends to understand how interstitial cultures generated in the classroom interactions by the teachers and their learners; produce critical consciousness that gets enacted to overcome dominant ideologies, injustices and inequities in the classroom (Kincheloe, 2008). By bringing unconscious verbal and non-verbal actions of participants to conscious awareness, such actions become resources that structure positive emotional energy, which is salient for synchrony and solidarity (Collins, 2011). I focus on how such critical awareness helps teacher and her students' appropriate capitals and how these capitals (social, cultural and symbolic) enhanced positive emotional energy (Collins, 2004) and subsequently the point where the learners attains the point of self-efficacy (Bandura, 1977) which further develops into the formation of identities of successes in the classroom. All these are frameworks I bricolaged to contribute to knowledge production from different perspectives.

Research Methodologies

Employing multiple perspectives in qualitative research methods focuses on discovering and understanding the experiences, perspectives, and thoughts of participants (Kincheloe, 2001). In previous paragraphs, I cited that I will be bricolaging theories and methodologies (Kincheloe, 2001) in other to weave through the tapestry of this research work. Kincheloe (2001) describes a bricoleur as represented by a handyman who makes use of the available tools to complete a tack; hence, at each stage of the task, he picks the tool to use before moving to the next stage. At the end of the task, it is most likely the handy man has used multiple tools which also resonates' with the use of multiple lenses to see through at different stage of the research journey. The term Bricolage was first used by Yvonna Lincoln and Norm Denzin (2000) in the spirit of Claude Levi-Strauss (1996) in his book *The Savage Mind* (Kincheloe, 2001). Rogers (2012) writes that "bricolage research, as conceptualized by Denzin and Lincoln (1999) and further theorized by Kincheloe (2001; 2004a; 2004b; 2004c; 2004d; 2005a) and Berry (2004a; 2004b; 2006; 2011), can be considered a critical, multi-perspectival, multi-theoretical and multi-methodological approach to inquiry" (p. 1). Berry (2004a) elaborates further that this bricolage of methodologies and framework approach will enable researchers embrace multiple dimensions that might come up in the research rather than delineating the dimension. The synergy of multiple perspectives as argued by Kincheloe (2001) describes the 'how' and the 'why' of this research. In resonance with this approach, Chilisa, Major and Khudu-Petersen (2017) posits for an indigenous paradigm integrated with the western methodologies. "Indigenous and non-indigenous researchers are encouraged to adopt multi-paradigmatic research perspectives" (p. 328). Unpacking my data using multiple lenses, there are aspects of indigenous knowledge coming through. The fact that I am alluding to cultural artifacts and dealing with indigenous learners creates a flavor of indigenous knowledge.

Qualitative research. This study is qualitative, interpretive, and indigenous with a case study approach. The study is qualitative because it accentuates the qualities of entities, processes and meanings that are not experimentally determined (Denzin & Giardina, 2016); interpretive on account of the context (Creswell & Creswell, 2017) and natural settings (McMillan & Schumacher, 2010). McNiff (2010) also elaborates that qualitative research is a situated activity (place-based) that locates the observer in the world as well as emphasis on processes and meanings of entities. Denzin & Lincoln (2005) describes qualitative research as pragmatic, interpretative and grounded in the lives experiences of people. Rossman and Rallis (2003) further highlighted five hallmarks for a qualitative study as (i) followed through in a natural setting (ii) draws on multiple methods (bricolage) that respect humanity (iii) context dependent (iv) emergent and evolving (v) fundamentally interpretive. Pragmatism, participants' experience based, situated, emergent and insightful are all characteristics of this study. Tobin (2005) addressed qualitative study as a form of participative observation that tends to discover what is happening and why is it happening. The process of discovering 'what' is happening and 'why' appears to involve a depth and thick descriptions and details about human behavior, emotion, and personal characteristics which can only be provided in qualitative research as opposed to measure in numbers and quantity that quantitative research provides (Johnson & Christensen, 2008).

The situated and place-based nature of this study necessitates the thick, deep and insightful inscription and of description peoples' experiences; hence a case study approach. According to Yin (2009), the study of a case (the use of beads and beadwork (cultural artifacts) to create instructional materials as models for teaching life science concepts in the life science classroom) in a context is as important to set the case within the context. Hancock and Algozzine (2016) posited that a case study design is employed to enable an in-depth understanding of a process rather than the outcomes, in context rather than specific variable and in discovery rather than confirmation as insights from the study can directly influence practice. Case study research is particularistic, interpretive and descriptive (McMillan & Schumacher, 2010). As an interpretive bricoleur, I employed multiple perspectives to enrich the research study (Denzin & Lincoln, 2011). It enhances further exploration of a phenomenon within its context using a variety of data sources. This ensures that the issue being explored is not carried out through a lens, but multiple lenses which allows for multiple facets of the phenomenon to be revealed and understood through multiple data sources (Baxter & Jack, 2008).

The exploration of the possibilities of using beads and beadworks (cultural artifacts) to create instructional materials as models for learning of simple and complex organic compounds in the life science infuses a taste of indigeneity in the research study. Asante (2010) posits that in the ontological and epistemological space in educational research, the incorporation of Afrocentric research will advance and foster the ideals, identity, culture and values of African people. Asante (2015) also explains that the Afrocentric core of a study can enhance the re-location of the African person as a subject.

Data Gathering

Data sources influence how data is gathered and managed as information that enables me to answer my research questions (Denzin & Lincoln (2011). Merriam (2002) further states that there are three major sources of data for qualitative research namely interviews, observations and documents. For the purpose of this study, interviews and observation and documents were explored. The documents explored in this study are the cultural artifacts created by the teachers and learners, CAPS and NCS policy documents used for teaching and learning. Merriam (2002) further posits that, “the strength of documents as a data source lies with the fact that they already exist in the situation: they do not intrude upon or alter the setting in ways that the presence of the investigator might” (p. 13) However, in this case, the artifacts were created by the participants (teachers and learners) and not already existing in the situation. I examined these documents myself, observed the teachers and learners’ behavior and interviewed participants (Creswell, 2009). Focus groups and interviews of the teachers were conducted after the professional development and training seminar and the classroom lessons where the learners used beads and beadwork to teach the learners. Open ended questionnaire for teachers and learners were also used after their lesson with (CRIM). Also, Grbich (2012) posits that the process of qualitative analysis entails (1) the researchers’ views and choices; (2) the design and method used as well as the quality of data gathered and how this data was managed; and (3) the researchers display of findings and theoretical interpretation of the analyzed data. Flick (2014) defined qualitative data analysis as the process of classification and interpretation of linguistic (or visual) material to make statements about the internal, external, dimensions and structures of meaning-making process in research. To ensure my research questions were answered to provide a thick description, how data was gathered and measured became important. The accuracy of data necessitated the use of appropriate data collecting instruments such as video and audio recordings, semi structured interview questions for the teachers and learners and field notes. I also had personal interviews with teachers on their experience on creating models from beads and beadwork (cultural artifacts).

Cultural artifacts created by the teachers and the learners were also captured as documents for close observation and analysis after the classroom pedagogical practice with the teachers and learners. More than one method was used as researchers are encouraged to “use more than one method of data collection as multiple methods to enhance validity of findings" (Merriam, 2002. p. 12). The main participants in this research study are the teachers and their indigenous learners, as I was a participant observer. Each phase of the study was video and audio captured (the primary method of collecting my data), coupled with the field notes taken. The decision to engage the use of video and audio capturing instruments such as the camera stemmed from the importance of what is to be captured such as teacher and learners interactions in the classrooms. According to Griffin (2017), using the video enables the sharing in co-participants stories as well as an opportunity to reflect to enhance interpretations afterwards. Also, Chandler, Anstey and Ross (2015) opines that video data creates an opportunity to transcribe dense data to enable a thick description and in-depth interpretation. Video data also provides a platform of richness of findings which also in a way demonstrate the quality of data. This study further explores learners' emotions and feelings, gestures, body orientations and how voice is raised and lowered during classroom pedagogical dynamics. Catalani and Minkler (2010) further posits that the use of audio, video have become a recurrent method in data collection procedures as it gives room to allow even marginalized groups during classroom interaction become expressed. Although it is time consuming to carry out, it tends to allow video stimulated recall and short vignette analysis at a micro analytical level; hence, it worth been used.

The use of semi-structured interview questions and field notes afforded me alternative means to capture the experiences of co-participants (teachers and learners) as well as member checking the participants' narrative were interviewed using semi-structured interview questions individually. The teachers did not participate in the focus groups. This helped me provide detailed, coherent description and meaningful reflections of my observations. According to Merriam (2012) Observation becomes the best tool when the activity that participants are involved with entails first hand observation. Focus group discussions were held with the teachers in the professional development and training seminar. The interview of learners was held after the classroom teaching with the use of beads and beadwork (cultural artifacts) to create instructional models in the science classroom. As required, follow-up interviews was conducted with the teachers after the classes where they facilitated the learners understanding of simple and complex organic compounds. I also obtained participants' perspectives in order to provide polysemic (multiple perspectives) and polyphonic (multiple voices) of data interpretations.

By providing both emic (insider – teacher and learners) and etic (outsider – university researcher) perspectives, I made efforts to do justice to all participants and provide balanced accounts (interpretation and analysis). The video data were examined on the micro, meso and macro level to gain an adequate understanding of what happened. This was done by varying the speed where at normal speed; video clips provided meso-level interpretations of events that unfolded. At meso-level, analysis also allowed me to develop broader understandings of classroom practices and interactions between the teacher and their learners. Slowing down the video speed allowed for *micro*-level analysis and frame-by-frame interpretations of non-verbal interactions and micro-transactions such as gestures, body movements, orientations and head movements and positioning. *Macro*-level claims were made possible through analyzing varieties of data sources over a period of time and by paying close attentions to patterns of actions that persist over time across different fields and during various types of social encounters. As posited by Merriam (2012) "Data analysis is simultaneous with data collection and as such I started the process of data analysis data as soon as my first interview and observation captured. This process allowed me to make needed adjustments to further classroom observation interviews with teachers and learners.

Participants

I am a participant observer in this research study as it enables me to collect, understand and gradually examine the data from the field (Creswell, 2009) and as a participant observer; I was part of the activities as I recorded what went on. In cases where a teacher had more than a class, I simultaneously facilitated the lessons with the teachers. I created cultural artifacts (beads and beadwork) as instructional models from the knowledge of the professional bead and beadwork maker (Bridget) as she narrated in her story. I worked with selected teachers who eventually did work with learners in the classroom. I had a form of co-generative dialogue (Otulaja, 2010) with the teachers. Before working with the teachers, I, at first had a chat with the principal and subsequently the teachers (Tobin, 2006) about the possibility of using beads and beadwork (cultural artifacts) to create instructional materials as models of simple and complex organic compounds in the life science classroom. As I said earlier, methods and frameworks for the research was bricolaged. This study was carried out in three phases.

Phase 1: Creating cultural artifacts as instructional models using beads and beadwork. In phase 1 of this study, having being a life science educator previously and having drawn from the knowledge as narrated by the professional bead and beadworks maker (Bridget), I used the knowledge of beads and beadwork to develop models of biological (Life Sciences) concepts of water, carbon dioxide, fructose and glucose , lipids and protein macromolecules. Both structural forms of Glucose: linear and cyclic were created. The teachers I taught the use of beads and beadwork (cultural artifacts) to create models of simple and complex organic compound suggested that I start with the simplest form of bonding in water and carbon dioxide before moving to the more complex structures of glucose and fructose. During the professional development and training workshop, I introduced the teachers to the already created culturally related instructional models (CRIM) of simple and complex organic compounds and the materials it was made from (beads and beadwork). I subsequently allowed the teachers to create their own structures before allowing them to explore other structures they can use beads to create. I also helped to facilitate how to write lesson plans for classes where CRIM will be used to teach. I documented the process of making the models which will be found in the next chapter. The documentation process included video and audio recording of the process as well as reflective field notes. These served as part of my data.

Phase 2: Working with teachers. For the professional development and training seminar, eight science (life science, natural and physical sciences) teachers from two schools were involved.

	NS	LS	PS
EQ	I	II	I
TS	I	II	I
	2	4	2

NS represents natural science, LS represents life sciences while PS represents physical science. EQ represents a pseudonym for one of the schools while TS represents the other school. Moreover, two of the Life sciences teachers had two life sciences classrooms which they teach; hence, both the teacher and I simultaneously facilitated learners learning of the use of beads and beadworks to create instructional models of simple and complex organic compounds in the classroom. The other life sciences teachers demonstrated the teachers' create instructional models to the learners. Prior to this, I had facilitated the teachers learning of how to create instructional materials as models in the teachers' professional development seminar. The teacher's engagement was on the account of Ogunniyi (2013) posits that engaging teachers in curriculum development process not only helped them to acquire technical and practical knowledge but emancipatory knowledge or practical wisdom whereby they own the curriculum and run with it.

The teachers subsequently created their own models mimicking the models I had created. Teachers were observed and video-recorded as we discussed how they created their own models using beads and beadworks. Teachers were asked to articulate how they constructed their cultural artifact and how they intend to use what they have created. They were asked to draw up lesson plans for teaching these structures using their created models. I captured these processes with video-recordings and used clips from these videos as video-stimulated recalls (VSR) during reflective interviews of teachers. Prior to these, I observed teachers in their classrooms as they normally thought life Sciences concepts (simple and organic compounds) so as to establish a baseline for comparison of how teachers teach, what resources they used and how they use the resources prior to intervention. I documented the processes through video recordings as we talked through the processes. I collected reflective field notes and collect reflective journals notes from the teachers.

Phase 3: Classroom teaching using models made from beads. After consents were obtained from the school principals, the school district, the provincial Department of Education, I proceeded to the classroom with the participating teacher. The participating teacher on my behalf spoke with the learners informally before the classroom and further informed the learners when the time for life sciences lesson was due (Tobin, 2005). Tobin (2005) further posited that informal talks usually take the form of conversations and can occur as lesson unfolds. Generally, each participating teacher's classroom was observed as the instructional models were created to teach simple and complex organic compounds. The learners were introduced to the use of beads and beadwork to create abstract concepts of simple and complex organic compounds. The teachers followed their lesson plan in teaching them. As the lesson went on, the pictures of the models they were to create was placed on the chalkboard or in some cases drawn on a big paper which was subsequently pasted on the front side of the classroom. The learners were subsequently given materials (beads and Bostic glue) in groups as the teacher facilitated the teaching of simple and complex organic compounds. The teacher did the teaching while I was a participant observer. The observation was captured on video and later transcribed for data analysis. Participating learners' experiences were solicited by personal interviews using semi-structured questions developed for the study and after watching the video stimulating recall (VSR) clips. Selected groups of learners were also interviewed following the lessons and these interviews were audio-recorded. The teachers showed the learners how to make selected models with beads and beadwork (cultural artifacts) as I also participated in enabling the learners' learning and understanding where the need be.

The names of three teachers were anonymous in this study. They indicated not to have their names published. Only one teacher (Mr. Brighton indicated that his name may be published. Again, teachers participated in the professional development and training seminar and only after the teaching in the classroom were they involved in focus groups interviews to elucidate what their experience was during the use of beads and beadwork to teach in the science classroom.

Ethics of the Study

The research study presented in this dissertation was approved by the ethics committee of the University, as required before researchers go out to the field. This study was also approved by the Gauteng Department of Education. It is in compliance with the provisions in the tenets of the Belmont Report (1979) in terms of 1) *respects for persons - individual participants in this research study were* treated as autonomous decision makers capable of articulating independent goals. There was nobody who was not capable of making decisions themselves as the co-participants were teachers and grade 10 learners. 2) *beneficence*– the benefits accruing to participating outweighed the harm; and 3) *justice*–distribution of benefits and harms across all participants was fair and just. All consent of parents and assent of learners (minors) forms was filled and collected as a way of instructional improvement to the research. The participants were chosen because of their school grade hence, the learners' ability to participate and contribute. I ensured that participants did not feel uncomfortable or pressured to participate in the study. They had the choice to withdraw from the research at any time without any prejudice or penalty against them in any way. Their participation was voluntary and was not mandatory to any fellow. Participants consented to their images and voice being recorded. I also employed the use of pseudonyms in place of the real names of co-participants or the name of their school which makes the co-participants anonymous and therefore secures the co-participants names and place.

Summary of Chapters

Chapter One comprises a reflection of my past experiences and epic moments on mu unconscious use of cultural artifacts to enhance learning in the science classroom and how it has shaped up my epistemological and pedagogical practice. It has also propelled the will to unpack the possibilities of using beads and beadwork (cultural artifacts) in this study. I also described the frameworks I used in carrying out this study while I subsequently stated my research questions were modified as the research study progresses as well as how data was collected and analyzed was also explained in the chapter.

In Chapter Two, I discussed the many views of scholars and their scholarly works. The debatable views from different perspectives and paradigms were not exempted in my discussion while a bit on history of science nature, indigenous knowledge, culturally responsive learning as well as cultural tools was discoursed. I compared views from the Euro-centric fronts with those of the Afro-centric and arrived at a third space (Bhabha, 1998) where the integration of both methodologies can be employed to enhance the learning processes of the indigenous learners. Further discussed are the possibilities of employing culturally related instructional models created from beads and beadwork to teach simple and complex organic compounds in the life sciences classroom.

In Chapter Three, I discussed the knowledge of beads and beadworks (cultural artifacts) as narrated by the professional bead maker, how the knowledge was applied to create models of simple and complex organic structures for instructional models for learning in the classroom as well as the models as created by the teachers.

While Chapter Four, I described the understanding of data findings as captured in themes from the traditional teaching-centered classroom and the learner-centered classroom where beads and beadworks (cultural artifacts) were used to created instructional models used to learn simple and complex organic compounds. I elaborated on how the data descriptions elaborates the research questions in chapter one. This chapter also describes the epic moments in each of the classes of the four teachers as captured in the study as well as the interactions of the learners.

In Chapter Five, more detailed comparative experiences of the learners in the traditional-teacher centered classroom and the classroom where the use of culturally related instructional models created from beads and beadwork (cultural artifacts) to teach simple and complex organic compounds was explored as evident in the classroom teaching. Constructs from the two classrooms were compared and contrasted to further interpret the findings of the study. The captured themes are also elaborated further to describe what the use of cultural tools had enabled the learners to express with beads and beadwork.

Chapter Six, showcases the learners' practice in the classroom theoretically. These theories were weaved together to elucidate through the framework, meaningful frames to further interpret the findings and illuminate the affordances the use of cultural artifacts in learners learning of life sciences in the classroom with the use of beads and beadworks (cultural artifacts).

Chapter Seven presents an overview of the study as well as recommendations, areas of future study and conclusions.

Summary of the Chapter

Owing to the defining moments that characterized my childhood learning curve and the activities my learners were enabled to undertake which signaled a change in my learners' ontological and epistemological perspectives towards life sciences, the use of placed-based (cultural artifacts) for teaching and learning seem to act as an enabler in the teaching and learning processes. These defining moments seems to have enabled my momentum into undertaking this study. To unpack the details in co-participants experiences on the possibilities of creating models from cultural artifacts (place based) requires an in-depth and thick description of data unearthed; hence, the bricolage of theoretical frameworks, methods of collecting data, different perspectives through with data collected was organized and interpreted.

Chapter Two

Literature Review

Introduction

In Chapter One, I reflected on holistic learning experiences that was generated and characterized by use of cultural artifacts (place-based) in achieving more meaningful learning experiences of indigenous learners. The chapter also incorporated frameworks alluded to in carrying out the study on the possibilities of using beads and beadwork (cultural artifacts) as instructional models in the teaching and learning of life sciences concepts. The study contributes to how culturally-related instructional models (CRIM) created from bead and beadwork (cultural artifacts) can be used to teach simple and complex organic compounds. Likewise, the study provides insights into learners' affordances as enabled by CRIM in life sciences classrooms. Also, in this study I explored how cultural artifacts in the learners' lived-world can be integrated with westernized science knowledge in school teaching. This chapter provides a detailed review of studies conducted over the years on indigenous knowledge, westernized knowledge, and integration of both knowledge bodies as well as aspects related to the culture of the learners such as culturally relevant pedagogies (Ladson-Billings, 1998). The chapter also reviewed recent studies on learners' interaction in the science classroom and the teaching and learning of sciences with the use of culturally related materials as models for instructional purposes in the life sciences classroom.

Ogunniyi and Rollnick (2015) opined that there is actually nothing wrong in alluding to indigenous knowledge (place-based) when teaching westernized science (WS) to the indigenous learners to understand sciences better. These authors posited that this allusion provides a rationale for probing into a systematic review of past studies involving indigenous and westernized knowledge. Past studies into what indigenous knowledge (IK) can be integrated with westernized science (WS) in the indigenous learners' science classroom; and how IK can be integrated provides me with opportunities to explore and ascertain the possibilities of using beads and beadwork (cultural artifacts) to create instructional models for teaching and learning of simple and complex organic molecules. As I beam my research light into recent past studies, a better understanding of these possibilities (what, when and how to use beads and beadworks (cultural artifacts)) to create instructional models for teaching and learning of simple and complex organic compounds can be ascertained. In placing my study in the context of existing literature and relating my study with the larger body of literature (Creswell, 1994), I tend to describe the relationship of each researchers' work to the others in the same context and research domain. I also described the relationships of the theories I utilized in the study to weave (bricolage) the theories together to create a tapestry in establishing the importance of the study. The core of this study elaborates the integration of CRIM and aspect of indigenous knowledge in learning simple and complex organic compounds (westernized science). Unconsciously, there are learning moments, which I described in Chapter One that are depicted in this approach.

Indigenous Knowledge as Place-based

This approach became more meaningful as the materials used for enhancing learning were actually place-based and indigenous to the learners. In Bridget's lived-world, the materials used for learning the skills she became embodied with was also place-based and indigenous. The sum of different skill acquisitions and accumulation of different learning moments during an individuals' childhood becomes embodied in the growing individual. This Bourdieu called habitus (Bourdieu, 1997, 2006). Hence, this accumulation of skills overtime enabled teachers and learners to understand science concepts better at different learning moments. There were also collaboration and interactions in the learning context such as at the home schooling I had as well as in my relational pedagogical approach when I taught high school life sciences learners and as I experienced in this study. It was a sort of communal practice that provided a context to enable interactions both individually and collectively.

In Bridget's learning moments (Chapter four), she formed a close relationship with her maternal grandmother; she also learnt her beading skills from her maternal grandmother all along till she became a professional bead maker. In the four teachers' classes with the use of beads and beadworks (cultural artifacts), the learners' understanding of organic compounds was enhanced by collaborations and interactions in groups, which is an indigenous philosophy (communalism).

The learners learned in a context enabled by collaboration and interaction as learning became a sort of mentor-mentee, master-apprentice, and learning. Learning in groups, as demonstrated in the classes of the four teachers in this study, as described in Chapter Four, or from a mentor/mentee relationship, as that in Bridget's case, highlighted place-based learning that should be integrated into learn westernized science.

Indigenous knowledge definitions. Emeagwali and Dei (2014) defines Indigenous Knowledge as "the cumulative body of strategies, practices, techniques, tools, intellectual resources, explanations, beliefs, and values accumulated over time in a particular locality, without the interference and impositions of external hegemonic forces" (p. 1). This knowledge is as a result of accumulated experiences (experiences from beadworks creations) of a people with their natural environment (place-based) that has been handed down from one generation to the next (Bridget's granny to Bridget) according to Odora-Hoppers (2002). A similar term I use interchangeably is indigenous and/or place-based. The term indigenous knowledge has, over the years, enjoyed different definitions and conceptualizations (Mawere, 2012, 2014; Mapara, 2009; Shizha, 2013). My reflection on the term indigenous reveals it was synonymous to uncivility or an uncivilized way of life. Another synonym was 'being primitive, naïve and unscientific'. This was perhaps because I was previously schooled in a context that acknowledged westernized science as the only valid knowledge while indigenous knowledge was seen as not valid to enable an individual's overall development.

By overall development, I mean, an individual's educational, symbolic, image of successful development. I grew up to think that if an individual speaks English fluently, the individual represents a well-cultured civilized citizen. As Memmi (2013) posited, the colonized tends to take after the colonizers. The Africans tends to take after the colonizers. In this case, anyone not able to speak the language of the colonizers is considered, local, rural and uncivilized. Being local here depicts an individual whose hopes at being considered successful in a carrier seems slim. In my high school, I was scolded when I spoke in my native language and was prohibited from also speaking it. The school had a rule that prohibits the speaking of local language called vernacular. Every language apart from English was labelled "vernacular".

Since it was a rule in the school that defaulters were punished. Years after, I became aware that, what was labelled "vernacular" was indeed my language and indigenous to me while English (the language of the colonizer) was another local people's language. According to Emeagwali and Dei (2014), the English ways of life became hegemonic to my local knowledge of living. My practices, techniques, tools, intellectual resources, explanations, beliefs, and values accumulated over time (my indigenous knowledge, according to Emeagwali and Dei (2014)) all became subdued and all I wanted was to imitate western lived-world. The materials, languages, lived-world during my childhood became an embodiment and became my knowledge about life. Grolink (2005) synonymously called it "local knowledge and said it is the knowledge belonging to a specific community or local group and that which has enabled the people in a given community to develop over time, and still continue to develop. Further explanations by Grolink (2005) said it is based on the experience, and tested over the years, adapted to local culture and environment and as their basis for natural resource management.

Indigenous knowledge is dynamic and a non-conventional body of knowledge dealing with theory, beliefs, practices and technologies developed without direct inputs from the modern, formal, scientific establishment, and towards the management of farms (Chambers, 1989). Some call it "traditional knowledge" while others describe it as "indigenous traditional knowledge," or "indigenous technical knowledge". It could also be called "traditional environmental knowledge" or "rural knowledge" which is similar to my then notion of indigenous knowledge. Some other people call it "traditional ecological knowledge" (Nakashima & Roué, 2002). Whichever names they are being called, these terms have similar meanings- the language local of the people. However, in a context specific line of thought, it could appear to be a sense of belonging, naturally to a place. Orlove, Roncoli, Kabugo, and Majugu (2009) define indigenous knowledge as place-based knowledge that is rooted in local cultures. Throughout the study, I will be referring to beads and beadworks (cultural artifacts) as place-based knowledge. Most writers favor the use of the term indigenous knowledge. I am one of its suitors. I became aware of the word indigenous and had to consolidate my educational knowledge as an indigenous knowledge learner. In studying more about indigenous knowledge (IK), I found out that almost every nation or country is inhabited by indigenous people, and they have their own indigenous knowledge. Countries such as the United States, Canada, New Zealand, Australia and most countries one can think of.

Haverkort and De Zeeuw (1992) defined indigenous knowledge (IK) as an actual knowledge of a given population that reflects the experiences based on traditions. What is clear is they hold on to the knowledge of their experience as they live it (indigenous knowledge (IK)). Learners' thoughts/understandings, whether right or wrong, can be reflected in their creation of simple and complex organic compounds as instructional models from beads and beadworks (cultural artifacts). Indigenous knowledge consists of the knowledge of a community, society or people, who evolved over time as people in that community have adapted to an ecosystem. The knowledge includes technological (agriculture, engineering, medicine) mathematical and social knowledge (Onwu & Mosimege, 2004). The knowledge of patterning, designing, numbering, grouping, color, are inherent in the knowledge of beads and beadwork which is also inherent in the community, society or people.

The notion of indigenous knowledge is defined in literature as the sum of all knowledge and skill that individuals in a particular area harnesses and possesses and also enable them obtain the most out of their environment (Odora-Hoppers, 2005; Maxwell & Chahine, (2013). Bridget had over the years accumulated skills such as crocheting, weaving, designing, from her maternal granny and which is harnessed into the beading skills. These aforementioned skill are environmental or place-based. In the teachers classroom, the learners had prior knowledge which is also place-based that provided a repertoire of knowledge to be expanded to accommodate the new ideas. In essence, the knowledge of bead and beadwork (old) practices in the learners' repertoire of knowledge links with the new knowledge (the use of beads and beadworks to create simple and complex organic compounds) to enhance the learners' meaning. My High school leaners brought materials which were used to create instructional models of some life science concepts from materials found in their environment. According to Semali and Kincheloe (1999), Indigenous Knowledge System (IKS) can generally be used to differentiate between local knowledge from western knowledge. It can be a term for comparison.

Odora-Hoppers (2000) contends that indigenous knowledge systems is characterized by its embeddedness in the cultural web and history of a people including their civilization, and forms the backbone of the social, economic, scientific and technological identity fabric of such a people in reference to the findings in chapter five and chapter six, the fabric of identity formed by the learners involved in this study was formed from learners successful in the use of beads and beadwork (indigenous knowledge) to create instructional artifacts in the science classroom. The process of successful identity formation is not confined to tribal groups or the original inhabitants of an area. It is dependent on the success in the use of indigenous knowledge positioned in any community and the ability to use this knowledge to solve the surrounding challenges (Grolink, 2005; Snively & Corsiglia, 2001).

In another view, Fernandez (1994) defined indigenous knowledge as greatly affected by social stratification. How? Women have much more knowledge of soil classification for cultivation, because they are the ones that go to farm in the old days to cultivate for hut construction and pottery, while men have more knowledge on livestock management as determined by their social roles. The communities have social roles for individuals, which if they are successful in their endeavors is assumed the individual is a complete man or woman; by "complete", they are looked at as superhumans. Odora-Hoppers (2000) asserts that Indigenous knowledge is predominantly tacit, embedded in the practices and experiences of its holder. It is commonly exchanged through personal communication and demonstrations from the teacher to the apprentice, from parents to children, from neighbor to neighbor. The more reason why interaction among learners is necessary for learning. Kalumuna (2000) defines indigenous knowledge system (IKS) as the knowledge system possessed by people of ethnicity and used by such people in the organization of their livelihoods. An overview of these definitions depicts IKS as people's way of life.

In essence, indigenous knowledge has been defined based on comparison, locality of knowledge, social roles, the dynamic nature, tacitness, environmentally inclined and experiences. In resonance with Chilisa (2012) position on the determining factors of indigenous knowledge, she posited that the local phenomenon, context, and paradigm determines what counts as indigenous knowledge (IK). Thus, the local phenomenon (beads and beadworks creation), found in the learners lived world with the indigenous way of knowing determines what counts as indigenous knowledge (IK). As Bridget narrated in Chapter Three, her knowledge of beads and beadwork was passed on from her maternal grandmother, which depicts the nature of IKS, intergenerational dissemination. The learners (co-participants) in this study demonstrated, embodied local knowledge (cultural knowledge of bead and beadworks) in using beads and beadwork (cultural artifacts) to create instructional model to enhance their own learnings. The learners' knowledge (cultural knowledge of bead and beadwork) became a stock of indigenous knowledge, which they could allude to while learning in the science classroom.

Stock of indigenous knowledge. Indigenous Knowledge is disseminated and preserved through various family histories, taboos, symbols, myths/legends, rituals, sounds/dances, festivals, proverbs, poetry, literature, songs, beads, food, nature, taste, dresses and other cultural artifacts. All these form stock of indigenous knowledge (SOIK). Indigenous knowledge (IK) is also disseminated through practices as legitimized by the community that lay claim to the knowledge. All these emphasizes the nature of indigenous knowledge systems as specific, local, dynamic, deals with beliefs, based on experience, tacit, embedded in practice and disseminated through different forms of artifacts. This is how indigenous knowledge (IK) looks if we decide to personify it. People living with this knowledge are called indigenous people. Learners with this view to life can be called indigenous learners likewise the teachers embodied with this knowledge can be called indigenous teachers. Every knowledge is local to the people who own it. This means it is owned by a person or group of persons living in a specific place over time. Despite the rich cultural heritage we have as Africans, I was taught to see my indigenous upbringing as less civilized, therefore playing second fiddle to the western knowledge being taught in the classroom. Understanding the value of the indigenous knowledge (IK), what it used to be in the past, its role in the lived-world of individuals in the present and the future may be important at this time of integration with western science. Again, Understanding what value indigenous knowledge has earned in the past will enable me to project further the increased value of IK in the present (use of beads and beadwork (cultural artifacts) for the creation of instructional models of simple and complex organic compounds for teaching and learning in the science classroom.

Education Rewind in Africa

In making sense of how indigenous knowledge has evolved from the past, I begin from the western invasion into African continent. Prior to the invasion of the African continent by the west, and the imposition of the Eurocentric educational system, African nations had their own knowledge system (Pewewardy, 2002) African nations had their own practices and principles that they upheld as structures with rules and resources? Over the years I was taught that the western nations brought education and civilization to Africa. Were Africans without knowledge or not civilized? Or how did Africans live in the centuries before now? If there were no universities, were there also no institutions that were instrumental in building knowledge? Africans had institutions that were pillars of the society. Examples of such African institutions are chieftaincy, secret societies, shrines, banking, trading, communication, music (Kaya & Kale, 2016). These examples show that Africans had, before the advent of the colonizers, had, their own lived-world. Hence, the belief I had, that African indigenous knowledge is an inferior knowledge or a less civilized knowledge than the western knowledge seems far from the reality. Furthermore, the advent of civilization in ancient Egypt and way back 3000 years BC seem to ascertain that civilization in Africa began way back 3000 years BC. Years before any western colonizer hegemonized African civility.

The Egyptian colony had its architectures and educational system which seem to be the highlight of civilization. The Egyptian educational system established two formal education systems (one for the scribes and the other for the priest) (Zulu, 2018). According to Zulu (2006), the ancient Nubia in the east, the Great Zimbabwe in the South and the University of Sankore in the west are all ancient institutions, which upheld the African continent. Notwithstanding, the ancient and modern notables such as the Pesechet (an ancient Egyptian female physician of the middle kingdom), Mansa Kaka Musa (the great emperor of the ancient Mali) who among other activities, built the University of Sankore at Timbuktu in the early fifteen centuries which depicts that Africa's civilization had been much more earlier than the time the Europeans came to Africa Zulu (2006) criticizes contemporary survey on Education and development in Africa (EDA) which opines that "before the introduction of western style schooling the only formal schooling received by millions of people in Africa was the Islamic system". According to Zulu (2006), this statement is quite untrue as there are overwhelming evidence to suggest civilization started in Egypt and other selected regions of Africa.

As I said earlier, these African institutions were all before the adventurous coming of the colonial masters. I called the movement of the westerners adventurous because, to me, it appears that the Europeans were explorers who wanted to discover "life at the other end of the sea". Perhaps, on getting to the African shore, the Europeans discovered that Africans are accommodating; hence, they had the opportunity to first come in, get accustoms and thereafter claim our epistemologies and ontologies. Enquires into how the western colonizers penetrated into various African countries, every African country has her own history. For example in

Nigeria, during my undergraduate and post-graduate days, I learned that in the history of Education (a compulsory course during my undergraduate days) that the West brought civilization through the adoption of education in Nigeria. They (west) also came with the Christian religion through the Badagry-Abeokuta route (in Nigeria). As a Nigerian, I am aware that, before the advent of Christianity in Nigeria, there has been other means by which Nigerians communicated with God. This is the similar to other African countries. There was the emperor of the ancient Mali (Another African Country). As I said earlier, one of the ancient African countries is Egypt. It had existed even during the times of Jesus Christ as evident in the Holy Bible. Egypt already had structures to disseminate knowledge, communication systems, judicial systems, marriage systems, technology and other systems. Civilization would have spread to Nigeria before the westerners brought westernized education to Nigeria. According to Oyelekan and Omiwale (2017),

> "Nigeria gained independence from the British colonialist on October 1, 1960. Prior to this date, western education had been introduced into the country through missionary activities. Missionary activities in Nigeria dated back to the later part of the 15th century when the Portuguese, in search of commerce, arrived in Lagos and Benin" (p. 45).

The excerpt shows that prior to the coming of the Portuguese and the British, Nigerians had their form of education; hence these colonialists were attracted to the people's commerce majorly and wanted to acquire them (Zulu, 2018); hence they camouflaged as coming for the purpose to introduce a new approach to education (western education). We as Africans had our own way of life since the inception of the continent. Whichever route education came through, African had their way of life. We had our own knowledge of living. When I say living I mean, means of livelihood: cooking, child delivery, carpentry, trade, security, bank and religion. Indigenous knowledge, I posit as a vital part of life to indigenous peoples because it a form of knowledge that has empowered its citizens. It is also a type of knowledge that is been discovered every day in view to solving our numerous challenges. Another categorized knowledge is the westernized science which also has its nature and characteristics that describe its processes. South Africa is not left out of the African countries in the colonization process. In South Africa's case, it is not just colonization but also apartheid (Morrow, 2007). Colonization of values of indigenous knowledge is apparent, and the effect is still evident in all fabrics of the South African society.

Most African societies have since struggled to recover as Edem Kodjo in his book ‘*Africa Tomorrow’* described the African continent as ‘torn from the past’.

In essence, the present African continent is torn from the ‘past African continent’ as a result of the hegemonic role (Memmi, 2013) of the western knowledge on the indigenous knowledge. The past represents the indigenous knowledge being valued and it been comprised of the African continents’ lived-world. This past became dominated by the western knowledge leading to the present where the westernized knowledge seems to be vetoed as the only valued knowledge. The loss of value, identity, way of life, of the African peoples’ indigenous knowledge seems to have activated the push for inclusion and recognition of African peoples’ way of life (African knowledge system). Rollnick (2017) argued that “the dawn of new hope was precipitated by a national revolt of thousands of students, mostly recognized by the 1976 Soweto uprisings caused by dissatisfaction with their educational provision” (p. 27). This statement appears to suggest the discontentment and frustration at the western educational provision as supposed to the way of learning they were accustomed to. Similarly, the agitation for integration of western and indigenous knowledge (Aikenhead, 2011; Ogunniyi (2017), was necessitated by the continued hegemonic role of westernized science on indigenous science in the science classroom (Aikenhead, 2001).

Aikenhead and Ogawa (2007) argue that westernized science established a monoculture in many indigenous communities that threatened indigenous knowledge cultures, structures and environment largely. In addition, they posited that because it represented the colonizer’s legacy, it threatened the indigenous people’s identity, practices and culture, which upon heightened consciousness resulted in the questioning of the westernized science hegemonic role which has appeared to reduce the potent epistemologies in the indigenous communities. The integration of westernized and indigenous science strengthens the possibilities of using beads and beadwork (cultural artifacts) to create instructional models of simple and complex organic molecules for teaching and learning in the science classroom. The integration of these two knowledge paradigms (westernized and indigenous science) may necessitate the probe into the nature of both westernized and indigenous science.

The Nature of Westernized Science

The nature of westernized science (NoWS) is a term that could be used to describe an individual's understanding, conceptions, perceptions, images, ideas, views and values about the westernized science enterprise (laws, theories, principles, models, facts and explanations) making up the body of knowledge called science (Lederman, 1992; Abd-El-Khalick & Lederman, 2000; Schwartz, Lederman & Lederman, 2008). In literary form, nature of science (NoS) could also mean "how does science looks". Lederman (1992 p. 331), whose definition has been widely used both nationally and internationally, describes nature of science (NoS) as the epistemology of science, science ways of knowing or the values and beliefs inherent in the development of scientific knowledge. Meichtry (1999) explained the term nature of science (NoS) as the ideas of science as understood by an individual about the products of science. It is also predictable using natural principles. As there is Eurocentric science, there is also indigenous science, neo-indigenous science and personal science that learners bring to the classroom as preconceptions (Aikenhead, 2006). As I enumerated earlier, both knowledge (westernized and indigenous) systems are of different epistemological and ontological perspectives (Cobern & Aikenhead, 1998) but they still have a common ground. Vhurumuku (2004) says nature of science is the individual's psychological and socially mediated understandings, beliefs, values, assumptions, views, images and perceptions of products and processes of science. Scientific knowledge is by its nature abstract and theoretical and it often contradicts 'common sense' (Wolpert, 1993). It is also didactic in teaching methods, which results in short-term recall (memorization). Ogawa (1995) defined science from the pluralistic view as rational and an empirically-based way of describing or explaining nature. Various perspectives hold different views to scientific method.

As a paradigm, the positivists hold the view that the scientific method is the only way to establish an objective reality and the singular basis for true knowledge (Chilisa, 2012). According to Denzin and Lincoln (1994), paradigms could be discussed based on the nature of their ontologies, epistemologies and methodologies. Hence, the positivists convey the ontology of a realist, the epistemology of an objectivist, and methodology that posits controlled experiments (Creswell, 2009). The real phenomenon according to the positivist answers the question, 'is it real'? The post-positivist embodies the ontology of a critical realist which

Creswell (2009) posits that their realist view of phenomenon is critical. Although reality is objective, but it is not conscious to human while the epistemological goal is objectivity and the objectivity in a phenomenon is questionable. Based on methodology, the post-positivists approach is both quantitative and qualitative. Other paradigms are (i) critical theorists (ii) constructivist (iii) pragmatists (iv) participatory (Creswell, 2009). More specifically, this study is in resonance with the constructivist paradigm. I agree that children learn by doing and by actively exploring; hence, learners must actively discover and transform complex information (Piaget, 1971). To the constructivist, new knowledge is processed by constructing, storing and retrieving information. The teacher becomes the guide and facilitator, helping the learner to discover new information. It is cooperative, discovery in approach while the learner scaffolds and self regulates (Dewey, 1938). Constructivism also supports the interaction between adults or a more advanced learner to make sense of a phenomenon - mediated learning. In a context where African indigenous learners and cultural artifacts are the focus, an Afrocentric paradigm will not be far-fetched. According to (Mkabela, 2005), the Afrocentric paradigm is rooted and centered in the African culture. It is also the umbrella for indigenous knowledge.

The Nature of Indigenous Science Knowledge

Indigenous knowledge is holistic in nature (Goduka, 2005). It also embodies the philosophy of oneness as the learning process associated with indigenous peoples is framed around relationships and interactions among humans. Indigenous peoples co-share, co-habit, co-creates in their learning process (Adeyemi & Adeyinka, 2003). According to Barnhardt and Kawagley (2005), indigenous people learn through experience, modeling, ritual and storytelling. Indigenous knowledge is tested in practical scenarios rather than in only examinations as evident in the methods of assessment in western paradigms. Furthermore, according to Barnhardt and Kawagley (2005), indigenous knowledge is sacred, spiritual and stored in cultural practices. According to Warren and Rajasekaran (1993), indigenous knowledge is cheap and socially desirable while it provides a productive context for activities that will benefit the community. As a paradigm, indigenous knowledge (IK) is local, context-sensitive, and integrative and, as such, results in locally relevant constructs (Chilisa, 2012).

Why the Need for Integration?

According to Barnhardt (2013), indigenous people have traditionally acquired their knowledge through direct experience in the natural world. It is also apparent that westernized science is more often presented in abstract form. Therefore, there is the need to inculcate direct experience (indigenous) with the abstract nature of westernized science to bring to the learners such learning experiences that becomes more meaningful to the indigenous learners. Further evident is the holistic nature of indigenous knowledge, which can be aligned with the individualistic nature of western science to form a sort of "particulars (individuals) to be understood in relation to the whole" Heidegger, M. (1995, p. 439). This appears to be a complementary terrain for each other (indigenous-holistic and western-individualistic) as evidenced in the research work of (Gay, 2002). On account of an absence of hegemonic epistemology over the other (westernized science over indigenous science), the hybrid can evolve to become more valued as it would have representations in both western and indigenous epistemologies and ontologies. Ogunniyi and Mushayikwa (2015) are of the opinion that there is nothing wrong in the integration of both knowledge bodies.

Another need for integration is the 'common grounds' between both epistemologies. Common grounds to the western and indigenous knowledge are embedded in their organizing principles and knowledge. These common grounds are (i) pattern recognition (ii) verification through repetition (iii) making inference and prediction (iv) a belief that the universe is unified (v) having a stable body of knowledge but subject to modification (Le Grange, 2004). These epistemologies (western and indigenous), I suppose would, without doubt, evolve into a strengthened form (complementing each other) more enabling to the indigenous peoples' lived-world. This, Bhabha (1994, 1996) notion of the third space or hybridity holds for reasons regarding "the colonized and the colonizer" where the colonizer attempts to translate the identity of the colonized. Creating a complementary process, which allows the integration of both indigenous and western methodologies, could evolve into a sense of bricolaging epistemologies and having a beautiful epistemological edifice. Attaining this hybridity of knowledge can be empowering, particularly in form of capital exchange between peers in the classroom. It also seems to be able to enhance science learning in the classroom.

Their differences (western and indigenous science) can perhaps be challenging in form of discordant worldviews. It seems to create an incompatibility. On the one hand, learners' self-identities (e.g. who they are, where they have been, where they are going, and who they want to become); and, on the other hand, learners' views of [Eurocentric] science, school science, or their science teacher, and learners' views of the kind of person they think they must become in order to engage in science (Aikenhead 2006, pp. 107-108) are needed to be explored. Learners already have an identity of who they are, where they have been (their being), where they are going and then, what they see themselves becoming but misalignment in paradigms seems to leave the learners confused. This happens when the westernized science as taught in indigenous schools seems to result in mis-alignment in self and cultural identities of learners. Having the abstract nature represented by instructional models created from artifacts and aided with the knowledge of indigenous science appears to better position the teachers' pedagogical practice to enhance the seemingly difficult concepts for the learners. It also provide an opportunity to cognitize cultural artifacts. Joe Kincheloe (2002) argued the importance of identifying ideologies that structure life in school. Ideologies do not exist as a named entity. They operate as structuring schema which seems to relate dialectically to the practices they afford. Can schemas and practices that resonate with the nature of indigenous learners' ways of knowing be contextualized for learners learning? The contextualization of what and how indigenous learners learn can be enabled by the use of cultural artifacts such as beads and beadwork for the teaching and learning of simple and complex organic compounds. Hence, learners learn through an approach that not only contextualizes their learning but integrates ideologies to enable learners learn effectively. Lack of these perspectives to education has contributed to African learners present being "torn from the past" as posited by Edem Kodjo's words in the book *Africa Tomorrow* (1987).

Education as a Discourse

Education is a tool for empowerment as posited by educational scholars (ex. Gagner, 1984; Piaget, 1952). It enhances learners' being (Dewey, 1938) that comprises who they are and who they become. It is a process in which the learners can build information structures with their minds (Sebeok, 1988). Masote (2017) also has the view that education is a process of transmitting skills and values for the enhancement of the society as a whole. In this sense, spaces for cognitive development (schools) are organs through which societal values are passed on to the individual, the next generation. This transfer of societal norms can be attained through a process of socialization, which involves the classrooms interaction between the teacher and the learners, between learners and the content of learning. The socialization process can also include the learners and the instructional models as well as the classroom environment generated. Education, as evident in the capitalist views, can be a tool to place individuals in different social classes. Louis Althusser (1971), a Marxist, argued that the main role of education in a capitalist society was the reproduction of an efficient and obedient workforce but stratified and regimented.

Different perspectives. The capitalist, through the schools, enabled competition as a method of assessment. In essence, by trying to out-perform an individual, the individual who appears the best will be rewarded. The capitalist method of transmission of knowledge enables those workers in the work force to be trained to be submissive to the authority. This idea of being submissive was instilled in the individual from the elementary school. The ideologies been passed on to the next generation through the schools; I suppose to prepare individuals for the functioning of the capitalist society. Bowles and Gintis (1976) argue that rewards in education are based not on ability but on social background as the capitalist has structured it. In addition, the higher a person's class or origin, the more likely they are to attain top qualification and a top job in the capitalist idea. This is in line with the thoughts of Bourdieu (1967) in articulating the capital theory and Bernstein (1971) in discussing language and class. This seems as a fragmented knowledge that is disconnected from the students' lives (Bowles & Gintis, 2001). However, in the real sense, according to Bowles and Gintis (2001), education should be integrative, egalitarian and developmental. By integration, they (Bowles & Gintis, 2001) seem to mean that education should muster an individual for roles in the society by accumulating in the individuals the skills needed to negotiate their lived-world. They further argued that by egalitarian, they mean equally enhancing individuals to excel. Providing the same context and opportunities; hence, education may reduce the inequality between the rich and the poor and perhaps the ones with more capital to the ones with less capital. While the developmental function of education can means providing the individual with a context to explore their potential and content in a way that enhances interest also enhancing the in achieving an individual molded to function in the society.

Other perspectives to education can be seen evident in different ideologies. According to the Marxist, education divides the society into distinct social classes-bosses and workers in another words an instrument of the ruling class. This is a direct opposite of the socialist view of the society of equals. Education for them aims at developing a society where all are in the same class. The functionalist is of the opinion that Education provides the society with division of labor (Haralambos, Holborn, & Herald, 2008). Education prepares people for their specific roles in the society. The feminist argues Education has helped and enhanced male dominance in the society. They believe the society is male dominated. They believe it accounts for the supposed male domination in the family setting as well as the society at large. Maya Angelou - an important figure in the American civil rights movement once quoted “segregation shaped me, Education liberated me”. For her, Education was a liberating agent. Her history as a black American speaks volume of the story of how slaves were brought to America which has not gone down well in the history books. The effects of slavery thereafter is still been felt in the society till today as well as the push for equal treatment in the hands of the authorities. Education did the liberation, gave her the knowledge to liberate herself and her generations not yet born. In her process of her liberation, education became an enabling tool; an acquired capital towards liberation. Apparently, the education in her past, and the type of education received during slavery, and in other cases, during colonization and apartheid would differ.

The type of Education needed for liberation would also differ from the past, the ones during slavery and the present. Education ideologies advocated for to perhaps heal the ‘wounds’ of these different times would be different. A Yoruba (a large tribe in the western part of Nigeria) adage says “Oju apa, ko le jo oju ara”. Translations in English means, the scars (healed spots of these wounds) cannot look the same way as the original skin looks if no wounds have occurred, at all, at the spot. In other words, the scars caused by the times during slavery, colonization and apartheid cannot be totally healed. Because the experience and stories passed from generation to another would be different from the experience that would have been if these happenings had not surfaced. In relation to education, if the sole indigenous knowledge systems we had as Africans before it was subdued and undervalued cannot be achieved, then the integration of indigenous knowledge with western knowledge can be achieved. The apparent gap between the past (before slavery, colonization and apartheid) and the present (after the effects of slavery, colonization and apartheid) constitutes the 'torn part of the past can be gradually mended educationally by integration of both ideologies. Hence, the use of beads and beadwork (cultural artifacts) to create instructional models of simple and complex organic structures for teaching and learning in the science classroom can help enable a learning context where learners can learn better.

In a society whose educational ideologies seems "torn from the past", mustering an individual to take up a role in the society could be enabled by the integration of western knowledge with the learners' lived-world. The scenario seems to look like an individual, whose learning process and approach to learning was indigenous from the onset. Thereafter, subdued by external influences to education, and then on account of conscientization and the awareness to minimize the western knowledge hegemony, has to allow the integration of indigenous knowledge to western knowledge. The external influences are the colonizers, capitalist and other approaches different from those of an indigenous learner. In South Africa, education has evolved over the years from the colonials to the apartheids and then to this moment of heightened consciousness what had become evidenced by the various calls for integration of western and indigenous knowledge. In South Africa, Education was at a time used as a limiting tool by the apartheid government. In Morrow (2007) argues on the intensive use of education for segregation.

> I just want to remind the Honourable Members of Parliament that if the native in South Africa is being taught to expect that he will lead his adult life under the policy of equal rights, he is making a big mistake. The native must not be subject to a school system which draws him away from his own community, and misleads him by showing him the green pastures of European society in which he is not allowed to graze. 'With these notorious words, Dr. Hendrik Verwoerd introduced Bantu Education to Parliament in 1953. This began the era of apartheid education. In 1959 universities were segregated. In 1963 a separate education system was set up for the 'colored.' Indian education followed in 1964. And an Education Act for whites was passed in 1967. (p. 9)

Education was also used to disenfranchise the black people of the needed knowledge they needed to be in the ruling class or the so called "Education for the bosses'' as Morrow (2007) posited during the apartheid regime. The blacks were not allowed access to university so that their stock of knowledge would only be for the lower class (Morrow, 2007). They needed emancipation. This as a result of the education they had access to during the apartheid era. Morrow went further to explain, along almost any dimension of comparison, there have been, and are glaring inequalities between the four schooling systems in South Africa. This applies to teacher qualifications, teacher-pupil ratios, per capita funding, buildings, equipment, facilities, books, stationery and also to 'results' measured in terms of the proportions and levels of certificates awarded.

Hence the use of Education again as an emancipating tool from the apartheid government and symbolic violence (Sideris, 2005).The roar of the apartheid regime was all through Africa and the whole world at large. The oneness (a characteristics of indigenous knowledge) in the fabrics of the African ideology seem to spur other African leaders to action. African leaders from all disciplines and fields of endeavor as in Africa, not only Head of nations are leaders, but all in whose hands responsibility is placed. In essence, leaders can be at any level whether local (family, local government area), state (organizations), National and international. These leaders were disturbed and therefore agitated for solidarity of the African community with the nation of South Africa. One of those perturbed leaders is Wole Soyinka. His concern is evident in his book titled "The Literary Lion''.

> In England, he joined a close-knit community of West African students. The petty racism they encountered in Britain seemed less important than the reports they read from South Africa of black Africans being subjected to legally enforce racial discrimination in their own country by the white-led apartheid government. Along with his fellow African students, Soyinka imagined a pan-African movement to liberate South Africa. He went so far as to enlist in the British program of student military education, in hopes that he could use this training in a future campaign against the apartheid regime in South Africa. He dropped out of the program during the Suez Crisis, when it appeared that students might be called up to serve in Egypt. As Britain prepared to leave Nigeria, students like Soyinka were excused from further military service (p. 23).

There were agitations internally and externally for the emancipation of the black peoples. Emancipation from not only economic starvation but educational stagnation; hence the peoples' agitations increased despite efforts to subdue them. Perhaps the people had become aware of the barrier placed on the black people educationally. Possibilities are the agitators had discovered the educational system only enabled a section of the people while the other section were disenfranchised of the valuable learning experiences and learning approaches. At first, the blacks were not looking "outside the box" because of the level of education or knowledge they had access to. In other countries where independence was attained earlier than South Africa, like

Nigeria, where the colonials left the shores physically, the nation's leaders were somehow enabled to pursue or learn in an educational system similar to that of the colonials. Perhaps, this enabled them the courage to resist further dependency in some ways to be granted their independency at an earlier stage. Ethiopia was not even colonized. They defended their indigenous ways of knowing. Their knowledge was sacred to themselves and they taught and learnt in their own context. However, in countries where the colonials left, physically, their footprints still remained in all aspects of the African fabric. The colonials still had and still have organs to propagate the western ideologies in all sectors. From the state's finances to fashion ideologies and from the nation's economies to education, the influence of western ideologies remains apparent.

The present state of agitations to integrate both western and indigenous knowledge together can possibly be because of the will to have an educational system that values the learning process of those the teachers teach (indigenous learner). In bringing the present state of education to what appears similar to how indigenous learners learn, re-considering how indigenous learn seems to make sense particularly with the use of beads and beadwork (cultural artifacts) to teach and learn simple and complex organic compounds with instructional models. Besides these perspectives (capitalism, Marxism, feminism) are theories (behaviorism and constructivism) that have evolved over the years and mediated in making sense of learners experiences and the social world. These theories are also set of principles that orchestrate activities in the learners lived world.

Approaches to Education

Over the years approaches to teaching and learning has changed and evolved from viewing knowledge processes as just a repertoire of behaviors (Skinner, 1976), but knowledge that allows the mind into exhibiting cognitive processes (Frith, 2012) with social interactions. As Lesh and Lamon (1992) posit that behavioral psychology (based on federal and procedural rules) has given way to cognitive psychology (based on models for making sense of their real life experience).This cognitive turn in psychology is often referred to as the constructivist approach. If learners' behaviors continue to be recognized as significant during learning in and out of the classroom and the cognitive processes remains cardinal, I argue that the resultant product may be a hybrid of both behavioral and cognitive processes. Because imitation and observation are all part of how children learn. They imitate their teacher and their environment. These two processes contribute to the way learners understand basic concepts. Perhaps other cognitive processes, not captured in the behavioral approaches have necessitated the shift to the constructivist view to learning. The shift from behaviorist theories to more dominant constructivist, social constructivist, has lightened up the push for a learner-centered learning process in the classroom. This push has been received by different countries in different ways.

According to Country profiles developed for sub-Saharan African countries by the Vrije Universiteit, Amsterdam, as part of a larger study on Science, Mathematics and ICTs in Secondary Education in sub-Saharan Africa,(SMICT, 2005),countries like Tanzania, Uganda is said to revolve round the predominantly behaviorist model of curriculum and instruction rather than inquiry based teaching. According to the same statistics, in Botswana, the read-regurgitate learning cycle prevails despite a formally sophisticated competency-based and learning curriculum being put in place for the change. Nigeria seems to lean towards promoting a learner-centered curriculum but the implementation of the policies has been far from implementation. Other countries like Canada, New Zealand, China, Japan, and Ethiopia are front runners in the policy change. Many other countries like Cameroon and Ghana are coming up but the Achilles heel is the actualization of the integration process. In South Africa, there has been the rigorous push to implement policies that resonates with the learners' live world but the implementation of these polices seems inadequate. The curriculum and assessment policy statement states learners should use beads to create simple and complex organic molecules (CAPS, 2011). But as discussed in Chapter five and six, the teachers are not even aware of the curriculum stance on the use of beads and beadwork to teach simple and complex organic molecules. The Government through the department of Education (DBE) has also not provided these beads for the school's use. Perhaps, if they have provided the beads, the teachers would have gone further to check what the beads are to be used for. This use of beads by both teachers and learners is envisaged to enable learners interact socially as well as cognitively drawing on their prior experience to create a whole new experience especially for the learners; hence constructivism.

The constructivist approach is based on the teachers' and learners' experience, experiment and evaluation of activities in a continuous process as influenced by beliefs that are also being continuously reconstructed through the process of social interaction (Kagoda, 2009). Through the social interaction process, the beliefs change over time, as it, in a way depends on the respective results from previous assessment and evaluations. Constructivism could be either cognitive constructivism or socio-constructivism. From either of the constructivist perspective, the teachers use materials with which learners become actively involved through manipulation or social interaction. This approach gave direction and empowerment to the use of beads and beadwork (cultural artifacts) to create instructional models for simple and complex organic molecules. In the activity (creation of models from beads and beadwork (cultural artifacts)), Learners become actively involved in their learning process as well as in the social interaction; between themselves as learners and also with the teacher. The materials the teacher uses to teach (creation of instructional models) in the classroom are materials learners are familiar with; hence, they are materials with which the learners get actively involved with. Unlike the teachers-centered traditional approach to teaching where there is less interaction (as seen in the four traditional teachers centered approach to learning) between the teachers and the learners or between learners themselves as well as between learners and instructional materials. The use of only instructional in form of lecture and textbooks neither fully encourages engagement between prior knowledge and new knowledge nor the conversations that are necessary for internalizing and deep understanding (Barnhardt & Kawagley, 2005). Most times, the teacher reads out and explains from the textbooks to the learners. This may not possibly enable engagement that ensues cognitive interaction between the teacher and learner in the classroom as the learners also tends to just read. Reading by the learners might be just fulfilling an instruction from the teacher and not necessarily an act that enhances the link to prior knowledge.

I suppose the connection between prior knowledge and the lesson being taught enables teachers' pedagogical practice in the classroom by enhancing learners understanding of the present concept being taught. Learners' appears to make allusion to what has been learnt before in order to understand the present. It also appears to be a strategy teacher uses in order to make learners understand the present concept and link up with what the learners' prior knowledge. This resonates with my experience from childhood till my elementary school, high school and afterwards with my high school learners as I highlighted in Chapter One. It is also a similar process to Bridget's learning process in Chapter Three where she learnt from her granny, preceded to her high school and also her professional life. In addition, it resonates with the learners' use of beads and beadwork (cultural artifacts) to create simple and complex molecules as instructional models (in Chapter Four). These learning processes picture a sort of integration between the western and indigenous knowledge, to enhance learners' various understanding. It has been observed that what a person knows and understands is not passively received but actively assembled by the learner (McLeod, 2011). Learning is also a process of internalization (Mortimer & Scott, 2003). In this case, the learners are active contributors to the two-way interactive processes (teaching and learning) as it requires mental activity which buttresses the transposition of approaches from a teacher–centered education to a learner centered teaching approach.

Chisholm and Leyendecker (2008) argue that learner-centered education is one of the most pervasive educational ideas in contemporary sub-Saharan Africa and elsewhere. Assumably, learner-centered approach was seen as pervasive on account of the heightened awareness in the need to enhance indigenous learners' learning with an enabling context to learn science concepts. Despite this push for a shift from the traditional styles of teaching that is largely characterized by verbal recall of factual information and definitions, it has been somewhat difficult to actualize the integration process. Most science classrooms have structures that promote teacher's power dominance and learners' inactiveness during lessons in the classroom (field). These structures could possibly be tangible (sitting arrangement) and intangible (power dynamics). Other constraints are the sometimes disapproval of indigenous knowledge (learners' socio-cultural background) by the government, teachers and learners themselves (Baquete, Grayson, & Mutimucuio, 2016). As in my case where it was a taboo to speak my local language, every other indigenous aspect of my growing up seemed valueless. My sense of dressing, aspirations, value and even religion was an imitation of the western world. Ogunniyi and Hewson (2008) further posited that often times, teachers are not able to allude to indigenous knowledge due to the negative attitude it might connote. Teachers also have limited professional support to integrate indigenous knowledge in classroom teaching (Ogunniyi, 2007)

In a recent study on teachers' ideas on indigenous knowledge and their attitude towards alluding to it in the science classroom by Keane and Moyo (2010), findings showed that Black township teachers were inclined towards alluding to indigenous knowledge to teach in the science classroom but asserted that indigenous knowledge is better understood by rural teachers.

According to these findings, predominantly white teachers and urban teachers that were trained to adopt westernized science only were doubtful on the inclusion process and undervalued indigenous knowledge as a very primitive knowledge. This so-called primitive knowledge comprises the learners' lived-world. It becomes more complex when teachers value less the indigenous learners lived world while learning in the science classroom. According to Rousseau (2015), asking teachers to reflect on personal experiences may shift their views of teaching from teaching science as general and universal but contextual. This also provides opportunities for integration of western and indigenous knowledge. This integration possibly could make learning more meaningful to the indigenous learners. Learning is meaning making (Kull, 2014). It is also an enlightening experience. This experience should be viewed as intellectual resources and assets and not deficits (Hayes, 2010). The intellectual resources should be a sort of repertoire which could be accessed by the teachers and learners themselves. Learners are more likely to engage in learning that resonates with their cultural identity (Johnson & Fargo, 2010, p. 45). Hence, the learners' want to see their learning process enhanced by aspects of their culture and not the absence of their culture in their learning process. Implementing this type of practice where the learners are valued seemed far from accomplishment despite some governments' policy to integrate indigenous knowledge in the classroom. As stated before, there are different government policies and different way these government has gone about implementing the policies.

In South Africa, it is evident in the curriculum, the government stance to implement the integration of both western and indigenous knowledges. However, how these knowledges is to be integrated remains unstated. For example, the curriculum states, the teachers should use beads to create models for learning simple and complex organic compounds; however, how it will be used was not stated. The knowledge to be integrated into the curriculum as envisaged in the South African curriculum Assessment policy which is aimed "valuing indigenous knowledge systems" (p. 5). The value of indigenous knowledge increases in the "how" it will be integrated into the teaching of simple and complex molecules. This how is absent from the curriculum. These indigenous knowledge systems are place-based. Place-based materials are accessible to the learners both physically and mentally. Physically in the sense that, the learners can touch, feel and manipulate to different structures like the creations from beads and beadwork (cultural artifacts). These creations can be formed and reformed into another structure of organic compounds. Mentally, learners can make link-up between the prior knowledge and the new knowledge in their brain when they try to understand concepts being taught in the classroom. Hence the need to unearth the possibilities of using beads and beadwork (cultural artifacts) to create models of teaching and learning life science concepts in the classroom. The classroom is a microcosm of the society which in the South African context comprises learners from nine major ethnic groups. Added to that is the fact that migration has made the society a lot diverse and multicultural. Sine, the classroom is a microcosm of the society; the classroom will be multicultural also. How do we teach these kids from diverse and multicultural background life science concepts? Understanding and alluding to their local language may proffer` one of the solutions.

Learners Translanguaging

Nowadays many learners speak more than one language (the mother's tongue and other languages learnt as the child grows up). Apart from English language, evident in the learners classroom interaction where beads and beadwork (cultural artifacts) where used to create instructional models for teaching and learning of simple and complex organic compounds) in the classroom, were the learners conversed cognitively in different languages. The teachers also at various times during the lesson conversed in the learners' language perhaps so that they understand more. The learners also discussed in some street language when explaining to themselves cognitively despite the apparent language the learners are used to converse is in English. The Department of Education's (DoE) policies on language encourages some languages are compulsory to learn and understand in the high school. This may have contributed to learners' ability to speak more than their home language. In fact, these learners code-switched/translanguaging from a language to another language in the science classroom (Baker, 2011). Baker (2011) explained translanguaging as "the process of making meaning, shaping experiences, gaining understanding and knowledge through the use of two languages'' (p. 288). Also, Canagarajah (2011) posited that translanguaging is a process of shuttling between languages. In using the languages to communicate, the learners value these diverse languages which form their repertoire from which an integrated system can evolve. An integrated system means a system that is part of the learners lived world. Could it be that the learners had mastered the art of translanguaging since their child hood? Why did the learners translanguaged in a science classroom where cultural artifacts (cultural artifacts) were used to create simple and complex organic structures when in the traditional teacher-centered classroom, the learners conversed in English only.

The learners found translanguaging as a better method to enhance communication between each other in the science classroom. Through translanguaging, the learners peer-tutored, peer assessed and evaluated each other, formed identities of success or identities of positive performance, questioning and complementing themselves, imitating and mimicking each other. It was a valuable channel to utilize in learning. There remains the possibility of not been involved in these constructs if they had not been provided a context where they can express and converse. As described in Chapter Four, learners through translanguaging negotiated their learning in the science classroom. The learners used the languages to convey the meaning they would understand since English language may not be their first language. It seems a sort of using indigenous knowledge (learners' first language) to explain western science (English as second language) to an indigenous learner (the multilingual speaker). According to Karlsson (2018), in multilingual classrooms, the instructional language is used to negotiate not only between different discourses but between the learners' first language and second language.

For those whose first language is the same as the language of instruction or the instructional language as their mother tongue, it becomes less challenging with understanding the concepts. It also becomes easier to learn in such contexts unlike those whose first language is not the instructional language in the classroom, Karlsson et al. (2018) says, they face additional challenges. Again, according to Thomas and Collier (1997) study that shows that, it takes five to ten years before second language learners can appropriate the subject matter on the same terms with learners whose first language is the language of instruction in the science classroom. The classroom cognitive space becomes a capacity that accommodates western and indigenous knowledge. Not only a hybridized knowledge but language, philosophy and other artifacts in the classroom. In the case of knowledge, it's the third space while for language it becomes a hybridized space for language as well as hybridized space for artifacts. According to Karlsson et al. (2018), Science Education can be enhanced by enabling a hybridized language space for subject matter discussion. This means enabling an environment that houses learners' lived-world (local language) and the language of science. Would teachers enable this? Lee (2005) argues that science teachers often exhibit a lack of knowledge and experience on how science instruction can be organized to support multilingual learners' cognitive needs in the science classroom.

Learners have challenges accessing science content in the science classroom (Turkan & Liu, (2012). To them, this is because they do not have necessary language skill in the language of instruction. It also hinders them from demonstrating their actual knowledge. It can also result in motivation, interest and knowledge at risk of ebbing away. As consequence of this inability, teachers tend to lower their subject matter expectations of the learners (Van Laere, Aesaert, & Van Braak, 2014). In terms of knowledge, there is also the third space in terms of knowledge capacity. Bhabha (1994) explains this space as a place that accommodates the culture of the learners' lived-world (place-based) and the culture of Western science'. The integrated knowledge will also have influence on learners' expressive construct in the classroom. Leaners are accommodated in a cognitive space that is enabled by the integration of cultures to enhance their learning. The third space also allows the learners a space to move back and forth between the two cultures, becoming better citizens in a society and enriched by cultural differences (Aikenhead, 2000).

The Gap between Policy and Practice

In the implementation of this cognitive space in the science classroom, there seems to be a wide gap between policy and practice according to a research survey (SMICT, 2005). It is also evident in the curriculum stance on using beads and beadwork to create models of simple and complex organic compounds for the teaching and learning in the life science classroom while the "how" it will be done was not stated. Also in South Africa, the learner-centered goals of the outcomes-based education are proving far harder to achieve in practice than in policy (Harley & Wedekind, 2004). According to Ogunniyi and Mushayikwa (2015), in 2004, the South African parliament adopted an Indigenous Knowledge Systems (IKS) policy as part of its transformation and empowerment agenda. The policy marked the first milestone in the government's efforts to "recognize, affirm, develop, promote and protect indigenous knowledge systems in South Africa" (DST, 2009, p. 3). Policy implications for education involve the integration of indigenous knowledge systems (IKS) into the school curriculum and advocated for the need for science, mathematics and technology teachers in South Africa to review and adopt teaching approaches that will help learners to relate school science to their home settings. It will also enhance their African identity. The policies, as I have enumerated before, should be put in motion as consciousness of the value of our indigenous knowledge increases.

However, in the South African CAPS document, there are aspects of the revised curriculum noting that some aspects of indigenous knowledge that has to be taught to the learners but the "how" it will be implemented is not enumerated. Chisenga (2000) argues that very little of various innovations in indigenous knowledge have been discovered in enhancing teaching and learning in the classroom. Yet it represents an immensely valuable database of knowledge that provides humankind with insights on how numerous communities have interacted with their changing environments. African's indigenous knowledge needs to be codified into print and electronic formats for both audio and video to make it widely accessible on the global information infrastructure. It appears there is more to the interaction of the communities with their changing environment. Policies to ensure these interactions were enacted as well as the process of implementation should also have commenced. Another challenge is the discoveries of 'what indigenous knowledge are to be taught in alignment with the western science'. This remains to be discovered as well as, as how the teachers will also teach the indigenous knowledge along with western science to the learners. This is the gap this research aims to fill in exploring the possibilities of using beads and beadwork which are cultural artifacts as instructional models in the teaching and learning of life science. This research study aims to address the position of "what" can be aligned with the curriculum and how the "what" can be implemented. The knowledge to be implemented is science and this knowledge has enabled the indigenous peoples' lived world. On the other hand, western science has also been part of the world of the indigenous peoples, only that perhaps it was relayed to indigenous peoples in a different paradigm and worldview.

The Science Space

Thomas Kuhn (2012) argued that scientific knowledge, research and thought are defined by “paradigms,” or conceptual world-views. This term was used by Kuhn to imply a sum of procedures or ideas that instruct scientists, implicitly, what to believe and how to work. Also according to Kuhn (2012) these paradigms are subject to change as they solve a problem whose solutions re-energizes and stretches the boundaries of the original paradigms. Kuhn (2012) argues that paradigms change as the peoples culture change; therefore paradigms are dependent on the context. Kuhn gave an example that different groups and the same group at different time can have different experiences and hence, the experiences’ that produces knowledge becomes different in a different world. To me, these words depict that knowledge discovery is contextual. To Kuhn (2012) these paradigms change (perhaps as a result of the contextual change) and as they (paradigms) many times are confronted with phenomena that are not accountable for the individual as these phenomena sometimes cannot be accounted for and are called anomalies. The accumulation of these anomalies amounts to revolution which Kuhn elaborated as paradigm shift. Paradigms has shifted from Aristotle’s science to popper’s views and then Kuhn who has acknowledged the dynamic nature of western science and which to me reverberates indigenous knowledge as also dynamic and evolving.

Indigenous Knowledge Value

Acknowledging my indigenous knowledge system (IKS) has increased the value I placed on indigenous knowledge system. It has been a sort of change in paradigm from an all westerner to a paradigm integrating western and indigenous knowledge. As a recipient of both indigenous knowledge and western knowledge, I discovered that knowledge can be created and acquired in the teaching and learning process. Teachers play a critical role in mediating the social and academic knowledge through the curriculum. Researchers have repeatedly confirmed that teachers need to know more about the world of the children with whom they work in order to better offer opportunities for learning successes (Pransky & Bailey, 2003). There are possibilities that this was what happened with the learners in this research study where they learners formed identities of successes after the lesson on the use of beads and beadwork (cultural artifacts) to create models of simple and complex organic compounds. While teachers should allude to what students' already know, they (teachers) should help connect the present lesson to a frameworks and model to enable thinking and organizing knowledge. A lot can be done in accessing prior knowledge of the learners as there are a lot to be accessed in to those embedded within all disciplines. Active engagement, high communication, anchoring the curriculum on the everyday lives of students, facilitation of learning , structures for reflection , ways of knowing and doing as well as sharing the classroom control with the learners are part of the key features or resource tolls of a culturally relevant teaching and learning. Can these resource tools enhance communication (an integral part of the classroom) as students express their ideas and thoughts through negotiation of meaning between themselves and the teacher?

Negotiation of content meaning by learners in the classroom can be enhanced through sustained communication process. In the traditional teacher-centered classrooms, there was less communication between learners and also between teachers and learners. The teachers (four) who participated in the study did all the teaching throughout the lesson duration as learners just listened and kept quiet. As reported in chapter four and five, these classrooms (teacher-centered) learners were kept quiet in other to allow the teacher pass across information successfully. It was assumed that if the learners talk or interact, they would not assimilate what was been taught. I also assumed this during my high school teaching days before I adopted the use of cultural artifacts to teach life sciences concepts in the classroom. Learners sit firmly on their seats; stay quiet until the lesson ends as I stand in front of the classroom to teach the classroom. Only if I sense learners at the back murmuring in the classroom will I go to the learners' space (the back of the classroom). Learners could not change or move from one position to another. The advent of the Information and Communication Technology (ICT) has helped innovation in schools accomplishable. Schools now appear to have magnetic boards, markers and other communication gadgets. These communication gadgets seem to mediate learning in the classroom by enabling learning while the learners see, touch, and feel science. This is in a way similar to the envisaged outcome of the use beads and beadwork to create simple and complex organic compounds for teaching and learning because of the mediation and difference because of the allusion /alignment to the learners' culture and also with the use of ICT seem not do. The learners could feel, touch, see and imagine these simple and complex life science concepts in the science classroom.

In these teacher-centered classrooms, the teacher is the "know all" and the learners is seen as a "clean slate" more so Plato as reported by Bloom (2008), Socrates (1978) and Dewey (1997) nudged us that learners were not empty vessels, blank slates, or passive observers (Freire, 1970; Piaget, 2013). These constructivist (Piaget, 1970; Dewey, 1997) elaborates further on learners not been clean slates. According to Piaget, children are innate and learners' learn naturally, as new knowledge is built on the premise of the previous knowledge. He went further to say, learning is social as well as situated and activity based. Has efforts to have a learning condition similar to this been achieved? Perhaps not a significant effort is evident. Learners are to be provided with more learning activities in the classroom or to enhance learning in a way that learners' interest in science constantly increases as well as their pass rates in science subjects. Cuban (1993) asserts that perhaps the most critical shift to happen in education will be a move away from "when teacher talks, learners have been directed to listen" to a dynamic mode where co=participants have equal power of expressing each other. Freire (2002) referred to the teacher and learner in the pedagogical process as the "known and the knower". With respect to teaching and learning in the classroom, teaching is more than the direct delivery of some pre-planned curriculum as Ayers (2001) argued. It is spectacularly unlimited. As a matter of thought, the teacher tries to pass what he knows or what the curriculum says to the learner. I was part of a classroom where the teacher is the 'know all' and the learner is the 'know nothing".

The teacher sees himself tasked to transfer what is in the curriculum to the learner's consciousness. In the teacher-centered teaching method, learners are 'lectured' and any attempt to think outside the box (critically think) would not be seen as wanting to know more as the teacher thinks s/he is deviating from what s/he taught them (learners). The subject I enjoyed reading was Life Sciences just because I could relate it to my environment (place-based relation). All we knew was that it was compulsory we attend school and pass because we wanted to be in the university. Some teachers whom we ask questions from in the classroom sometimes feel we (learners) pose a threat to his classroom pedagogical practice. Seeing us ask questions from him or her, some teachers perhaps label us as stubborn (as it happened in Mr. Kagiso's classroom in Chapter Four) till a time came we no longer wanted to know what the teacher teaches but willing continue in the act of being stubborn by probing the teachers competence to teach us. We wanted to know if his fund of knowledge will sustain the learners as our subject teacher (Freire, 2008). Perhaps the same reason Mr. Kagiso's learners might have when one tries to understand the reason they always act stubborn in Mr. Kagiso's life sciences classroom. Learners sought a goal in the classroom and that was that learners wanted to know if the teacher was smart or not. The curriculum was not presented as something useful to us as learners for our everyday lives but something we must read and pass to be admitted into the university. And for this reason we would memorize word for word so that we arrive with a very good grade. I could now see how boring learning science was.

Shor and Freire (1987), in the book, *Pedagogy for Liberation*, argue that the teaching and learning process should include the learners as co-searchers, co-participant and co-sharer of new knowledge in the classroom. The learners should be active agents in the process of teaching and learning. Knowledge has to be re-created in the context the learner sees with their live-world. What actually happens is that the teacher is saddled with transferring knowledge produced somewhere (curriculum) to the learner in another different context; whereas science is also contextual (Rolin, 2012). Knowledge can be related to a corpse of information or a dead body of knowledge by Ira and Freire (2004) if it does not have a living connection with their reality of learners. Perhaps this was what happened in my class in chapter one where at first, they were not interested in science until I made them active in the teaching and learning process. Perhaps another reason why they resisted the school authorities despite the punitive measures and rules but in place to discourage them from jumping out of school, perhaps they became more alienated to the curriculum as it seems not to make sense to their lived world. Looking at these critically can enable a cognitive space where integration of learners and teachers into a mutual creation and re-creation of knowledge takes place (Shor & Freire, 1987). Again, the teacher cannot teach what s/he does not know: hence I decided to facilitate teachers learning of the beads and beadwork (cultural artifacts) to create instructional models for the learners in the classroom. The teacher who intends to access indigenous learners' knowledge and help them align their prior knowledge to the knowledge of science needs to first learn more about his/her own cultural background knowledge (Peshkin, 1992).

Teachers’ Indigenous Knowledge

Teachers can use their own prior knowledge to make instruction more meaningful (Lee, 1992) as science and its methods of investigation cannot be divorced from a people’s history, cultural context and worldview (Sarpong, 2002). The teachers’ history, cultural background and worldview can be drawn to make abstract science concepts more meaningful to the indigenous learners. Teachers has to first acknowledge their own knowledge as a repertoire to draw resources from, then develop the capacity to draw from the repertoire before helping the learners to do same afterwards. Spindler and Spindler (1994, p. 19) made case for teachers to understand how their student’s culture affects their educational process. The authors explained that “teachers carry into the classroom their personal cultural background. They perceive students, all of whom are cultural agents, with inevitable prejudice and preconception’’. Strategies for improving the performance level of indigenous learners in the classroom are premised on culture. Culture is also a change agent in science knowledge formation as seen with Kuhn (2012); hence science knowledge formation is not context free. In the science classroom, the creation of knowledge is facilitated by the teacher; hence teaching is also not context free. Teaching is dependent on the context where the activity is taking place-the culture. “Much of what each society wants the learners to learn is being learnt in school and teaching is most clearly responsible for learning” (Stigler & Hiebert, 1999, p. 3). I am not undermining the effect of other societal factors like peer group influence, parental influence etc. but teaching is a major factor that influences learning in the school.

Culture Matters

How does teachers-approach impact on learners understanding of science concepts in schools and to what extent? Brunner (1996) argued that culture provides a channel through which learners can mould their lived-worlds. A child comes from the society, spends some hours or years in the school and then goes back to the society to function after the learner has been assumed to be enabled and prepared for the responsibilities of the community, the learners can be said to embody his/her culture. Culture matters because teachers bring ‘’themselves’’ to the classroom. The teachers’ brings their beliefs, experiences, histories, assumptions, their knowledge of education, personalities, teaching styles that are shaped by social and cultural interactions (Giroux, 2007). Maathai (2009) explains culture as a means through which individuals express their language, politics, religion, architecture, music, tool, greetings, symbols, values and ethics. Teachers express their culture in the language they use in classroom, the clothes they wear, the words they say as well as their pronunciation.

The teacher can be said to be culturally-enabled to teach the learners. "Coming to an understanding of the ways in which one's beliefs, experiences, values, and assumptions are linked to culture is an essential feature of culturally responsive practice" Giroux continued. In another tem, the teacher can be said to be culturally enabled to teach the learners. According to the *Teacher's Guide to Folk-life Resources for K-12 Classrooms* in the United States, teachers need to create space for mutual engagement of lived-experience that does not require the silencing of a multiplicity of voices by a single dominant voice. Teachers who understand and value their own cultural identities recognize culture as a complex construction. In doing so, they create the possibility for deeper connections with their learners and families (Haberman, 1995).

Idang (2015) argues that culture comprises the whole traits and characters of an individual as well as those characters distinctive to some people; who are marked out because of these characters. These markers could be their language, dressings, values and taboos, norms, music, religion. In the classroom where beads and beadwork (cultural artifacts) were used to create simple and complex organic molecules, their local languages became markers of indigenous learners. To the African, these values could be economic, aesthetics, political and religious, moral and social. Besides all these characteristics, it could also be educational. In most African countries, the society has attributed some values educationally; hence, an educated individual are respected than others. An individual that graduates with a university degree is accorded more respect than someone who has just had the high school certificate. And someone with the High school certificate is accorded more respect than someone who has not graduated from high school.

We were taught in elementary school cultural songs and folklores to encourage learners to work hard. The school had to draw from the cultural pool of resources to enhance the individual learners learning which also buttresses how black learners learn as a process where they make relations to the environment or what Goduka (2005) calls relational ontology. The knowledge was passed across to the children through stories and songs (form of artifacts). A song from the Yoruba tribe in Nigeria says “Bi o ba ka iwe re; bata re a dun ko ko ka. The song is also a Yoruba song. In English translation means, “if you study hard, you will be more successful”. Perhaps this song motivated my dad; hence he started teaching me as early as possible with home-based (place-based) materials before going to school. There are also possibilities that the song made me work harder anytime I remember because it sinks into my unconsciousness and eventually seem to become a philosophy. We sang these songs everyday morning and afternoon before we go to class on the assembly ground also and before going home in the afternoon. Those days at school, it’s the culture/ritual to first meet to pray and be addressed on the assembly ground in the school before moving to the various classrooms. This is a form of repetition which Vygotsky (1978) says it is a process that leads to internalization as I would have experienced it as place based with my dad’s tutelage and as well with Bridget in Chapter Three with her maternal grandmother. It is also a way the society is deposited in young learners (habitus). Repeatability is also a characteristic of science method as various science texts would suggest.

Therefore if an idea is not repeatable, observable, testable and falsifiable, it is not considered as scientific. This suggests a link between indigenous way of learning and science method. If this is the case, indigenous knowledge is science. Science text also says science is a body of knowledge and a process. Newton and Galileo were science method giants which I read about over the years and have shaped the scientific world. They have refined and expanded our scientific horizon of the universe. I actually thought that only what was taught in my science classroom is science until I had to falsify my own thought by discovering that our indigenous knowledge is also science. It is knowledge organized and produced through which its people have gained. Probing into what learning is all about for an indigenous learner?

According to Qvortrup, Wiberg, Christensen and Hansbøl (2016), learning a subject can be viewed as a process of gradually becoming part of a new disciplinary community which involves a gradual enculturation into the disciplinary discourse and thereby imply identity changes. They envisioned learning as a process of gradual movement from the state of apprenticeship to the state where the individual becomes a master. A master-mentee relationship as well as a master-apprentice association, explains the scenario Qvortrup et al. (2006) wants to elaborate. The context of this type of learning process appears to be place-based. Wilson (2001) explains that

> [l]earning is an everyday exercise that is social in nature because it occurs with other people; it is 'tool dependent' because the setting provides mechanisms . . . that aid, and more important, structure the cognitive process; and finally itis the interaction with the setting itself in relation to its social and tool dependent nature that determines the learning (p. 73).

Psychological and behavioral understandings of learning processes elaborate on the learning context as an internal, individual and mental process in which the mind acquires and stores knowledge for future use in any context. Other research works elaborating on learning is Auguste Comte (1988) who acknowledges that knowledge exist independent of the learner. As a result of this, knowledge is transferred from outside to inside the learner. Learning here is teacher-centered (Durkheim, 2002) as the goal of every lesson is pre-determined. Indeed learning has moved from the core traditional teacher-centered to more cultural learner-centered way of education. This is a poststucturalist approach to learning and also a textual analysis where the reader replaces the author as the primary subject of inquiry and without central fixation to the author.

Culture in teaching and learning. The constructivist view of the epistemological approach to education is that knowledge should be constructed by the learner. Hence the learners' lived-world is valued in constructing the learners learning. Vygotsky (1978) holds the view that the learner has to be guided in constructing knowledge as reality is not directly knowable. The reality is the teachers-lived world or the learners lived world. The view the culture is important in the teaching and learning in the classroom supports active learning, social learning, and cultural learning, multiple meanings of a certain context, prior knowledge and schema. Amidst these various world views, Education is an empowerment tool and it empowers a child towards developing the mental, psychological, and physiological part of the child with the virtues to help the society grow as the cultural pool in the society is somehow constant. The relationship between teaching, learning and culture can be explained pictorially as seen below;

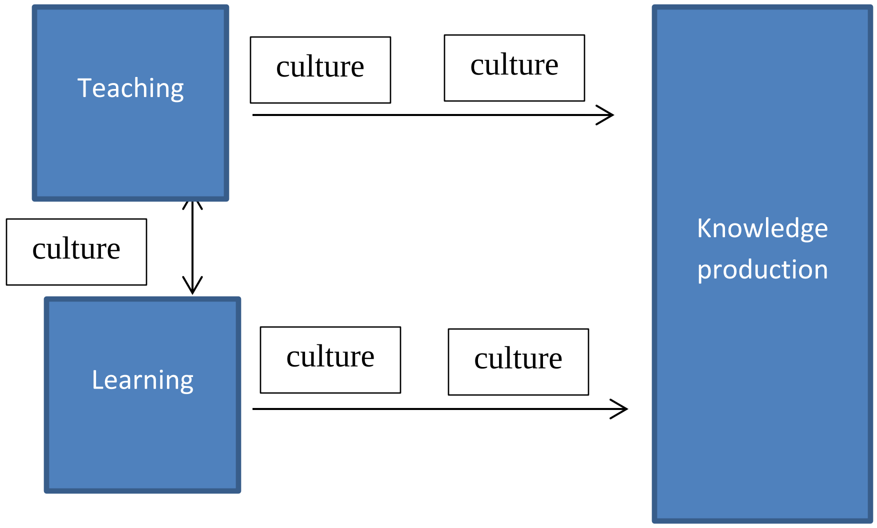


Fig. 1 – Teaching, Learning and Culture Relationship.

The teacher (from the society) comes to the science classroom with culture that is embodied in the individual, likewise, the learners (from the society) and meets in the cognitive space. One of the ways culture influences learning could be the culture of showing respect. According to Sesanti (2010), most traditional African cultures have a high respect of authority and it is highly considered disrespectful to challenge authorities. Authorities such as, older siblings, parents, religious persons, political leaders and people in positions of responsibility are meant to be shown respect. In most cultures, one dare not question or challenge these people meant to be respected. This has been transferred to the traditional teacher centered classroom where learners are restricted from questioning the learners. Musalika (1994) posits that apparently, one of the practices in the African culture is the excessive respect without questioning bestowed on elders and those holding power. From the perspective of the one who is accorded respect, the African philosophy of not been allowed to challenge or ask question except permitted may allow room for much control of the whole scenario.

While the individual who is tasked to respect the other individual is restricted to ask questions even when questions needed to be asked, the individual suffers in silence. This seems to be in resonance with the scenario in the traditional teacher-centered classroom where the teacher controls what happens in the classroom. The learners are not allowed to talk while the teacher is teaching; hence, it is considered disrespectful. The learners may be at a point where asking a question from the teacher will enhance learning at that time, but because he is not allowed to. He is deprived of the chance to understand more the taught concepts. In this way, the culture of the society has influenced the science classroom and promoted the type of methodology needed to further promote the teachers dominance in the pedagogical process.

Culture somehow finds her way into the learners' embodiment through various channels. It would make sense if the culture of the teacher and the learners are alluded to as teaching and learning repertoires by the teachers. There remains the challenge of how knowledge (science) can be mediated for the learners. In order words, who, what and how the teacher teaches becomes paramount in the classroom pedagogical enterprise. Gay (2010) argues that learning should be centered on cultural values as a tradition as learners should be encouraged to explore the African culture. According to Boykin, Albury, Tyler, Hurley, Bailey and Miller (2005), culture is viewed to be able to influence learners learning preferences. This means that the culture can enhance or constrain learners learning styles in the science classroom. He also went further to state that the curriculum should be culture based, one that emphasizes civic responsibility of all members of the community. Hood, Frierson and Hopson (2005) posits for the integration of culture into the curriculum (i) design (ii) learning assessment (ii) teaching assessment. Probing into the question of what type of teacher should be in the classroom (Who should teach) they said educators should consider the qualities possessed by literature of social vision as a creative concern which conceptualizes or extends actuality beyond purely narrative (Soyinka, 1988, 1993).

Cultural affordances. Some cogent concepts are extending reality beyond purely narrative which I explore with the use of beads and beadwork to create models as instructional materials in the teaching and learning in the classroom. Making real and actual; things more practical and relate it to their culture. Aikenhead (2007) posited that most indigenous learners tend to see school science as a foreign culture because it is not linking up or aligning with their own culture. It is now considered strange. For learners of this status to be successful, learners must without teacher assistance learn to cross a cultural border between their own culture and the culture of academic school science (Pearson, 2008). If the learners would not align his prior knowledge with the western science, I presume wholesome learning will not take place. According to Aikenhead (2006), western science has failed in some ways including the alarming rate of decline of interest and enrolment in secondary school science despite the value they placed on Eurocentric science in their world outside school. Rennie (2007) says despite learners grasp scientific ideas as needed in out-of-school settings; they gradually fail to learn academic science content meaningfully in school. Since we live in a world dominated by western science, how do indigenous learners learn science? How do we integrate the learners' cultural context in science learning in the classroom? Possibilities are that learners become engaged in a way the learners lived-world is valued, whether ontologically, epistemologically or axiologically.

Fostering learners' learning with these three cardinal aspects in mind can enrich the educational experiences of learners; rural and urban, indigenous and non-indigenous (Gruenewald, 2003). Other reasons are (i) teachers' instructional behaviors are determined by teachers' ethnic racial, cultural diversity. Beliefs and behavior are interactive (Gay, 2010) (ii) Culture influences what and how learners' learn both in and outside school (Gay, 2010). (iii) The teachers' diverse learners require a learning process that caters for the learning styles. In Ladson-billings' book titled "Towards a theory of culturally relevant pedagogy", the push for a culturally relevant way of teaching was posited. But this effort appears subject to different cultures because as we narrated before knowledge production is subject to culture and context. Furthermore, Ladson-billings according to Charlesworth (2008) posits that culture enhances the learners' ability to construct their world through their worlds and perceptions. In the light of this, scholastic arguments about culture could be elaborated to unpack its underpinnings. Shizha (2010) posits that all forms of knowledge are grounded in culture. Therefore, when conceptualizing the word "culture" and those related to it, I think of the anthropologist. The meaning could be polysemic according to Baker and Taylor (1995). Both contended that it stemmed from the agricultural term-cultivate.

For centuries it meant producing or creating. Some could use it with other words such as culture of arts or culture of bacteria. As time went on, it was used to describe the qualities of an educated person. Culture is seen as not only from the eyes of the anthropologist but from the lens of the academics (Sewell, 1999). Gyekye (1997) sees culture as socially created and nurtured meanings constituting ''the greater portion of our necessary social context" (p. 44). Culture has evolved from the anthropological context to a more round academic context as seen in Wolcott (1991) view about learning science as culture acquisition, where culture means "an ordered system of meaning and symbols”. Taylor (1958) assumed the word civilization as synonymous to culture. Taylor described culture as a complex whole that includes knowledge, beliefs and other capacities acquired by man as a member of a society. In His widely acclaimed book, Hofstede (1984) first cited an earlier definition by Kluckholn (1951) similar to but not identical with Krueber and Kluckholn’s (1952). They wrote…….. “I treat culture as the collective programming of the mind which distinguishes the members of one human group from another” (p. 21). “During the 1980s and 1990s, the intellectual ecology of the study of culture has been transformed by a vast expansion of work on culture-indeed, a kind of academic culture mania has set in” Sewell continued. Sociologists see culture as a category of social life where behavior is learned. They continue to say that the body of practices, beliefs, institution ,customs, habits and myths are built up by humans and passed on from generation to generation. In this case, culture serves as a teaching entity as the individual grows from generation to another and if managed well, the next generation becomes an embodiment of knowledge facilitated by culture.

According to late Fela Anikulapo Ransome Kuti, a Nigerian musician and activist, who launched the Afro-beat style of music, sees culture as being enrolled as a teacher; an embodiment of the whole society. See below excerpts from his song.

Who be teacher,
I go let you know …
When we be pickin,
Papa, Mama be teacher,
When we dey go school,
Teacher be teacher,
When we dey university,
Lecturer be teacher,
When we start to work,
Government be teacher,
Who be government teacher,
Culture and tradition.

Fela spoke in Nigerian Pidgin English-derived from the British English language and acknowledged culture as a teacher in the society. He actually acknowledges the parents and siblings as teachers in the child's learning process; also resonating with my childhood's learning process and development where my dad and siblings facilitated my learning.

From generation to another, the child is passed on the societal norms by culture where the child finds his\herself. Cole and Parker (1996) think of culture as a dynamically changing environment that is transformed by the artifacts created by prior generation. In the same view Oyserman and Sorenson (2009) understands this cultural word as cultural syndrome effects on what and how we think. They regarded culture as a single unified whole and isomorphic entity. The Marxist-Thompson sees culture as related to creativity and agency. Clifford Geertz (1973) made the concepts of culture as system of symbols and meaning more popular. Claude Levi-Strauss (1966) talks about culture as practice. While Krueber and Kluckhohn (1952) is of the same opinion that culture consists of patterns, explicit and implicit of and for behavior acquired and transmitted by symbols, constituting the distinctive achievement of human groups. Furthermore it is said to include their embodiments in artifacts which is the essential core of culture and it consist of traditional (i.e. historically derived and selected) ideas and especially their attached values.

Culture systems may, on the one hand, be considered as products of action. It is a sphere of practical activity shot through by willful action, power relations, struggle, contradiction and change. Culture stands for a concrete and bounded world of beliefs and practices. Culture in this sense is commonly assumed to belong to or to be isomorphic with a "society". Culture can also be a category of social life. This is an abstract definition of culture but it is equally a platform towards the practicality of culture in the active sense. This definition seems to be at variance with Levi -Strauss structralistic view of linguistics and anthropology arguing of the shift from the study of conscious linguistic phenomenon to unconscious infrastructure. Phelan, Davidson, and Cao (1991) posit culture as the conventional yardstick of a group, the significance and perspectives and supposition of the same group. The meaning I always had was that culture was the way of life one is brought up with. The beads and beadwork (cultural artifacts) is an entity part of the learners' lived-world. Part of their everyday life; hence, introducing it to the learners in the classroom was a surprise to them in the science classroom. Perhaps not because the learners has not seen it before but perhaps because it is different from the western science culture in the science classroom. It intriguing for the teachers and learners to see how these aesthetic materials can be used for cognitive practices in the classroom especially life sciences concepts. Beads have been used to construct an "abacus" to enhance learners' mathematics calculation skills. However, little literature exists on the use of beads and beadwork (cultural artifacts) to create models of simple and complex organic compounds.

The use of beads and beadworks tends to provide an indigenous context in the science classroom. Learners seem to begin to see science as related to their lived-world. In essence, the context began to and re-shapes how individuals view life science. Learners seemed enabled to ask questions from the teacher when they are challenged by a task, recognized themselves as resources which they can tap from; hence, they peer tutored, self-assessed and self-evaluated. Learners imitated and mimicked the teachers' words when they were to write what was taught later on. The act of imitation and mimicry seems to resonate with those of the indigenous peoples where they (peoples) imitate the cry of animals such as birds, goats and other animals. In imitation, the individuals learn as a result of repetition. As soon as learners tend to discover that they are also resources that can be accessed, they continue to access this repertoire as resources.

The resources can be viewed as knowledge. In resonance with all the above definitions is that of Odora-Hoppers (2005) who understand culture "as the totality of socially transmitted behavior patterns, arts, beliefs, institutions and all other products of human work and thought" (p. 1). Part of the institutions is the school that houses the formal space for pedagogical practices: hence, the school is surrounded by the culture of the society. The language the learners in the four teachers classroom where beads and beadwork (cultural artifacts) were used to create instructional models of simple and complex organic models, depict the language characteristics of the surrounding community. From the above representation, the school is shown to be embedded in the learners' culture, therefore having a different approach to teaching and learning enterprise may not enhance learners understanding of science concepts while aligning both western and indigenous knowledges to the pedagogical practice in the classroom appears to be appropriate. Kalolo (2015) posits that situating the pedagogical practice in the learners' cultural context provides a means through which science concepts are understood much better.

On a cultural note, some practices in the learners' culture may seem to sometimes interfere with the culture in the science classroom. African practices like how respect is accorded to the young or old. Respect is shown no matter who an individual is addressing and no matter the context. When greeting an elder in the Nigerian context, the male young prostrates while the female young knells down to greet the elder or older one. In most African cultures, when the younger one greets the elder, he/she either bows the head down or with two hands respond to the elder's hands. In the case of greeting with the hands, the younger individual does not first stretches his\her hands out to the elder. It is the elder that first extends his his/her hand out to the younger individual. The way Africans show respect extends to younger individuals not contributing to any issue involving elders or older ones. When older individuals are in a discourse, the younger individual does not talk until asked to do so. It is considered disrespectful for the younger one critiquing the older or elder one as the culture considered the older individuals wiser than the younger ones. A Nigerian adage says when a younger one cuts a tree; the older one knows the direction where the tree will fall. This is often extended to the traditional teacher-centered classroom where the learner does not interact until permitted by the teacher. The teacher controls every happening in the classroom. It is also considered rude when the learner talks or even ask a few questions when the teacher has not allowed you to do so. So there could be lot interference between the learners' culture and the school culture.

Why Integration

The call for integration of indigenous knowledge in school science teaching and learning appears to be as a result of continued dominance of western science without effective solutions to the learners' environmental challenges (Semali & Kincheloe, 1999; Michie, 2002), and also from the emancipatory perspective, as a result of aged dominance of western science as against indigenous science which has invoked a huge debate in science education. Debate about whether it is really important to integrate western and indigenous knowledge together while teaching and learning in the classroom (Berkes, Colding, & Folke, 2000) and also debates about implementation of polices as regards the indigenous knowledge. While some scholars like Cobern and Loving (2001), are of the opinion that western science is the only true science that results in reality and truth, others like (Aikenhead, 2005; Jegede, 1995; Kincheloe, 1999; Otulaja

& Ogunniyi, 2017) advocates for the integration of indigenous knowledge systems into classroom science to enhance learning for indigenous learners. Also as reported by Mavuru and Ramnarain (2018), with reference to the Taiwanese curriculum, Lewthwaite, McMillan, Renaud, Hainnu, & MacDonald (2010) posits for a science curriculum that indicates learners' lived-experiences and that Hayes (2010) argues that learners learn better when teaching relates to their home language and culture. Another justification for the integration of both western and indigenous knowledges especially in South Africa is that for so many years, South Africa has accumulated a large amount of indigenous knowledge which seems not to have been harnessed and valued by the current generation.

Reasons for integration. Incorporating these knowledges into the curriculum to enhance science learning is anticipated to: (i) broaden the teachers' and learners' knowledge of science thereby enhancing both worlds (Angaama, Fatoba, Riffel, & Ogunniyi, 2016). They went further to elaborate on other reasons such as; (ii) giving indigenous knowledge systems the place of value in the knowledge systems; (iii) since science is universal hence indigenous knowledge is also science. Therefore, it should align; (iv) to enable and enhance the understanding of science; lastly; and (v) indigenous knowledge systems is interesting, spiritual and emotionally encouraging. Ogunniyi and Hewson (2008) further argue that the ideas the learners bring to the classroom should be valued therefore used as resources to engage in classroom dialogues and discourses. Hooley (2000) thinks that including indigenous knowledge in science pedagogy is a way of acknowledging its importance as well as celebrating the cultural heritage as important as western knowledge. However, 300 years of colonization and apartheid resulted in atrophy of indigenous cultures and knowledge systems (Ogunniyi & Hewson, 2008) in South Africa.

Awareness about the need for integration of Indigenous knowledge system has become more evident in the various efforts for its inclusion in literature and more evident in the South African CAPS document. According to Ghebru and Ogunniyi (2016) the directive that enforced science teachers to integrate school science and indigenous knowledge in their classrooms was initiated in the 2005 curriculum which was revised to the National Curriculum Statement (NCS) and examined in 2008 at grade 12 levels. The Curriculum Assessment Policy Statements came into effect with grade 10 in 2012 and has continued to call for the inclusion of indigenous knowledge in science lessons. Also indigenous knowledge systems contain components such as traditional beliefs, values and artifacts which are considered admissible in western scientific discourse specifically considering the nature of science (Zinyeka, 2011). Indigenous knowledge system gives the learner a more comprehensive world-view and the ability to interact with a broad range of entities in his or her environment (Onwu & Mosimege, 2004). According to Onwu and Kyle (2011),

> One of the reasons for integrating IK into the science classroom is the recognition for the emancipatory effect this move has. What it means is that the learners are liberated in learning processes. The argument here is that if learners are enabled to form personal opinions, motivation to learn science is likely to be increased, and willingness to apply the knowledge gained in real life situations is likely to be cultivated. (p. 5)

The conventional interpretation of learners failure in science subject, low interest in studying science or the myriads of problems befalling the society without immediate solutions that are forth coming implies that the fault lies with the indigenous individuals, families and their communities whereas researchers and scholars argue that it is the school system and not the indigenous learners or their culture that must be fixed (Battiste, 2002). Whoever has the fault, the way forward is for the learning context of individual learners be enabled by the teachers.

Another reason for the integration is the consciousness and heighted awareness that educated and enlightened Africans are not cultural captives of the west (Mazrui, 1978; Nyerere, 1968). Therefore our generations to come will have been emancipated from the shackles of an all-western curriculum been used to assess and teach an African child in his or her village. More so it could help the learner navigate from his ‘known’ to the ‘unknown’ where the known is the indigenous knowledge that the learner has already been used to. Taught by the community as he is not independent of the sociological, psychological and linguistic structures over which he has no control (a stucturalist philosophy). Since indigenous knowledge generates from the children’s real life experiences, its incorporation into the school curriculum can motivate and bolster the intellectual fortunes and interest of learners as they realize that recognition is given to what they already know. There is the opinion that poor performance is due to ignorance of and/or the lack of sensitivity to aboriginal learning styles and to teaching strategies which do not conform with the indigenous worldview (Agbo, 2001; Cardinal, 1999; Castellano, Davies, & Lahache, 2000;

Hughes & Sharrock (2016).The learning styles and teaching strategies are different from the western science teaching strategies as evident in the traditional classes in the study and the classroom with the beads and beadwork cultural artifacts to create simple and complex organic compounds. In the traditional teacher-centered classroom, learners depended on the teachers as sole repertoires of knowledge. Whereas in the classroom with beads and beadwork, learners had varieties of repertoires (teacher, learners themselves , cultural artifacts) to choose from in the science classroom despite the multiculturally-assembled classroom.

Globalization, forced and voluntary migration have resulted in increased number of family and individual mobility (Kirk, 2010; Manik, 2014; Sharma, 2012). These factors have resulted in a multicultural classroom where the teacher from a different culture teaches learners from other different cultures. This comes at a time when the western culture is seen as the most valuable while indigenous peoples discard their own culture, language and beliefs for the hegemonic one (westernized science). Whereas less-valuing the lived-world of the indigenous peoples, at the expense of the knowledge, foreign to the indigenous individual’s lived world, I supposed will probably continue to strengthen the western knowledge as against the indigenous knowledge. The indigenous individual would learn the foreign way of livelihood and would also be assessed from the eyes of the owner of the knowledge while subsequently graded or degraded. Only in rear cases would the new learner become more adept in the knowledge of the actual holder of the knowledge than the original holder of knowledge. The new learner will for the most of his life be second behind the knowledge owner. When I was in both primary school and high school, as I had narrated earlier, was prohibited to speak my dialect in the class. It is either you are caned or made to pay a fee as a punishment. I was made the English prefect because I was only brought up knowing how to speak English language. I did not speak Yoruba, my native dialect/tongue, before until I was in high school and had friends who could speak. Learning from my peers was without hassle. The same exhibited by the learners that co-participated in this study. Not only did the learners peer tutored each other, they peer-questioned each other, peer-discussed and demonstrated the content, divided and shared tasks among themselves, imitated themselves and the teacher, formed collective identities of success, peer assessed and evaluated themselves as well as having positive responses for themselves.

Learning from each other was a process they appeared to enjoy; hence, the positive emotional energy the learners exhibited during lesson (where beads and beadworks (cultural artifacts) were used to create instructional models of simple and complex organic compounds) was different from the mood in the teacher-centered traditional teaching. It appears there are possibilities for increase in learners disinterest in science in the traditional teacher centered teaching classroom. Indigenous learners who are taught with English language (language of instruction) seems to find learning easier when instruction is passed across in the learners first language (local language) Therefore, if given the opportunity to converse with his peers, his peers will most likely converse in the local language to explain the real meaning of what the teacher says. The teacher, if s\he understand the learners' world very well, may converse in the learners' language in order to enhance learners' understanding of the concept being taught. Perhaps this gets to the child's psyche and he/she feels the school is either the best place to be or the worse place to be. A lot of havoc has been done to the African child's psyche making s/he depressed and not interested in science which results in the employing round pegs in rectangular holes in the society.

The dare need to develop resources familiar to the learners lived-world and viewing the leaners lived world as valued knowledge. Makinde and Shorunke (2013) contend that African knowledge has been exploited without giving credence to the owners of this knowledge. Aikenhead (2000) and Cajete (2000) supports that traditional cultural values should be rekindled in the learners' lived-world. This could mean the integration of both Western and Indigenous worldviews to avoid teaching science as abstract. Kawagley, Norris-Tull and Norris-Tull (1998) and Snively and Corsiglia, (2001) are of the notion that there are many ways of knowing as they forge ahead from the notion that western science is the only way of making sense of the world we all live in. Objects can be viewed from more than one perspective and will subsequently mean different interpretations. The culture and language of an individual, influences how they approach science learning (Aikenhead, 1996, 1997; Jegede & Aikenhead, 1999). South Africa is a major player in the quest to achieve the integration of both indigenous and western hybrid of teaching and learning as I have highlighted before from the caps documents. However, there are some doubts in by some researchers on the integration of western and indigenous knowledge.

These challenges are according to Angaama, Fatoba, Riffel and Ogunniyi (2016) are that the worldviews are premised on different assumptions. Again, from Ogunniyi (2004)'s work states that, from the western science world view, all events are caused naturally whereas, in the indigenous worldview, events are caused in both natural and unnatural circumstances. Also, Ogunniyi (2004) proceeded to acknowledge that in the school science (western knowledge) world view, scientific laws and generalizations are casual, logical rational and universal but in the indigenous worldview, generalizations are casual, personal rational and non-rational, logical and non-logical in dimensions. Further scholastic view posits that the policy documents did not explicitly enumerate the "how" the integration of the two worldviews will take place nor did were the teachers to implement these policies consulted (Ogunniyi, 2007). Hence the teacher become disinterested in the implementation of these policies and even become confused as to what to do in the science classroom.

Again, as reported by Roehrig and Luft (2006), teachers had been embodied with the western science teaching methodologies and mode of inquiry as they were taught in the teacher training. Teaching indigenous knowledge and methodologies with western knowledge and methodologies could also seem an arduous task. This is especially when the teacher is embodied with less indigenous knowledge to work with. Hence this research work tends to fill the gap of how both knowledge can be integrated by the teachers perhaps to avoid conflicts in the integrating process. This study also tends to illuminate the integration process of enabling learners' understanding of simple and complex organic molecules. It also tends to shed more light on how to integrate cultural artifact with western science. Onwu (2009) argued that these challenges include too many indigenous practices according to different culture making difficulties to choose which indigenous knowledge to use and which to leave out. Besides, Onwu (2009) further argued that some teachers are holds the perception that indigenous knowledge is outdated, demeaning and not in tandem with modern and current thinking (as it happened to me) perhaps because of the aged domination of western science and devaluing of indigenous systems. A similar sort occurred from Bridget's narrative when her colleagues would ask her, why does she put on these beads every day, and she answered by telling them, this is my culture, my identity; hence they (Bridget's colleagues) stated calling her Mama Africa. There should be no hegemony of any sort as regards knowledge and especially on the integration of both knowledges as even the child or learners may be confused. The child speaks his local language at home and gets to school, suddenly, he is prohibited from speaking his language. This could possibly cause a sort of science concepts misunderstanding? Learners tend to readjust to the new environment (from the home to school) and then readjust again (from home to the school). Why would an indigenous learner continue to re-adjust each time s/he gets to school and home respectively? This could be a disadvantage in their learning processes as against the learners whose language at home is also the language of instruction in the classroom.

Culture and Science

Understanding science concepts to the constructivist entails the development of the mental in relation to the learners' social interaction in the classroom. The framework of socio-constructivism, from social constructivist studies argue that, the effects of culture on science especially in non-western countries remains devastating. Ogawa (1986) posits that science evolved from the western culture, which is also reflected in western history and western foundational beliefs or worldviews. The beliefs of the western learners shape their understanding, so also the indigenous learners. Otulaja and Ogunniyi (2017) also is of the same view that most scientific curricular in African Nations are modeled on western curricula (colonialist) and hence do not reflect the cultural background of the African learner. Mpofu, Mushayikwa, and Otulaja (2015) contends that scientific concepts are best learned and understood in the student's mother tongue regardless of the technical limitation of the language. Brayboy and Maughan (2009) found that the dominance of the learners' prior understanding can quite lead to unintended interpretation of what is being taught.

Likewise Schutz and Luckmanns (1973)'s foundational theory which suggest that the learners tend to typify experiences in order to create meaningful structures. This is similar to the possibilities that emerged from the use of beads and beadwork (cultural artifacts) to create models of simple and complex organic molecules. Learners were enabled to join together the carbons, hydrogen and oxygen structures without any rigorous explanation. They (learners) already had the experience from their lived-world how these beads and connected to each other. In connecting these beads together with the glue (Bostic) they, related their experiences when creating the basic structures such as H_2O and CO_2 to enable them create a more complex structure. These experiences also tailored their habituses towards meaningful experiences at the end of the lesson.

Therefore the level of which prior knowledge (learners' culture) can affect learners' learning of scientific concepts can be colossal (devastating). The concept that learners' prior knowledge can enable understanding is at variance to what Gilbert, Osborne, and Fensham (1982) argues when they elaborated on teacher's science. By teachers' science, they mean that the teacher is the centre of the learning process. Learning in these classes were beads and beadwork (cultural artifacts) were used to teach simple and complex organic compounds in a learner centered classroom. Hence, it is no more teachers' science but both teacher and learners' science. Christie (2008) has indicated that the cultural background of the learner may have a greater effect on education than does the subject content. According to Kaahwa (2011) learners bring their ways of interacting, observing, problem solving, and thinking to the classroom and if aligned to, will enhance their learning. While if not, might cause disinterest in science for the indigenous learners. These ways of being, seeing, thinking and doing, in the learners' lived-world are culture-based and can be utilized to develop instructional methods, avenues for learning, and bridging home and school contexts. This is related to findings from Okafor (2011) who suggest that rural communities explain natural phenomenon through non-rational means. Nhalevilo and Ogunniyi (2014) argues that we do not see things as they are, we see things as we are-from the individuals perspectives. Ogunniyi and Hewson (2008) contends that the present gap between the western and non-western understanding of science might be bridged by harmonizing western scientific views of the world with some of the traditional views held by those in non-western societies. Hence a culturally responsive pedagogy for indigenous learners in the science classroom with the use of beads and beadwork (cultural artifacts) to create instructional models thereby enabling learners learning that is integrated in the learners' culture.

Culturally Relevant Pedagogy

Of course, learners love subjects they pass excellently and not only that, learners seem to love a class lesson that resonates with their lived-world. I loved the teacher in whose class I was excellent as a high school learner. I never felt bored, let alone sleeping as my life sciences teacher related the science concept with things I find in my environment (prior knowledge) while he also makes the class more interactive. My life science teacher made the lesson as interactive as possible. This means that I was adapted with what he was relating the concepts of lesson to and it made sense to me as he related the science concepts to my lived world. I never forgot these concepts and I began interested in knowing more of my life sciences. With my heightened awareness on the efficacy of relating learners' prior knowledge to science concepts, in his own way, my teacher made the lesson more culturally relevant to my lived-world; hence, my soft spot for life sciences. I also unconsciously applied this same pedagogical practice to my high school learners. This pedagogical practice also motivated the possibilities of the use of beads of beadwork (cultural artifacts) to create models of simple and complex organic compounds. Culture and the curriculum are human artifacts argues (Bourdieu, 1967). If so then both has to be culturally inclined with the teacher and learner perspective in view. Villegas and Lucas (2002) used the term culturally relevant pedagogy to describe teaching that recognizes that all students learn differently and that these differences may be connected to background, language, family structure and social identity. According to Osborne (2002), culturally relevant pedagogy refers to building on the students' lives and cultures in such a way as to foster ethnic pride and academic success using teaching strategies with which students are comfortable. Gay (2000) defines culturally responsive pedagogy as using the cultural knowledge, prior experiences and performance styles of diverse students to make learning more appropriate and effective for the learners as it seems to enhance the learning strengths of the learners.

Gay (2000) proceeded to argue that culturally responsive teaching connects students' cultural knowledge, prior experiences, and performance styles to academic knowledge and intellectual tools in ways that legitimize what students already know. Some researchers has called it culturally appropriate learning (Au & Jordan, 1981, p. 139). This is because of the pedagogy of teachers in a Hawaiian school that infused aspects of students' cultural background into their reading instruction by permitting students to use what he calls 'talk-story'- a language interaction style among Hawaiian children. By doing this, it was reported that teachers were able to help learners achieve more than the outcome they were expecting. Mohatt and Erickson (1981) synonymously coined theirs as culturally congruent. Cazden and Leggett (1981) coined a name similar to all those already mentioned as culturally responsive while Jordan (1985) and Vogt, Jordan, and Tharp (1987) called it culturally compatible. Irvine (1990) argues it is called cultural synchronization between teachers and then African – American children as reported in Ladson-

Billings book titled, *But that's just good teaching! A case for culturally relevant pedagogy*. All these definitions tend to describe the learning process that becomes relevant to the learners culture.

In addition, drawing from the work of Gay (2010); Nieto, Bode, Kang, and Raible (2008), and Ladson-Billings (2009), teachers who adopt cultural relevant pedagogy practices reportedly value learners' cultural and linguistic resources and view this knowledge as capital to build upon rather than as a barrier to learning. And of course a culturally responsive teacher would not adopt in the classroom what the learners seem not to value. As earlier studies that incorporated learners' culture in an instruction-centered pedagogy, revealed that there has been a cultural mismatch between school and home, hence the low indigenous learners' engagement with science (Ladson-Billings, 2011). These teachers use their capital (i.e., personal experiences and interests) as the basis for instructional connections to facilitate student learning and development. A number of indigenous writers have contended on the importance of connecting school science education to students' cultural knowledge and vice- versa (Cajete 1994; Kawagley & Barnhardt, 1999; Mckinley, 2007). Making this connection to the cultural background of the learners can be done in two ways according to Cassie (2010);

1. Making science relevant to the learner which usually involves teaching in culturally relevant context and
2. Using culturally responsive teaching or culturally based pedagogy (Ladson-Billings 1995).

Teaching simple and complex organic compounds with instructional models created from beads and beadworks (cultural artifacts) in the life sciences classroom corroborated making science relevant to learners in a culturally relevant context. Learners interest in beads and beadwork (cultural artifacts) provides a basis for interest in learning organic structures as they created these structures with beads. To the learners, the reality of the creation of scientific models (now indigeno-scientific models) from beads and beadwork (cultural artifacts) seem to enhance their identity and value of their own knowledge. "So I can also create these structures with beads" a life science learner said in Mr. Brighton's class. This is a sense of identity which indicates and validates the increased relevance of indigenous knowledge to western science to the learner; hence, western science has been made relevant to the learner in a way that resonates with the learners-lived world. In a supplementary perspective, making teaching culturally responsive to the learners appear to resonate with indigenous learning philosophy that accommodates communalism (Goduka, 2005), interactions (Chilisa, 2012) and practicality (Otulaja, 2012). Using beads and beadworks (cultural artifacts) in a way activated the teachers' instincts to arrange the learners in groups of 3, 4, or 5 to further enhance learners' interaction in the science classroom. These abstract concepts of simple and complex organic compounds were presented to the learners in a practical form as they were able to create structures that resembled the structures they read and memorize in their textbooks. These processes enabled the teachers teaching culturally responsive to the learners according to Cassie (2009).

Goduka (2005) argues that for African learners, aligning the context in which the learners learn with the context in the science classroom can enhance their better understanding of science concepts. Indigenous learners learn in a way where the relate what they want to learn to what they already know and further linking back to what they want to learn. This nature of learning seems cyclical; hence Goduka (2005) conceptualized the idea of gathering at the fire place (eZiko; classroom) where knowledge is produced (siPheka (we cook)) and share knowledge (siSophula (we dish out))". eZiko siPheka siSophula literally translates to, we gather at the fire place communally to cook and to dish out what we cooked; in essence, liking this to education, science teaching and learning, and connoting that we gather in the classroom (fire place; eZiko) to produce (siPheka) and to share (siSophula) knowledge, science knowledge. One of the pillars of the eZiko siPheka siSophula (the fire place theory) is relational ontology (there are six more, see Goduka (2005)), which is also, according to Chilisa (2012), is an African way of knowing and doing; a form of relational pedagogy (Otulaja, 2018, personal communication). On account of the relational ontology or pedagogy, cooking in the science classroom connotes the practice of knowledge production (teaching and learning) while the dishing out in the science classroom connotes the sharing and receiving of the knowledge produced ("cooked"). The practice of eZiko siPheka siSophula is communal. Indigenous learners are used to this culture of learning communally. Introducing indigenous learners to the westernized individualistic way of learning and knowing in the science classroom, may at first, result in cultural shock (Aikenhead, 2001) and eventually, resistance (Otulaja, 2017, personal communication) and thus emergence of learners' disinterest in science because the individualistic way of learning is in misalignment and incongruent with the way of learning that indigenous learners are accustomed to. Learners consciously or unconsciously place value on experiential knowledge (Chilisa, 2012) and as advocated in the Critical Race Theory (CRT) (Chilisa, 2012). Chilisa (2012) also challenges dominant ideologies such as individualistic westernized approach to learning by deconstructing dominat ideologies and reconstructing indigenous ways of interdisciplinary, transdisciplinary, multidisciplinary and intradisciplinary learning, valuing of experience as foundational to knowledge and use of language as the source of knowledge. These constructs contributes to the emergence of a culturally responsive pedagogy (CRP).

The Metropolitan Center for Urban Education, New York City, explained culturally responsive pedagogy (CRP) as one that acknowledges learners' background knowledge, values their social experiences, and takes into consideration learners' learning styles in daily lessons. Learners' background knowledge such as the knowledge of beads and beadwork (cultural artifacts), relating the models created to the abstract structure in the textbooks, and acknowledging the visual (different beads color), tactile (feeling of touch of the models), verbal and audible learners were catered for by the use of beads and beadwork (cultural artifact). Learners bring with them a set of values and beliefs, or their "funds of knowledge" (Moll, Amanti, Neff, & Gonzalez, 1992) from their homes and neighborhood (cultures) that may complement with the school culture, and make legitimate the social, economic, political, and cultural hegemonic values of the dominant society. Perhaps the need for the terms culturally appropriate (Au, 1980), culturally responsive pedagogy (Ladson-Billings, 1995), culturally alignment (Aikenhead, 1996) and cultural incongruities (Barnhardt & Kawagley, 1998). Teachers that are culturally responsive are saddled with recognizing the learners' biases and values while they reflect on how these influence their expectations for behavior and their interaction with learners as well as what learners look like.

Weinstein, Tomlinson-Clarke, and Curran (2004) advocates that teachers recognize that the hallmark of classroom management is not to achieve compliance or control by providing all learners with equitable opportunities for learning but to enable learners understanding. In the traditional teacher-centered classroom, teachers' classroom management skills was evident in how s/he could keep the learners quiet. In keeping the learners quite in their position, and the teacher can teach the lesson without learners noise, then the teacher is said to need a good classroom manager. However, according to Weinstein et al. (2004) the hall mark of classroom management is not to achieve compliance but to enable learners understanding; hence the teachers enabled the learners understanding of simple and complex organic compounds by allowing the learners to learn in groups and with culturally related instructional models and wholesome understanding thereby enhancing peer interaction. In addition to the above, Sheets and Gay (1996) argues that teachers need to become aware of biases, in order to develop skills for cross cultural interaction.

Science Teacher's Professional Development

Teachers needs to become aware of learners cultural background as well as gaining general knowledge about a cultural or ethnic group so that teachers can have a sense of insight about the likely behavior of learners. Teachers can also ascertain rules of decorum and etiquette, communication and learning styles of a certain group or individuals in the classroom. Professional development can be viewed as an ongoing learning experience a teacher engages in for professional and cognitive growth. The overall process of professional development is ultimately influenced by policy and is concerned with learners' learning (Julie & Peter, 2014). In Lieberman's (1995) study of professional development amidst in-service teachers, the argument is that learning is personal and professional, individual and collective, inquiry-based and technical. It is of the utmost importance to recognize that teachers themselves are personally responsible for their own professional development (Kennedy, 1999). The teachers' professional development program must be clearly defined according to its content, context and process (Gardner, 1972). The content should focus on disciplines that consist of domains and knowledge. The context can range from school environment to national policies while the process can consist of setting goals, planning, enacting and envisaging outcomes (Loucks-Horsley & Hewson, 2010). This should also apply in pre-service teachers' preparation.

For prospective and practicing science teachers, radically new ways of viewing the teaching and learning of science needs to be adopted to meet the new demands in science education (Hurd, 1993). The role of science teachers in the classroom necessitates the preparation of pre-service teachers for the rigors of the professions and engaging their cultural knowledge. One that values inquiry and thinking, that presents a coherent and consistent experience for the learners, and that seeks to be self-improving through processes of reflection, feedback, and critical inquiry, must be adopted (Kennedy, 1998). A fundamental role of science teacher educators is to get pre-service teachers to think about their own explicit and tacit thoughts, science education, teaching and learning and cultural knowledge. One way to accomplish this is to get learners to articulate and discuss their understandings, beliefs and prior science experiences as it relates to their cultural knowledge. It is assumed that the learners, teachers and their environment need to interact interchangeably. Effective class interactions can increase engagements among the learners and subsequently enhance their learning.

In the classroom settings, learners and teachers spend a considerable amount of time together. One-way interaction (monologue) may not work for the vast majority of learners. Therefore, multiple ways of interaction, enhanced by dialogues, which ought to happen as learning progresses, is suggested. A salient aspect of such dialogue-based teaching is to give learners voice and help them realize that their teacher wants to know what they think so that they will feel free to express half-formed or even confused ideas. Walberg (1976) emphasized that learners' perceptions of their teachers' behavior should not be underestimated; rather, it should be considered an important mediator between the instructional characteristics and academic achievement, that is, academic achievement is dependent on instructional strategies. In order words, the better the instructional model, the more likely that learning takes place. Learning is a relatively permanent change that can occur in motor, cognitive and psychodynamic behaviors of learners as a direct result of experiences shared by some learning theories (Lowyck, Elen, & Clarebout, 2004). In establishing a culturally responsive pedagogy in the classroom or a science classroom that is culturally responsive, I assume there are tools needed. And again, the teacher cannot teach what he does not know; hence the need to first teach the teacher before the teacher teaches the learners. Ogunniyi and Hewson (2008) reports that the teachers saddled with teaching these science concepts with both knowledges and representations (indigenous and western) are only western trained; hence they find teaching these learners with indigenous representations difficult. For this reason, I find it necessary to teach the teachers first the creation of instructional materials or models as tools (CRIM) for teaching in the classroom. These artifacts/tools, when cognitized becomes resources learners allude to while learning as well as access these artifacts and tools during science teaching as they are materials that enhance learning in the classroom. They are called culturally responsive resources (CRR).

Culturally Related Pedagogical Resources (CRPR)

These could otherwise be called cultural artifacts/ tools. According to Brown and Fleming (1974) cultural artifacts are objects that put more light on the history of a particular community or a particular phenomenon. These could be community owned or personal belongings used for aesthetics. The people identify with these objects. Can these artifacts be modeled into instructional materials? Yes, I believe and this study explored the possibilities. When these aesthetics objects are now used for cognitive learning (cognitization), they become CRR as they relate science to the learners' lived-world. Cultural artifacts become transformed into instructional models (CRIM) by the cognitization process which is a process whereby non-cognitive objects (aesthetics objects) become materials used cognitively for learning. The creation of indigenous knowledge resources for the integration into science curriculum is a goal when integrating indigenous and western knowledge in the science classroom. Studies relating to indigenous knowledge has switched gear from the possibility of integration of indigenous knowledge into science to what knowledge can be discovered, applied and how can the discovered indigenous knowledge be integrated with science for indigenous people. For Shizha (2015), culturally relevant teaching and learning does not necessarily mean the removal of western education, it means the increases value of indigenous knowledge to the indigenous learner. It is just that when teaching indigenous learners, the teacher should consider relating science concepts with examples in the learners' domain or context, his learning style and subsequently learners' culture.

An example is the use of beads and beadwork (cultural artifacts) to explain simple and complex organic molecules like linear and complex glucose structure, fructose structures, lipids and protein structures along with other concepts as against steering at these pictures in the textbooks as well as depending on the government to provide 3D pictures of these compounds. It is also a reference to Bridget's application of the knowledge of beads and beadwork to learning in the classroom. This is in accordance with Lee (2003) who argues for a "no one size fits all" approach to teaching and learning as more than ever, indigenous knowledge needs to be promoted and patented. It is an idea of finding a place for indigenous Education inclusion in the globalized world. Voices of Educators and indigenous people have led the awareness of the importance of indigenous knowledge application in the classroom (Cassie, 2009). No longer is it acceptable to treat diverse groups as homogenous whole with the same needs and experience.

Cultural objects as mental models. In Ellen Siebers's (1989) article on teaching with objects and photographs, she argues that employing these cultural objects as teaching aids engages learners who does not responds to written materials. Not only those who does not always respond to written materials but all learners in form of hands-on, minds-on activity. I am sure here she is in favor of taking into consideration, learners' learning styles. Rogoff's (1995, 1998) discussed the use of cultural tools (both in the object form and psychological form) in the development of understanding. These objects should enhance learners' learning and aids meaning-making in the science classroom. Cole and Wertsch (1991) argue that an important characteristic of tools or artifacts is that they do more than simply assist in the development of mental processes; they essentially shape and transform them. Lemke (2001) also focused on different contexts we live in as our lives within these communities and institutions give us tool for making sense of and to those around us. Looking back at Vygotsky (1978) who described psychological tools as what can be used to influence the mind and behavior, while technical tools are used to bring about changes in other objects. Vygotsky (1978) also contends that tools mediate social and individual functioning and connect the external and the internal, the social and the individual. If these tools/artifacts are cognitized to enhance teaching and learning in the science classroom, then it becomes a case of culturally related pedagogical resources (CRPR) used as culturally related instructional models (CRIM) to enhance pedagogical practice in the classroom. There is the interaction between these artifacts or cultural tools, the teacher and the learners. In this case, the tools are the beads as interactions between the three agents are a multiple way. Psychologically there are mental processes that occur during the process of making meaning or understanding the concepts being taught.

These construct of mental models as it emerged in cognitive science in the 1980s corresponds to a constructivist view on model-based learning (Seel, 1991). Proponents of the mental models argue that learning occurs when people actively construct meaningful mental representations with objects. In this study, learners constructed mental and practical representations with beads and beadworks (cultural artifacts) in the life science classroom. Mental models Such as schemas (Vygotsky, 1978) and coherent mental models that communicate subjective experience, ideas, thought and feeling (Seel, 1991) are formed. According to Rumelhart, Smolensky, McClelland, and Hinton (1986), People have three essential abilities for processing mental information and acting successfully in various environments. They are pattern marching, modeling of their own worlds and manipulating their environment. All these are evident in Bridget's narratives on how she acquired, developed and reproduced the knowledge of beadworks (cultural artifacts) and still create other bead creations. From these three abilities, I can figure out three essential abilities which are patterning, modeling and manipulating. This also resonates with Bridget's' narration on the knowledge of beads and beadworks in Chapter Three. From her narratives, patterning and the ability to design and re-design created (to manipulate) works was enumerated and was used to form instructional models. Creation of models as instructional materials can be very important in an African child classroom.

The importance of instructional materials cannot be less emphasized. Ogunniyi, Amosun and Otulaja (2013) contend that the materials (instructional models) enable an increased rate of learning as the teachers' time and effort is saved for the further lesson. It also helps to increase learners' interest and facilitate the retention of what has been learned. It is no more news that indigenous learners are battling with poor performances in science, technology and myriads of challenges as evident in the state of our society. Others such as poor laboratory and teaching facilities as well as teachers inadequately equipped for the tasks of teaching indigenous learners are also not left out. Another condition is the insufficient supply of instructional materials from the government as against increase in the number of learners and the non-provision of some instructional materials as seen in the South African curriculum such as the case of bead. The curriculum states that the teachers should use beads and plasticine to demonstrate the simple and complex organic compounds in the classroom which was not provided. The use of instructional materials between human components and the environment was explained by Engeström (1999) who supports studying with the use of artifacts as an integral and inseparable component of human functions. He advocates for an artifact-mediated and object-oriented activity

The agents for a culturally-responsive schooling can be models made from cultural artifacts, teachers and learners. Culturally Related Instructional Models (CRIM) can be cultural artifacts that can be created from beads and beadwork (cultural artifacts). The possibilities of using beads and beadwork to create models to teach science and life sciences is anticipated to bring innovations, increase learners engagement and sustain learners participation in the classroom. There are further possibilities to develop learners collaborative skills, enhance learning amidst different culture of learners, and imitate images of virtual scientific concepts. It can also develop cognitive and motor skills in learners as well as create a culturally responsive learning context for the learners. Beads are among the most intriguing and important symbols in African culture, past, present and perhaps into the future. The materials used in making beads/beadwork are of the largest variety, from bone, woods, glass to plastic. They are of different colors and sizes. Those who wear them do so often with affection, cultural pride and glamour. The use of beads differs across the globe. While some are used for prayers, as anti-tension devices, others use beads for currency or medicinal purposes. In other culture, beads are used for games, as adornment, as souvenirs, even as love letters. They are also used as body weight determinant, for body shaping and for teaching colors and numbers. Beads can be used to teach early mathematics concepts such as counting, sorting, patterning, addition, subtraction, multiplication and division from Bridget's narratives etc. More important is the designs (technology) carried in beadwork. Some beads are designed aesthetically and configurative in three-dimensions similar to DNA structure and chromosomes.

History of Beads and Beadwork

Historically, the use of beads in Africa can be traced back at least 12,000 years. The oldest known beads were found in the Kalahari Desert, Sudan and Libya. The earliest beads were made of eggshell, clay, twigs, stone, ivory and bones as glass beads were introduced later by traders from Europe, India and the middle-east. Beads were used in various parts of Africa as materials for adornment as well as items for currencies in different African countries. The beads were used as symbolic capital as it defined and identified the individual's status as well as class and tribes the individual's belong to. Works of art was inspired by the use of beads and beadworks (cultural artifacts). In Nigeria, beads are, apart from adornment and at a time currency purposes, beads are used for musical instrument such as Sekere. (See below).

Fig. 2 - Sekere

Some cultures use beads for what the Yoruba tribe of Nigeria calls Ileke-idi.

Fig. 3 – Ileke idi

Ileke-idi means beads made for the waist (waist band). It is the beads that make the buttocks shake/jiggle. The beads of the waist possess the power to attract, evoke and to send deep emotional signals and responses according to Onilu (2011). Some brides also seduce their spouses with the beads they wear on the waist. In the olden days, The Yoruba female elders can comment on a lady's moral standing by interpreting the movement of the beads on the individuals' waist. It also shows whether the lady is seductive or reserved. Sometimes the beads become signs of success and affluence. As symbols of affluence, it enhances the wearers' symbolic capital. Some beads make up healing stones that the society believes reduces and stops menstrual pain or cramps, lower abdominal problems or even some womb malfunction.

According to Yagbe Onilu (2011) who is a Yoruba cultural stalwart, “sekere” is also found in some countries in West Africa such as Nigeria, Togo, Ghana, Sierra Leone and Ivory Coast. According to him, different tribes in these countries with different language have their own names for the “Sekere”. The Sekere looks like a round cup-shaped calabash that is encircled with beads held together by thread. According to Onilu (2011), the sekere is never loaned or even shared with family members however; it is inheritable like from a Father to his son. It is given great respect and played in important traditional occasions. It is also used in various traditional worships. The water deity adorns waist beads for protection against spiritual attacks as part of their dress regalia according to Onilu (2011). Also, beads are used to adorn the “Ere-Ibeji” meaning “the wooden image of a twin” when one of the twin dies at birth. This is on account of the belief that when the wooden image is treated well, the spirit of the dead twin will not harm the living twin and will return to the family to stay. Furthermore, these beads is worn and laced with charms to ward away the “Abiku” spirit - mermaid spirit from a woman. The Yoruba, one of the major tribes in Nigeria, produces beads ranging from royalty, to body adornment to deification and decoration. Beads stand for unity, togetherness and solidarity. Beads are essential elements of African body adornment.

In Southern Africa, according to history and historical sites for beads, which include Mapungubwe, Great Zimbabawe, Botswana and Mozambique (www. marques.co.za). According to (Marques.co.za), Henry Francis Fynn, who came to Durban as a trader in 1824, was apparently the first English man to have offered glass beads as standard merchandise to the north Nguni-predominantly occupied by the Zulu. The Nguni’s was best known for their eloquence in expressing messages regarding male and female relationships. According to (www. marques.co.za), further in the South, the Transkei region of the Eastern province, the South Nguni - the Xhosas, Pondo and Thembu are well known to have had close contact with the settlers in 1820. The glass beads were used as commodities for currencies as they appear to have been a by-product of the discovery of glass in Egypt during the rule of the Pharaohs, some centuries ago. All in all, it appears that there cannot be a dichotomy between Africa and Beads -

it is part of our life and culture of Africans. If beads appear as part of our lives as Africans, why then do we leave the use of beads and beadwork and other cultural artifacts behind when we enter the classroom? I supposed, culture can be tangible in form of beads and beadwork (cultural artifacts) and can also be intangible in form of our embodied capital - all carried about by the individual.

Bead and beadwork as learners' prior knowledge. Learners come to school with personal cultural background that influences their perception of teachers, other learners and the school itself. Instructional Models can be created with knowledge of their cultural background in beads and beadwork (cultural artifacts) to enhance teaching and learning. In the African culture, there exist indigenous knowledge (cultural and community resources) that can be integrated into the school curricula and pedagogy for improved learning outcomes (Handa & Tippins, 2012). Artifacts such as beads are available everywhere; if conceptualized and cognitized for science teaching and learning (cognitization) can enhance learners understanding of science concepts (Aikenhead & Ogawa, 2007).The national curriculum is viewed as an instrument of empowerment (CAPS, 2012). Considering the goals of the curriculum, there is need for pedagogy that is culturally responsive. Culturally-responsive teaching is certainly not a new phenomenon; instead, it has been central to tribal nations' calls for improved schooling (Aikenhead, 2006). Culturally-responsive teaching in science education includes a number of dimensions like culturally-responsive curriculum, culturally-relevant science and culturally-responsive pedagogy. In Addition culturally-responsive teaching prepares teachers to teach in culturally-diverse environments. The agents for a culturally-responsive schooling can be models made from cultural artifacts. These cultural artifacts can be from beads and beadwork.

As I said earlier that the classroom has become more multicultural than years back as evident in the demographical make up in most countries especially South Africa, the population has grown ever more diverse over the years with the enrolment of racial minorities in today's schools projected to increase significantly in the future, there could be a case for cultural misalignment; a case Tobin (2005) called cultural incongruities. The teacher from a different background, experiences over time, cultural cues, accent, language and others that can cause cultural misalignment in the science classroom. The learners are also from different cultural background with different ways of pronouncing words, different accents, and different views to things may also cause cultural misalignment in the classroom teaching and learning. Can these artifacts be beads and beadwork which seems common to all cultural societies, worn by many and used by many others for different purposes? Culture appears to affects how people learn, remember reason, solve problems, and communicate as it is part and parcel of the learners' intellectual and social development.

These beads are cheap and readily available to the communities where the learners reside. Indigenous knowledge improves understanding of local conditions (Warren, 1993). According to Ogunniyi and Hewson (2008), South African indigenous cultures has accumulated a lot of knowledge over the years in any aspect you can think of from medicine, nursing, mathematics, life science, physics, chemistry, chromatography, architectural design, engineering to least a few. They went further to argue that integration of indigenous knowledge into the curriculum will enhance or glue together segregations caused by apartheid as well as give then learners a dignified identities. According to Nakashima, Prott, and Bridgewater (2000) very little of the indigenous knowledge has been captured and recorded for preservation yet it represents an immensely valuable database of knowledge that provides humankind with insights on how numerous communities have interacted with their changing environments including flora and fauna resources. It is also a database from which the inclusion /integration of culturally related instructional models is being taken from to enhance learners learning in the classroom. Efforts to capture and preserve indigenous knowledge have concentrated on the documentation of good practices that can be transferred across cultures and communities. African's indigenous knowledge needs to be codified into print and electronic formats for both audio and video to make it widely accessible on the global information infrastructure (Chisenga, 2000).

Conclusion

Studies in the literature concerned with how learners learn in the classroom have always had the goal of making learning better for learners. These processes have evolved over the years as highlighted in the chapter and still evolving to the present state of discovering what indigenous knowledge can be integrated into the science curriculum and how can it be integrated. The next chapter contains the narratives of a professional bead maker (Bridget) on how (Bridget) learnt the skill and how this skill has evolved over the years to enhance learners learning in the classroom and hence her name “Mama Africa” when her name “Mama Africa”. It also contains the knowledge needed to construct models of simple and complex organic compounds in the life sciences classroom.

Chapter Three

Theoretical Analysis

Introduction

In the previous Chapter, I reviewed divergent and discrete works of selected information relevant to teaching and learning within a cultural related pedagogy in the science classroom subsumed within the existing literature. The previous chapter also tends to locate this research work within the existing pedagogical space as well as to acknowledge works of scholars as evidenced in literature (Booth, Sutton, & Papaioannou, 2016). In this chapter, I discuss the theoretical underpinnings of the learners' expanded constructs in the classroom with the use of culturally related instructional models that was created from beads and beadwork (cultural artifacts) to teach simple and complex organic molecules. As earlier enumerated in Chapter One, on account of the multi-perspectival and multi-methodological approach to this study, a multi-theoretical approach was employed in unpacking cognitive enablement in this study. This approach provides for flexibility and multiplicity of theories in generating meaningful interpretations of research findings. The first generation of activity theory defined by Vygotsky (1978) mediated action and which extended to the third level of activity theory by Engestrom (1999) was weaved together (Bricolaged) with Bourdieusian notion of forms of capitals and Bandura (1977) learning by imitation and imitation by observational (theory of vicarious learning) as well as that of Lave and Wenger (1998) legitimate peripheral participation.

The Art of Bricolaging.

Roger (2012) argues that bricolaging has a connotation that describes craftsmen or craftswomen who creatively constructs new edifices with materials available from other projects earlier done. He also posits that according to Levi-Strauss (1966), "the rules of the game are always to make do of with what is at hand" (p. 19). On account of the different happenings in this study, different frameworks at varying levels of understanding are employed in making meaning of the emerging interpretations of what happened and why. Denzin and Lincoln (2000) employed bricolaging as a methodology in resonance with Claude Levi Straus (1966). According to Lincoln (2001), Claude Levi Strauss (1966) used of bricolage as a meaning making tool from the structuralist perspective. Roger (2012) posits also that Claude Levi Strauss's (1966) articulation of bricolage became momentous and exceeded the structuralist circles of practices in focusing on linguistics. Post structuralist such as Denzin and Lincoln (2000) use of the bricolage approach became infectious and described the trends in qualitative research approach. Further studies pushed the boundaries to the critical perspectives of multi-methodological research; hence, Kincheloe (2005) criticalization of the traditional multiperspectival methodologies. Steinberg (2011) posits that Kincheloe (2005) brought rigor to the traditional ways of carrying out multiple methods p. 178). Kincheloe and Tobin (2006) further envisioned studies in which bricolage can be used to see through social enquiries and realities with different lenses at different stages of the investigation. To them, the art of negotiating through different perspectives enhances the process of meaning making that Denzin and Lincoln (2000) began. In this study, I made efforts to weave together theories that helped me interpret and negotiate through the activities both in the professional development and training workshop and the classroom where culturally related instructional models were used to teach simple and complex organic compounds.

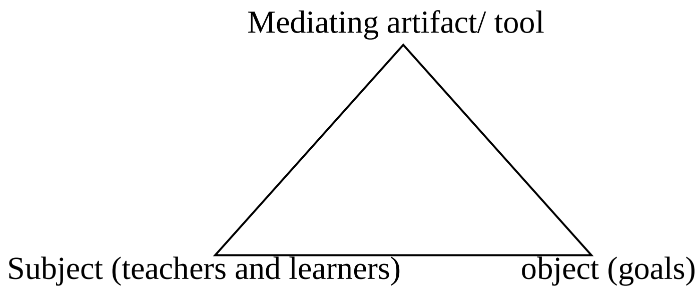
The Professional Development and Training

One of the major essences of the professional development and training workshop was to create a heightened awareness and consciousness of the possibilities of using beads and beadworks (cultural artifacts) cognitively in the classroom apart from its aesthetics uses. This is particularly significant as teachers voiced their lack of awareness of the possibilities of such uses of beads and beadwork (cultural artifacts) in the life science classroom; hence, the need to enable life sciences teachers' capabilities to teach through the professional development and training workshop. The goal was to heighten teachers' consciousness (acting as learners in the professional development and training) in the cognitive abilities in the use of cultural artifacts such as beads and beadwork (cultural artifacts) in the classroom. It was in a context of group learning with activities involving cultural artifacts (beads) thus enabling tripartite interaction among the teachers including the facilitator (myself) and the cultural artifacts.

Vygotsky (1978) elaborated on the interrelatedness between the individual, social others and the environment which co-creates human consciousness through human participation. I also sought to investigate how the individual, knowledgeable others, cultural artifacts and the environments enhances meaning making in the science classroom. According to Vygotsky's (1978) mediated action, individuals are not passive participants waiting for other dependent factors such as the environment, cultural artifacts and the social actors to generate meaning-making experiences for themselves. Experiences like the resulted heighted consciousness of the teachers as exhibited after the professional development and training became an enabler in enhancing the teachers' pedagogical practice in the classroom where beads and beadwork (cultural artifacts) were used to create instructional models to teach simple and complex organic compounds. According to Vygotsky (1978), meaning making is enhanced by interacting with other co-participants in an activity.

Vygotsky explains that in mediated action, the interaction between the teachers and the cultural artifacts results in impressions on the individual teachers. Impressions lead to expressions. The others see the expressions as markers of successful interactions in an activity. Impressions such as the smiles and sense of teachers willing to construct more organic structures apart from the ones they have constructed are indications of teachers' successes in the tasks. Other impressions are teachers' willingness to show other teachers what and how the teacher constructs his/her own organic structures. As success begat success, teachers suggest other life science concepts that beads and beadwork (cultural artifacts) can be used to teacher and learnt from. Success in creating one organic molecule leads to wanting to create other complex molecules. According to Vygotsky (1978) impressions do not have physical existence or tangible presence in the environment but they appear as results of the interactions between co-participants and the cultural artifacts (beads and beadworks). The subjects in the study according to Vygotsky (1978) is the participants (teachers as learners) in the professional development and training seminar, the mediating tools is the artifacts and also the social others (the individual peers). The mediating tools can also be conceptual as seen in the social capital elicited from peer interaction. While the object of the activity is the goal workshop which is to create teachers heightened awareness on the possibility of using beads and beadworks (cultural artifacts) to create instructional models of simple and complex organic compounds.

Vygotsky represented this three constructs (subject, object and cultural artifacts) in a triangular representation as he tends to elaborate on human conscious development or human cognitive heightened awareness of the use of beads and beadwork (cultural artifacts) in the life sciences classroom. The beads and beadwork (cultural artifacts) created a context whereby participants enacted by action to enable heightened consciousness that changed the teachers practice.



Thus the tripartite interaction between myself, the teachers and the cultural artifacts and among the teachers, the learners and cultural artifacts in the class where culturally related instructional models were used to teach simple and complex organic compounds as elaborated by Vygotsky (1978) mediation theory; was extended through the work of Leontiev and Luria (1999) to Engestrom (2001) activity theory. Leontiev (1974) posited object-oriented activities as the unit of analysis in an activity system according to Yamagata-Lynch (2010, p. 21). This elaboration was further expanded by Engestrom (1993) from Vygotsky (1978) mediated action which is used now as a model of human activity that accounts for interpersonal relations.

Interpersonal relationship between the subject and the objects and the enculturation of humans (social actors) creates an enabling value to the artifacts and as the formed impressions continue, there is also a transforming value of the artifacts in the perspective of the subject (Vygotsky, 1978). The interpersonal relationship between the subject and learners created increased value in the mediating artifacts as they value the interaction process. The teachers all suggested the importance of continued use of artifacts for teaching and learning in the life science classroom as well as the influence of the use of culturally-related instructional materials on learners' better understanding. From the process of mediation and the development of heightened awareness of the teachers, teachers seemed enabled to facilitate learners understanding of simple and complex organic structures in the life science classrooms. According to Vygotsky, the process between mediation and development of human consciousness is the process of internalization which occurs between people (social factor of interaction) and inside the individual as learners' learns by doing (Dewey, 1938).

From this study, the process of internalization of the life sciences concepts sometimes is described by semantic signs showing that the teachers are learning. Signs in form of phrases such as, “we get it”, “okkk…”, “it is true”. They represent cognitive signals that something is happening during the lesson. This semantic signs also signify the Zones of Proximal Development as Vygotsky (1978) explained. Vygotsky (1978) posited that, the learners (ZPD) is the distance or difference between the point when the learner achieved the task with the adult guidance and the distance which the individual achieves the tasks without adult guidance. These phrases seemed to depict that they (teachers) which were learners in the professional development and training workshop, understood the concept of simple and complex structures being taught. Understanding of these life science concepts by the use of beads and beadwork seem to enhance how other learners (teachers) view themselves in the classroom and also how I view them in the facilitation process in the classroom. It also suggests to me the points where they seem not to understand and the points where they seem to. The increased value of beads and beadwork (cultural artifacts) from aesthetics to cognitive seem to elaborate on the polysemic and polyphonic nature of activities in this study. The polyphonic nature of the study unpacks the different roles, perspectives and positions of change agents (actors) in the study.

Classroom as a Place for Knowledge Sharing

These change agents in the classroom where beads and beadwork were used to teach abstract concepts of simple and complex organic structure seem to express themselves more as they negotiated their learning in the science classroom. This did not happen in the traditional teacher-centered classroom where learners’ learning was all dependent on the teacher as the sole source of knowledge. Thus the learner-centered provided by the use of cultural artifacts, provided a situated learning context aligned with the learners’ lived-world. According to Goduka (2005) eZiko siPheka siSophula fire place theory, Indigenous learners’ lived-world is situated in communality. The idea of learning of collective rather than individualistic learning is also seen as holistic, participatory and experiential as depicted in the “si” meaning “we” in siPheka siSophula (we cook and we dish). The communal nature of learners’ way of knowing can be said to be situated in the circular or cyclical view of life from the indigenous perspective as a child comes from the ancestral world to the living world and back to the ancestral. In the CRIM classroom, the groupings of the learners also seemed to depict the communal, circular nature of learners' lived-world. The classroom can also be a place of gatherings (iZiko) for cooking (teaching) and dishing (sharing – giving and receiving) knowledge. The phenomenon is underpinned by seven pillars theoretically and methodologically namely, relational ontology, African epistemology, African axiology, African ideology, African logic, Relational cosmology and Relational teleology.

Learners formed positive identities of success and labelled them in relation to their neighborhood (hood of thembisa), in relation to their names (KP) and in relation to animals or totems (we are dogs1). To the learners, the identities are named by symbols that depict positivity in their neighbourhood. This is relational ontology. According to Goduka (2005), it addresses questions pertaining to the nature of reality or being. Furthermore, the communal nature of learners' lived-world mirrors the ways of knowing and processes used in order to know phenomena (Goduka, 2005). Goduka (2005) also alludes to these phenomena as An African epistemology that advocates for subjectivity in research over objectivity. Subjectivity over objectivity enables the teacher to value the learners' lived-world in enhancing the learners understanding of science rather than teacher-centered classroom pedagogy where the learners depend on the teacher for knowledge. This phenomenon Goduka (2005) argues as African axiology. The value of the learners' lived-world (African axiology) by the teacher as seen in the CRIM classrooms culminated in promoting interrelatedness among the agents in the classroom (teacher, learners and culturally related instructional models) or culturally responsive pedagogical resources (CRPR). The practice and process of interrelatedness is what Goduka (2005) called African ideology.

Learners, alluding to objects/animals in their environment to label their identities of success can be as a result of their interconnections and interdependency with their environment. This Goduka (2005) calls relational cosmology. As learners transfer the interconnection and interdependency in enabling knowledge production in the science classroom, these concepts tends to become epistemic concepts to the learners in enhancing better understanding of science as they tend to relate what they were taught to what they already know in their environment. According to Goduka (2005), this enables reasoning and organizes how and what the learners know. Goduka (2005) calls this indigenous or African logic as well as the emphasis on experiential knowledge by Chilisa (2012) in the critical race theory. The critical race theory characterizes: (i) rethinking language as the source of knowledge; (ii) importance of interdisciplinary approaches; (iii) history as the foundation of knowledge and the body of experience; and (iv) a challenge to dominant ideologies. The use of beads and beadwork as CRIM in the science classroom challenges the use of only westernized instructional models as the only valid type of instructional models that can be used in teaching and learning in the science classroom.

The Classrooms as a Social Field of Interaction

Our classrooms (both traditional teacher-centered and the classroom with the use of culturally related instructional models for teaching and learning) is a social field of social engagement/ interaction. It is structured by rules, roles and resources with humans as change agents. Human interactions require agency (power to act) and structure (rules, roles and resources). Structure and agency interrelates in a dialectical relationship i.e. both structure and agency cannot be separated from each other; in essence, they influence one another to enable human interactions. Therefore the classroom is a field of contention where teachers and learners exert agency to appropriate rules, roles and resources as they interact with one another. Similar to the tripartite interactions in the professional development and training where teachers (as I said earlier) acted as learners were agents as well as myself (facilitator) and the cultural artifacts as resources. And the life sciences classroom where culturally related instructional materials created from beads and beadwork (cultural artifacts) were used to teach simple and complex organic compounds.

In the traditional teacher-centered classroom, the teacher pedagogical practice was a sort of one-way didactic teaching. The rules (pronounced/explicit and non-pronounced/implicit) seem to favor the teachers didactic practice where the learners are allowed to talk when the teachers deem fit. By pronounced rules I mean those rules the teachers tell the learners as regards classroom management. Instructions like "do not talk", "stop making noise", "don't open your text books until I tell you to do so", "Nobody should murmur in the classroom", only talk when I allow you to answer questions and so on as seen in the four teachers traditional teacher-centered classroom in this study. And by non-pronounced, I mean, rules that the teacher does not say but exist during the teachers lessons. The learners sitting positions seems to automatically influence teachers pedagogical practice the sitting positions seems to depicts to the learners that they should face front and not talk to those around them). Teachers' expressions (perhaps a certain stern face or certain body gestures) can also depict to the learners that the teacher wants them to ask questions or not. These appear as rules that seem to hinder learners' interactions with each other and also with the teacher in the classroom.

Also, the use of power in this social field (Life sciences classroom) seems one-sided to favor the teacher. The teacher determines what happens and how it happens to a very large extent in the traditional teacher-centered classroom. These rules seem to affect the other agent (learners) in the classroom teaching as they seem passive in their learning process. The learners' agency is affected by the rules; hence, the learners' role is also affected as the learners are made to either not talk, or talk when allowed. The social field (classroom) has agents positioned in different roles with rules allowing (teachers) or disallowing agents (learners) some roles (peer tutoring, peer assessment) in the classroom as seen in the teacher-centered classroom. Rules by an agent (the teacher) seems to affect the science understanding of learners as in the traditional teacher-classroom of the four teachers(as seen in this study) as the teachers simply delivered the lesson to the learners and spoke for most of the lesson while the learners only responded in a one-word answer when asked questions. Sometimes in the classroom, a learner might decide even not to talk despite the teacher allowing him or her to talk.

There also seems to be little or no distributed leadership in the classroom. Leadership in the teacher-centered classroom can be seen articulated by the teacher while the learners remain passive. Leadership roles like peer tutoring, peer assessment, peer questioning, peer complements, are all form of learners expression absent in the traditional teacher-centered classroom. The teachers' rules (implicit or explicit) seem to inhibit these leadership roles in the learners. The teacher's rules in a way, hinders the learners' leadership expression in the classroom. The learners seem to have fewer roles in creation of their own knowledge. The learners power to act seems to be reduced to just hearing from the teacher. the teacher in the traditional teacher-centered classroom seem to be overwhelmed with the work he is to do and therefore tends to wear out as he moves from a classroom to another. In the four classes, the instructional materials captured were the learners' text books and the chalk and chalkboard. This seems opposite to the dynamics in the four teachers' classroom where culturally related instructional models were created from beads and beadwork and used to teach simple and complex organic compounds in the life science classroom.

The cultural artifacts (resources) in the classrooms where beads and beadwork (cultural artifacts) were used to create instructional models for teaching of simple and complex organic compounds, in a way influenced the interaction of the teacher's rules and roles. Perhaps because of the interest and familiarity of the cultural artifacts to both teachers and learners, the learners seemed to enact their ownership to the artifacts. They simply just waited for the teachers instructions on what they are to do in the classroom and carried on with their learning afterwards. At first, without the teachers' instructions on a change in their sitting arrangement, the learners changed their sitting positions to a circular/group activity form of engagement. This perhaps suits their sense of communality which according to Boykins (1986, 1994) indigenous learners' nature. Again, the learners' agency to use the cultural artifacts to negotiate their learning (construction of instructional models of simple and complex organic compounds) also increased. The learners seem enabled as they did not wait for the teacher to instruct them further and as such started to interact. The teachers' rules of not talking, not interacting while learning was collapsed and consequently learners became peer tutors, peer assessors as well as peer questioners.

Hence, there was distributed leadership, as the teachers already knew they were not the island of knowledge in this classroom scenario. The learners could allude to each other for clarification of concepts they do not understand as well as ask the teacher if they feel there is the need to do so. The learners' power to act was enabled and the learners discovered ways to expresses themselves. Those expressions were a sort of expanded constructs. Their roles now became expanded and they could function in more than being passive in the classroom. The contentions in the classroom were naturally softened as the teacher and learners' roles in learning were naturally distributed. The teacher acknowledges the learners as active agents in the classroom; hence, they were be allowed to contend for resources (lesson goals) as well as exploring more channels to access the teacher in questioning, evaluation and assessment as the learners now feel a sense of ownership of their own learning. The learners became agentic because they appear to be close to the artifacts; hence they could explore. The influence of cultural artifacts in learning looks enormous as the rules and roles of every agent in the learning process were adjusted to suit every one. As rules and roles were adjusted, therefore the structure of the teachers' pedagogical classroom was also re-adjusted. The role of these artifacts also seems to enable learners to own their learning process. They now see each other as to be able to teach each other. This seems to be a sort of the societal philosophy in the school (western classroom).

The classroom is a microcosm of the society and as such should serve the role of developing more responsible change agent back into the society. But from ways learners are been developed, using westernized approach to indigenous learners development, it seems that despite the schools being situated in the communities where the learners live, the schools are saddled with teaching learners, concepts, ideologies, notions that are mis-aligned with the societal cultural values. The classroom as a social space or field should in reality a representation of learners' lived-experiences mimicking the society the leaners came from and live in. Lave and Wenger (1991) also elaborates on learning from an adult in a non-school space as a community of practice. Relating the classroom learning to the same context, the classroom can be said to also be a community of practice where a group of people are eager to enable each other in the learning tasks as facilitated by the social agents. The cultural artifacts in a way changed the way each agent see each other, the way each agent view each other's roles, and the mediating potency of the artifacts. The teacher in turn has roles shared; hence, he can do other supervision roles, attend to the ones whose understanding of science concepts may be slow and monitor each learner's progress in the classroom.

Learners' capital as a resource. As enumerated earlier, the teachers' inadvertent grouping of the learners seems to resonate with indigenous learners' philosophy of togetherness as against individual arrangement in the classroom and the sense of togetherness seem to serve as a repertoire of social capital. Boykins (1986, 1994) alluded to this as communalism. I alluded to such togetherness in Chapter One when used as an analogy of my interaction with my dad where those I distinguished now as my uncles and aunties were members of a large family. Hence, we found strength in interacting among ourselves. Similarly, the learners in the classroom where cultural related artifacts were used to enhance their learning by creating instructional models of simple and complex compounds from beads and beadwork (cultural artifacts) could have seen themselves as communal, as it is in their cultural background. Grouping themselves in a community of practice seem to enhance their learning as they assessed themselves by peer questioning, peer tutorship, peer translanguaging as seen in this study etc. Learners' being able to access each other in the classroom lunched the learners learning into a context that is similar to what they are used to (situated learning) in their cultural context; hence, they (learners) valued their collective experience and interactions (social capital) as they negotiated their learning. Lave and Wenger (1991) argue that learning should be situated and contextual, which is in contrast with the traditional teacher-centered classroom practices that involves abstract knowledge that is alien to the learners' lived-experience. These learners, with their collective social capital, expanded their agentic constructs from being just passive responders in the classroom to active questioners, peer instructors, peer volunteers, peer evaluators and assessors and peer content demonstrators.

To the learners, social capital formed by their interactions became valued transactions to produce stocks of knowledge to be accessed for learning and understanding of science concepts or simple and complex organic compounds. Could social capital be an access the stock of knowledge for science learning? Depriving the learners' conscious access to each other and to the teacher in using peer translanguaging, peer tutoring, peer evaluation and assessment of each other and demonstration of the content seem to impede indigenous learners' understanding of science concepts as captured in the teacher-centered traditional teaching. In resonance with Lave and Wenger (1991) situated learning in a community of practice, learners interacted freely in their various groups (inter and intra grouping) as anticipated by the teacher. During learners' interaction, the learners' ability to translanguage is a form of cultural capital embodied in the learners' lived-world and enabled learners to make meaning of science concepts in the science classroom. According to Bourdieu (1985), cultural capital denotes the accumulation of symbolic elements such as skills, clothing's, tastes, posture, material belongings, credentials that are acquired as a member of a community or an environment. These material belongings could be artifacts such as beads and beadwork commonly found in the indigenous learners lived world. Wearing beads could symbolize a member of the African community as the wearing of beads is a shared culture for different purposes in Africa. The languages spoken by the learners are indigenous to them and also it is their first language. Indigenous language also seems to be a form of symbolic capital for the learners as the learners are identified with the language they speak. Hence, an interplay from a form of capital to another as a tool for negotiating learning for the learners in this case despite being in a science class where English is the lingual franca.

The interactions between the learners brought about strong social capital which resulted in using their indigenous language not only for communication but also for cognitive purposes. Learners interaction between each other generates (social capital) that enhanced their cultural capital (learners speaking indigenous languages) as they explain better the science concepts. The social and cultural capital because a source of wealth (cognitive power) in form of symbolic power which is also in resonance with Bourdieu (1985) notion of capital. The learners found translanguaging (cultural capital) valuable to their learning, perhaps because it makes deeper meaning and they have found legitimacy in their home language use in the classroom which could convey a certain nuance that English language could not convey. Language is used as a vehicle for meaning making as well as connection between different processes (Chilisa, 2012). Could the access to this capital (cultural) be a sort of motivation to the learners? Perhaps the learners would have seen the use as a sort of being agentic and a source of motivation to the teachers. According to Bourdieu (1977), if an agent has more capital, it has more opportunity to be more successful in an endeavor than the agent with less capital. The use of cultural artifacts (beads and beadwork) which resulted to learners mediating their learning with the use of different cultural languages to teach themselves appears to be a sort of transfer of capital from the society to the classroom thereby making the classroom equally place-based. In most classes, we found the learners wearing beads on their wrist despite the teachers taken them away from the learners come into the school. However, learners found a way to sneak these beads into the classroom and wearing them. It seems to be a form of objectified cultural capital.

In the traditional classes, learners have embodied their home language, but were not permitted in the classroom to express this capital. Hence, the rules and roles as dictated by the teacher only enabled the use of English as a medium of teaching and learning instruction in the science classroom. Learners could not speak their language. There seems to be an effort that premised English over indigenous languages. Teachers tend to discourage learners from translanguaging. But unconsciously, they themselves are also involved in it and discourage learners from doing same. It could be that speaking English gives teachers an advantage which enables them to cast symbolic violence on the learners. In the classroom where culturally relate instructional models were created from beads and beadwork (cultural artifacts) to teach simple and complex organic molecules, speaking indigenous languages became an accepted practice for the learners without hindrances from the teachers. When they speak their languages, it, does not raise any negative flag to the teacher. The teacher now sees it as normal. The ability to mediate /ameliorate the previous hegemonic language practices that learners must not translanguage seem to unpack the power of the cultural artifacts to transform classroom pedagogical practice. Furthermore, could it be that the habituses in the learners had enabled them switch from a language to another in mediation of their science concept understanding?

Rather than Bourdieu's assertion of social reproduction that posits that learners' cultural capital reflects inequalities in social class. Cultural capital here, enhances learners understanding of simple and complex organic compounds and afterwards equally enhances learners' identity as successful learners regardless of their social class. The introduction of these semiotic tools (beads and beadwork [cultural artifacts]) allowed the learners a context that is culturally relevant hence; place based /situated learning and the learners showed they could be responsible for their own learning. Vygotsky (1998) posits that, thought comes before language but the acquisition of language is affected by the thought as it always creates a dialectical activity with thoughts. These thoughts seem so important because they affect the language. From this study, perhaps the learners' thoughts were stimulated by the cultural artifacts (beads and beadwork) as a hands-on, minds-on, activity whereas in the traditional teacher-centered teaching class, the learners were not involved with the use of cultural artifacts and were not captured interacting let alone translanguaging.

In order for learners to mediate their learning of these science concepts, the cultural artifacts enabled, mediated and activated the learners thoughts, hence, the learners critically thought, peer questioned themselves, peer tutored and evaluated each other's work as well as imitated and peer observed each other. The learners were involved in other processes that are thought provoking and resultantly, the learners spoke in their language to give a deep and more understanding to the learning process. According to Vygotsky (2003) mediation describes the process of equipping and enabling learners with tools that aids mental development such as cultural artifacts. Beads and beadwork (cultural artifacts) seems to mediate learners understanding and therefore equipped learners with translanguaging as a form of capital to be utilized as a mental tool. In integrating cultural artifacts in the classroom pedagogical practice, the CAIM models appears to enable the cognitization[1] process as non-cognitive materials (aesthetic) are enabled for a cognitive use, particularly in the science classroom. (See below).

[1] Cognitization is the ability to enable aesthetic objects (non-cognitive) to become a cognitive enabling object. (Discussion with Dr. F. S Otulaja on the 18/06/2018)

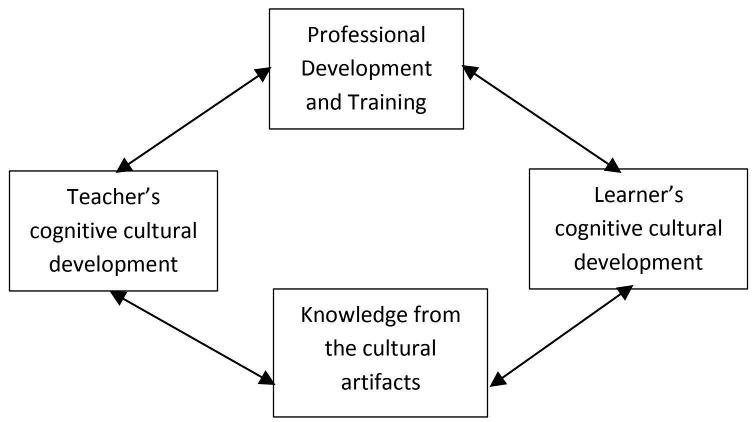


Fig. 4: Cultural Artifacts Integration Models.

The aesthetic objects (beads and beadwork) as seen in Chapters Three and Four appeared to have transformed the classroom pedagogical practice. The tools/ artifacts became cognitive instruments. Hence, the process of cognitization, which is elaborated as a process of making an aesthetic object (non-cognitive) to become a cognitive enabling object as it happened in the study. Learners became capitalized Capital as argued by Bourdieu (1998) can be appropriated by agents (teacher) towards a social energy in the form of reified labor, which in order words saddles the teacher to be culturally capacitated to cultivate learners' capitals (social and cultural) towards energizing cognitive learning (cognitive capital) in the classroom. Equipping learners with the needed capital (social and cultural place-based) to internalize what they are taught seems to stimulate processes required for self-regulation, self-planning and self-monitoring (Vygotsky, 2003).

Influence of Artifacts on the Learner's Community

As enumerated earlier, the interpersonal relationship between the subject and object influences the value placed on the artifacts (Vygotsky, 1978). The mediating artifacts can be tangible and/or intangible tools. From this study, intangible mediating artifacts that the learners alluded to as a result of the interaction between peer learners was translanguaging (Language as artifacts). This is an embodiment of the society or community as well as division of duties (labor) during classroom teaching and learning (Engestrom, 1993). Other intangible artifacts that have helped learners mediate their learning in the life science classrooms include peer tutoring, peer imitation, peer motivation, peer assessment and evaluation and peer collective identity formation. These intangible artifacts present a case for indigenous learners as being active in the lessons that value a context where they can learn. In engaging these intangible artifacts or expanded constructs, the value of an individual or another which Engestrom calls the significant other; hence a community of significant other which are guided by rules and division of labor. As also said earlier, these rules regulate the action of the subject towards the object. The rules roles, resources and division of labor are also the socio-historical aspects of the activity theory (Engestrom, 1999). The interrelationship between these six concepts (subject, object, mediating artifacts, division of labor, rules and the community) can be analyzed by the third generation cultural historical activity (CHAT) theory by Engestrom (1993). Before the third generation (CHAT) theory by Engestrom (1993) and after the first (CHAT) theory by Vygotsky (1978) was the second (CHAT) theory by Leontiev and Engestrom. (See page 3)

Leontiev's (1985) work emphasized on the collective nature of how human participates in an activity. He also emphasized interrelationship between the individual and the community, history and context. The third generation Engestrom model elaborates on the analysis and interrelationships and networks of interaction between the six concepts.

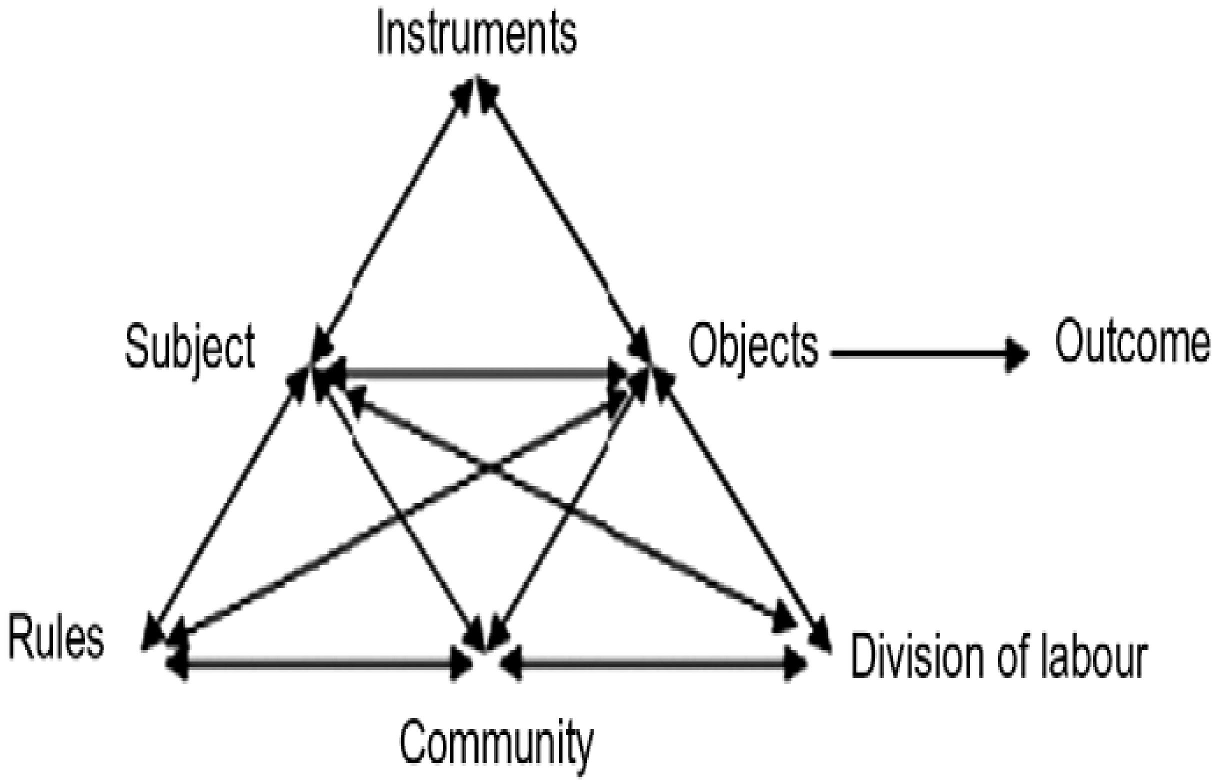


Fig. 5: Engestrom's Activity Theory.

The above figure is an extension of Vygotsky's (1978) triangularly mediated action. It elicits the relationship and analysis of interrelationship between the six concepts. Tools (cultural artifacts) according to Engestrom (1998) mediate the actions of the subjects (teachers and learners). These tools or artifacts also mediate the rules (collapsing of teachers' power in the life sciences classroom).

In the traditional teacher-centered classroom, the teachers' power remains absolute; hence s/he has total control the classroom whereas in the classroom with culturally related instructional models, the power of the teacher was willingly collapsed (distributed leadership); hence, the learners became more active in their learning. The interest of the learners to use the culturally related instructional models (made from beads and beadworks) also influences the community/group of learners where the learners created the instructional models from beads and beadwork (cultural artifacts). Learners in the same group were equally enabled to peer tutor each other, ask questions from each other, peer assess each other, trans-language among themselves as well as imitate each other perhaps because of the common interest they have in the aesthetics use of beads. Learners' aesthetic use of beads and beadwork (cultural artifacts) from their response in the questionnaire in Chapter Four includes for traditional jewelries, baskets, shoes cloths, decoration, knitting, designing, arts, traditional bracelets and necklaces. The learners' attributes to these artifacts as colorful, lovely, nice, fashionable, beautiful, decorative and attractive further solidifies learners' aesthesis value and interest. At this point, the beads and beadwork (cultural artifacts) is a non-cognitive object. It seems to only have aesthesis properties in the teachers and learners perspectives.

This interest of the learners to beads and beadwork (cultural artifacts) helps to create a social context that enabled positive interactions of the learners with the beads and beadwork (cultural artifacts) which is also the instruments/ tools in a hands-on, minds-on activity. The hand-on, minds-on activity stimulates the learners mental processes thereby enabling learning to take place; hence, a cognitization process occurs. After the successful creation of models of simple and complex organic molecules, learners' heightened awareness on the potency of beads and beadwork (cultural artifacts) spurred them to suggest further use of these aesthetic artifacts such as to show: (i) bonding; (ii) sharing of electrons; (iii) structures of molecules, elements, compounds, monosaccharide, disaccharide, polysaccharide, water; (iv) count mathematics and as a calculator; (v) learn mathematics, physical and natural sciences; (vi) highlight something; (vii) present experiment and make learning more practical; (viii) to see the difference between different compounds; (ix) to make giant molecular structures; (x) Lewis dot diagram; and (xi) to make examples about what you are learning about. The use of these artifacts is important in order to make: (i) them understand more and better; (ii) fun filled learning environment; (iii) abstracts concepts easier to see and feel; (iv) them to never forget what was learnt; and (v) the learners see what they are learning as they believe in what they see. These are cognitive expressions; hence, a transformation from aesthesis value of beads to the cognitive value of beads.

The process of cognitization is a process of making non-cognitive object or an object that does not evoke cognition and then you make it to evoke cognition. The cognitization process is enhanced by the interaction between the artifacts/tools and the community/group of learners with shared passion. Although Engestrom did not allude to this shared relationship, in the African context, there appears to be a commonality between the instruments/cultural artifacts and the community of learners with a shared passion. Indigenous learners are communal in nature; hence the community of shared passion in the activity theory. This recognition of the connection between instruments and the community is shown by an arrow in the activity model. (See below)

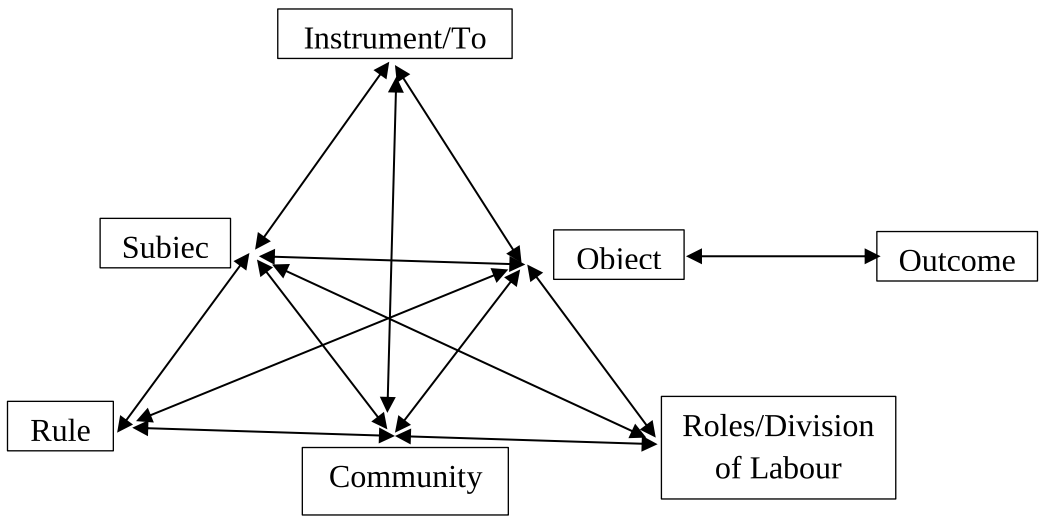


Fig. 5a: Engestrom's Activity Model: Connecting Instrument to Community through Cultural Artifacts

This arrow also shows the aesthetic to cognitive resonance. The learners' aesthetic value of cultural artifacts (beads and beadwork), on account of their interest and embodiment as cultural and objectified, becomes transformed in resonance to a cognitive artifacts. The criticalization of the process is the commonality between the artifacts/tools and the communities as the learners are comfortable sharing passion, artifacts, interest and so on. Again, the Object (goals of the lesson and the outcomes of the lesson have in between them the process of cognitization which includes peer aided tutorship, peer aided observation, peer aided questioning, peer aided imitation, peer aided zone of proximal development, peer assessment and peer aided identity formation.

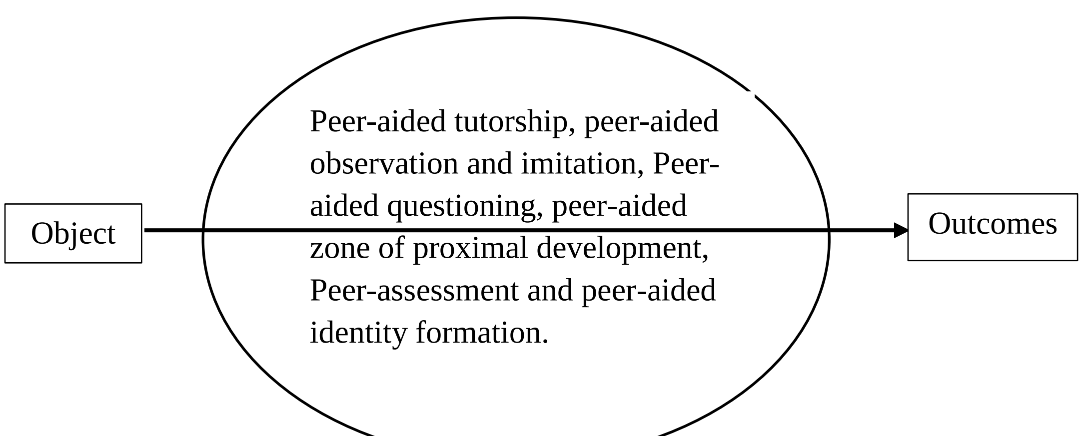


Fig. 5b: Object to Outcomes Transformation Process – Extending Engestrom

Showing above are the cognitive processes involved in the cognitization process from aesthesis use of cultural artifacts to the cognitive use of beads. In a group learning activity where the tools are culturally related to the social group (community) and the interests (aesthetic resonates with cognition) is shared, there is a positive tendency for a deeper relationship between the tools and the group (community) with which the subjects identifies while identifying in the activity (creation of instructional materials from beads and beadworks (cultural artifacts)).

Learners' interest as a common factor. As I alluded to, in chapter one, the use of caps of soft drink bottles to learn basic mathematics by my dad reminded me of the potency of cultural artifacts. What I learnt in this informal classroom became an embodiment as I can still remember it till today. It also rekindles the use of artifacts to teach and learn basic science concepts. In those early days, I would search and struggle with other kids to get more of these caps of soft drinks to be taught with. When we take these instructional materials to school (caps of soft drinks), we tend to guide the numbers of caps of soft drinks an individual has from the use by other nursery school learners. While participating in any activity, as kids, we cherish those caps both for games and for learning basic mathematics concepts in the classroom as we identify with the community. If one of the caps get missing, the kid gets angry; hence, not willing to share the learning moment with other learners. On the relationship between object (goals of the lesson and the tools), the instructional models (beads and beadwork) used to create structures of simple and complex organic compounds in the process of learning reveals that beads and beadwork (cultural artifacts) can be used to create other organic structures. It also revealed how the models can be improved which shows the interest of the agents to improve a model they identify with.

It is also a similar scenario with my high school life sciences learners in Chapter 1 where they were initially not interested in learning life sciences concept. As cultural artifacts were introduced, their interest in learning also increased as they became punctual and active in the learning process and was also enabled to work in their various groups on account of the shared passion. Bridget's learning process seem to also be based on the interest she had in the cultural artifacts and this was sustained as there was a shared passion with her maternal grandmother as she learnt the beading skills. In achieving the goal of the lesson (to create structures of simple and complex organic compounds as instructional materials), learners had to share duties among each other (division of labor). Sharing of duties seems to enhance the achievement of the given task in the community or group. Also depending on the shared interest in the community/group, the rules of the pedagogical process can change or remain the same. As the rules change, the interest of the learner can also change; hence, the learner decides to work with this group or that group.

On this account, the rules affect the subject. The subjects' decision to use the tools/instruments is also interdependent on the subjects' interest in the cultural artifact's use in the classroom while the subject can decide perhaps to continue to use the culturally related model or decide not to continue. At the end, the subject, depending on interest on the use of culturally related artifacts, does influence the goals of the lesson. Hence, the unit of analysis in the whole graphic description is the interest of the learners. Thus, in activity systems involving relationships between agents in the activity system theory, the interest of the subject seems to become more important. The subjects (learners and teachers) in the process of influencing the goals (object), is influenced by the artifacts (both tangible and intangible). Apart from the learners allusion to their local language (intangible artifacts), other intangible instruments through which the objects (goals) are influenced included peer aided observation and imitation (Bandura, 1977), peer-aided tutorship, peer-aided assessment, peer-aided identity formation and peer-aided zone of proximal development.

In a graphical representation of these constructs, Vygotsky (1978) mediated action between the artifacts, subject and object is carried out through the translanguaging channel. (See below). As learners' translanguaged, they peer tutored, peer observed, imitated each other, peer assessed each other.

Observation, Imitation and Modeling as Artifacts for Learners' Understanding

These constructs enables higher mental processes which seem to depend on the presence of mediating tools (beads and beadwork) in the learners' learning experience and subsequently create a place-based learning experience needed to enable the learners learning. In being responsible for their (learners) own learning and the understanding of simple and complex organic compounds, learners found ways to enable their learning by internalizing the content, one another and the context through observation, imitation and modeling. According to Bandura (2007), learners have the propensity to learn by simply watching others and replicating a modelled object, hence, the use of beads and beadwork to model the simple and complex organic molecules. Watching others mean at first, the presence of others in the learning activity, in consequence, the groupings made by the learners' teachers in their various classes as opposed to the teacher-centered teaching method where individuality in learning was evident. Learners imitated the models being created, imitated the teachers words as they created theirs (models) and at each point in creating the model the teacher spoke what they (learners) are imitating. Learners also imitated other peers from their group and from other groups at points where they find challenging in the process of model creation. They also imitated the positive vicarious experiences that stemmed from other groups. When the teacher shows approval of a step in a group, other learners imitate what was done by the learners in that group and when the teacher disapproves what was done in a group, the learners invariably decides not to imitate what was disapproved. Bandura (1997) came up with attention, retention, reproduction and motivation as the conditions necessary for constructive modeling.

According to Bandura (2007), following observation is internalization, and which could also be explained as encoding. After encoding comes imitation or reproduction of what has been observed. The use of beads and beadwork for the learners to create simple and organic compounds seems to have provided learners hands-on and minds-on activity which acted as an enabler for internalization and encoding so that reproduction of the internalized content is emanated. The use of beads and beadwork (cultural artifacts) seem to have also motivated the learners (increased learners' interests) to model these simple and complex organic compounds towards reproduction when needed. As the learners confirmed through their responses and showed interest in the use of beads and beadwork (cultural artifacts) to learn it became apparent that they were embodying a cultural artifacts used for aesthesis and also for cognitive purposes. Hence, the learners' cultural capital can be alluded to as an enabler for internalization of content and motivator for reproduction of what was learnt in the classroom. This cognitization experience positions the learner beyond just being involved in an activity.

The cultural artifacts (beads and beadworks) for the learners was more than aesthetic elements, they in fact, suggested beads to be used cognitively (cognitization process). The learners' confirms to love the beads, created affection and love for them as there seems to be a bond (interest through aesthesis) that connects the cultural artifacts to the learners. The learners appear to be endeared to the cultural artifacts (beads and beadworks) as the started to use the beads to create instructional models for learning in the classroom. In general, cultural learning appears to have an inherent energizer (cultural capital) for science learning and reproduction in the science classroom as mental states are fundamental in cognitive learning (Bandura, 2007). The use of cultural artifacts (instruments according to Engestrom (1987) also tends to have provided a mental state necessary for the learning of these simple and complex organic compounds in the classroom. Learners were captured on video, smiling, elated, and enthusiastic and ones with collective effervescence in what seems like a channel of entrainment from a group (community) to another (community) as well as attentively imitating the model given to them to create. Students appeared to be more engaged and entrained when there is a sustained positive emotional energy in the social field of the classroom as change agents in the process of learning.

As compared with the traditional teaching class, engaging an indigenous learner requires concerted efforts with cultural artifacts to engage, sustain engagement and interest of the learners. In energizing the learner cognitive processes, the learners' cognitive experiences become more memorable as it tends to affect learners attentiveness, memory recall and memory mood (Vygotsky, 1999). Further Vygotsky (1978) arguments reveal that the richer the learners' experience, the richer is the material (beads and beadwork) the learners have access to. He further posits that every feeling and emotion seeks corresponding images in form of impression that reveals thoughts and also images that resonates with moods at a particular moment and time. As the teachers moved around in the classroom, the teachers could see the faces and bodily interactions of the learners to suggest whether they understand or not what was been taught in the classroom individually and at different points in learning-situation that was rare in the traditional teacher centered classroom. Every member of the group in the various classrooms could also tell from the individual peer's facial expression, gesture and body orientation whether they understood what was taught or not. Hence, the learners could self-assess or peer-assess themselves as well as assess the teachers' lesson in the classroom.

Learners' Affect as Cultural Artifacts (Tools/Instruments)

At certain times, the learners were able to tell themselves if they got the given tasks right or wrong by the emotions they express. This construct that seems to be energized by the capitals (cultural, social and symbolic) that were enabled in the learners; hence, they (learners) indicated a type of self-regulation in their learning process (Piaget, 2015); Bandura (1997). Emotions in the classroom could also serve as glue in achieving an enabling experience (Dewey, 1934) which seems to be the precursor to identity formation as captured in this study. Emotions were evident in the learners' expression (Emotion energy, collective effervescence) when the models they created were considered by the teacher to be correct. And this enhanced their image of identity of success as expressed in their action such as jubilation; jumping up; smiling (positive emotional energy). Emotions seem to be a lubricant in their cognitive wheels turning towards attaining the state of attentiveness which results in learners retention of what was created. Emotions tend to enhance motivation which results in cultural reproduction of knowledge (production, reproduction and transformation) in a dialectic relationship.

Learner's self-critique, peer critique and teacher critique seem to have been enabled by the maintained state of emotion energy (place-based) that became entrained (Collins, 2004) in the classroom as the teacher taught the concepts and the learners modelled the organic compounds made with beads and beadwork (cultural artifacts). The state of emotion (place based) appears to enable the learners to express each other in peer critique, peer volunteer, peer correction, peer assistance. Self, peer and teacher critique are sorts of assessment (formative and summative) in the classroom which as well as assessment for, of and as learning (Biggs, 1999) to establish the extent to which learning has taken place. To attain this level of formative assessment, learners had accumulated enough capital to self and peer- assesses themselves as it seems to be another form of self-regulation which is captured as another construct exhibited by the learners during cultural learning reproduction of knowledge.

Learners might have accrued knowledge from the teacher by observing and imitating the teacher and because the teacher had been working with the learners. Contrary to the teacher-centered teaching method where the teacher appears to be the dominant knowledge holder and depositors of knowledge into the learners, in the use of cultural artifacts (beads and beadworks) as models in the teaching and learning process in the classroom, the teachers became a facilitator of knowledge production and also as a More knowledgeable other (MKO). The learners also imitated their teacher by becoming peer tutors, peer assessors. This is what the learners observed and imitated as the learners peer tutored while asking questions from themselves, peer motivators of others, peer assessors and evaluators, peer assistance and volunteers of themselves through the translanguaging channel.

Peer Tutoring as Artifacts (Tools/Instruments)

According to Vygotsky (1987), a more knowledgeable other is an individual with a greater degree of knowledge and understanding or a higher level of capacity and potential, about a particular subject or task than the individual who is in the learning process and this notion appears to resonate with lave and Wenger (1991) 's notion of legitimate peripheral participation which they explained as participations that results from a new member in an activity, learning from a more experienced member in a community of practice. They identified learning as dependent on the context in which learning takes place. In these terms, the learners were captured on video and audio (Polyvices) acting as peer tutors at different scenes in the classroom learning where learners acted with as ones with older experiences. While the ones being tutored were legitimate peripheral participants or what they (Lave & Wenger, 1998) called apprenticeships. As learners gained mastery of what the teacher was teaching, they were also gaining capitals which they demonstrate by tutoring other members of their group and as such group members started acting as peer tutors at different times to other groups during the lesson.

Vygotsky (1987) sees these cognitive functions as a process that must be guided by the more knowledgeable other (MKO) as he posited that the learners and wanting to explore, hence, learning with a (MKO) through interactions enhances their cognitive experience. According to Lave and Wenger (1991) the legitimate peripheral participants at first become members of the community of practice by attempting to solve simple tasks and then gradually move towards the more complex tasks. This was taken into consideration when the teachers had to get learners entrained in learning experiences that comes with the understanding of simple and complex organic compounds while the beads and beadwork (cultural artifacts) were beads and beadworks were used to create models. The learners were first introduced to creating water and carbon-dioxide structures before moving to the complex structures of glucose, fructose, lysine glycine and fatty acid structures. Learners' role as a peer tutor was not only determined by the teacher. It seemed to have occurred as a result of enablement of some agents at different times of the learning process. The enablement first stated from Bridget (Mama Africa). She explained to me (the researcher) the knowledge of beads and beadworks (cultural artifacts). Gradually I became enabled and attained the state of self-mastery and transferred the knowledge to the teachers (learners) in the professional development and training workshop.

After the professional development and training workshop, the teachers became enabled; hence, more knowledgeable other (MKO) to the learners in the classroom (community of practice) where beads and beadwork (cultural artifacts) where used to create instructional models as representations of simple and complex organic compounds. The learners also as a result of the teacher's facilitation of the science concepts by their teachers became enabled to teach each other. Hence, learning processes seem to comprise enablement of an individual by a more knowledgeable other. In essence, the learners become more knowledgeable other to each other. According to Vygotsky (1978), a (MKO) emerges from individuals with age differences and/or from individuals in a higher class. In this study, a (MKO) results from the individuals' access to capital and the enablement of the capital. The capital needed to act as a peer tutor was acquired and the learners peer tutored each other at different times in the classroom. Peer interaction with cultural artifacts as instructional models appeared to be effective in expanding the learners' construct in peer tutoring as the learners understood the lesson content as different times during the lesson. Hence, the learners' Zone of Proximal Development was at different times.

Vygotsky (1987) describes zone of proximal development "as the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under [MKO] (adult) guidance". Even a kid may be an adult (MKO) by the level of cognitive development the kid is enabled with. So from this study it is not only age difference and class as determinant for a more knowledgeable learner but, the amount of capital (cognitive) also determines a more knowledgeable other in a cultural context. It can be further explained as the difference between what a learner can learn with the assistance of a more knowledgeable other to what the learners can learn independently.

Learners Zone of Proximal Development as an Artifact

Every learner seems to have a certain point of difficulty in learning and a point when the learner can be involved in the given tasks independently. Crossing over the bridge between dependency and independency was facilitated by the teacher. The instructional materials (models from beads and beadworks) seem be a bridge across from a point of difficulty to an “aha” moment. As a consequence, the learner exhibited individual/collective effervescence.

It could also be explained as the process where the learners gain competence (concrete realization) from incompetence (abstract conceptualization) as assisted by the more knowledgeable other. To Vygotsky (1987), the cognitive process is not an individual construction alone but an interaction aided process as the learners grows into the intellectual and epistemological world that they seem to be taken into to achieve a state of independence or self-efficacy (Bandura, 1977). These cultural artifacts (beads and beadworks) as instructional models in mediated learning takes place in the classroom to enhance the learners learning of science concepts, facilitated by the teacher and peer tutors. These roles enable the learner in a form of more knowledgeable order (MKO) and assisting the learners to the point of epistemological independency. The learners seemed to have acquired the mental tools needed to aid learning of these science concepts in the science classroom. An apparent strategy employed by the peer tutors in assisting the learners in moving through the (ZPD) seems to be a result of verbal persuasion. Peer tutors assisted in moving the learners out of the point where the learners feel they can no longer proceed in the given task. The learners learning will without the more knowledgeable other seems to appear as a “stop gap” that needed enablement to move on. The peer tutors verbally persuaded the learning individuals to continue as it became a sort of strength for the learning individuals to continue in the process; hence, assisting in internalizing the concept.

During the process of internalization (a process learners try to make sense of science concepts), learners (legitimate peripheral participators) at different times needed guidance (more knowledgeable other) from the teacher or members of the same group or another. The task of helping other learners understand the lesson content appears to be easier in the lesson aided by instructional models created from beads and beadwork (cultural artifacts) because peer tutors partake in the role of teaching others. This is in contrast to the traditional teacher- centered classroom where the teacher seems the only one enabled to facilitate learners understanding of science concepts. In this type of class, the teacher is easily fagged out even before he finishes his teachings for the day. Fatigue at any point in the lesson can affect the teachers teaching, how learners see the teacher and how the learners react to the teachers' pedagogical practice and the outcome of their learning. Fatigue tends to constrain the process of learning. In the enabled classroom pedagogical practice, learners now view themselves as an active agent in the teaching and learning process because they construct their own knowledge and they are valued by the teacher as the teacher allows them to use that knowledge that they constructed to access and assess each other. In order words, they became co-teachers and the leadership in the classroom is co-distributed. The learners, after reaching their point of (ZPD), decides they can do the rest tasks without the help of either the teacher or peer tutors (More knowledgeable other). This point can be seen as a stage of self-efficacy where the individual beliefs suggest competence. It relieves the teacher that allows that.

Learners' Self-efficacy as an Artifact/Tool

Learners attained the level where they had created the glucose structure (cyclic and linear) assisted by the more knowledgeable other, mediated by cultural artifacts (beads and beadworks) and a strong sense of efficacy has been developed through successes in the given previous tasks (because success begat success) thereby the willingness of the learners to proceed to the next task (fructose structure) became productive. The mood of these learners depicted a lively, joyful mood which could be as a result of using teaching tools that are place-based and as such, resonates with the state of personal and individual efficacy in the given tasks; it also seemed an indicator to the teacher to depict they have understood the assigned tasks. Bandura (1977) posits that children learn faster if what their learning is consistent with their mood while learning. The happy mood shown on the learners face appears to be a product of the facilitation of their learning with place-based experiences as well as with the help of those who acted as peer tutors and co-teachers. In the community of practice as Lave and Wenger (1991) has argued, the legitimate peripheral participator gradually moves from the state of being a novice or apprenticeship with the help of the (MKO) to a more central position in learning where the individual becomes gradually acquainted with the task (state of mastery) and then to the point where the learners can solve the tasks independent of the mentor or more knowledgeable learner. According to the study, the cultural capital (beads and beadwork) which is place based appears to enable the learners further towards self-actualization of self-efficacy.

As stated by Bandura (1977), there are four principal sources of self-efficacy namely; enactive mastery performance, verbal persuasions, vicarious experiences and physiological and affective states. To enact the mastery experience according to Bandura (1977) means achieving more success on account of a robust self-efficacy, hence there is the tendency to do more because the individual was successful in the previous tasks. An example is that when an individual tends to attempt some exercises in the textbook which is structured in a way that the simple questions comes first, then followed by the next tough questions in an ascending order. When the learner solves a question, he tends to move to the next until the individual hits the brick wall (a more difficult question). If the individual is peer tutored or guided by the teacher, the learner then moves to the next question. From this study as stated earlier, the learners were captured on video peer tutoring-a function of a more knowledgeable learner to be able to facilitate and reach their state of dependency, hence, the learners could independently proceed to the next tasks.

Another construct the learners employed was verbal persuasion which is in concordance with Bandura (1997) principal sources for self-efficacy. Bandura (1997), elaborated on verbal elaboration as any teaching information communicated to the learner by another individual whether from the same group or the same group. Verbal persuasion seems to act like an impetus of a sort of motivation towards crossing from the unknown to known as Bandura (1997) posited that self-efficacy assumes that learners that are motivated are more likely to succeed than less motivated learners. Successful learners tend to be energized to go on to another task or challenge thereby enabling another learner if imitated. Imitation of this positive vicarious experience by the learners became the third principal sources for self-efficacy. As captured in this study, learners observed and imitated other members and groups behaviors, cognitive expressions in the classroom. A form of the cognitive expression is the winning gestures the learners were involved in such as smiling, movement of the hands to signify they have gotten the answers correctly, the glare in their eyes and other bodily movement to depict success in the tasks given. Learners' facial expressions seem to indicate learners' affective states.

Learners' affective and psychological state is the fourth principal source of self-efficacy. According to Bandura (1997) these affective states fuels actions that produces outcomes that the learners desire when they act at point of difficulties. The desire is seen in action and facial expression. The state of belief on ones capabilities to surmount a task can be indicated by the affective states of the learners which tend to become more visible when the teacher moves around in the classrooms as learners are placed in groups. These affective states could be influenced by learners' interest in the task given. The study shows that learner's interest in the use of beads and beadwork for cognitive development influenced not just the willingness to learn simple and complex organic compounds but to sustain the interest throughout the learning episode. Hence, when successful, the learners had the sustained impetus for more. On account of these, learners' capital (social, symbolic and cultural) could be said to be principal in attaining self-efficacy because, the learners are not unfamiliar with the cultural capital in their lived-world. Learners wear beads and beadwork; use these materials for various things in their lived-world, hence, the learners doubt does not exist in aesthetics purposes.

In exploring the cognitive capacity of beads, the learners built on the trust and familiarity the learners had towards the use of beads and beadwork in the classroom and became trilled to use these beads for cognitive purposes; hence, the learners became more proud of the use of beads and beadwork for cognitive purposes (cognitization). This prior knowledge of the learners enabled negotiation through the use of beads and beadwork to create instructional models for the teaching and learning of simple and complex organic compounds which made using it (beads) easier for cognitive purposes) and subsequently self-efficacy became the outcome. Another rationale is that individuals' beliefs resonate with the individuals' culture. Bandura (1997) notions about beliefs suggest that self-efficacy beliefs are at the center of social cognitive functions. Beliefs on the other hand can be conceptualized to consist part of what culture represents to a group of people as well as norms and values. To the learners, the beliefs around the use of beads are positive; hence, positive beliefs for the cognitive purposes in the classroom which was a force in achieving a successful model creation and subsequently a state of self-efficacy to proceed to other seemingly harder challenges.

Can learners' capital play a vital role to influence self-Efficacy as these resources (cultural artifacts) embody cultural schemas? Are there virtual intricate rules helping the learners in negotiating self-beliefs necessary for self-efficacy? In an attempt to answer these questions on achieving a state of self-efficacy by the learners, there appeared to be a human-observational learning being mediated by artifacts taking place. The learners were captured on video learning with beads and beadwork (cultural artifacts) in their hands (hands-on, minds-on) and simultaneously looks at the chalkboard to compare with the teachers instructions and also at the same time observing the fellow members work for assessment and evaluation. All these simultaneous tasks enable them to negotiate his way towards the state of self-efficacy during the learning process. After achieving this state, the learner's observes less of others work as other difficult tasks are tackled. As this might suggest, learners' cultural capitals served as mediating tool in reaching the learners state of self-efficacy, hence learners' cultural capital can be a principal source of arriving at the state of self-efficacy.

After achieving the tasks of creating glucose models, learners in the process of attaining self-efficacy, proceeded to the fructose structure because at this time of learners' learning, they no longer needed a teacher or a peer-tutor to facilitate their understanding. It was a period of mastery for the learners as one could see in their facial expression a state of excitement to go for more. This state of mastery seems to have influenced the learners' self-belief and how others perceived themselves (their personality) as possessing capital. Vygotsky (1997) referred to identity as personality. He alludes to personality as a state developed through individuals' self-regulation of affective states and behavior. He also posits that an individual's personality is dependent on the individual cultural development and the personality of an individual is not inborn as it develops as a result of cultural development. The personality of the learners in the four teachers classes where culturally related instructional models created from beads and beadwork (cultural artifacts) seem to develop from their understanding of scientific concepts. The learners subsequently developed an identity of success which was developed internally from the state of mastery attained and as well as identity of success as seen by other learners in the classroom.

Vygotsky (1997) also noted that personality is created only in adolescents because individuals become a master of higher psychological functions. This personality/identity according to

Vygotsky undergoes a formation process that is dynamic, complex and subject to change and development. In these learners' classes, the identity of success was formed cognitively as learners used cultural artifacts (beads and beadwork) to create models of simple and complex organic compounds. For the learners, the identity of success was formed as a result of the new experience as enabled by the cultural artifacts and facilitated by the teacher. While the experience has brought the learners into a re-invigorated sphere where the learners feel able to break boundaries to solve and create any structure they are being told to do.

Fig. 5: Identity of Success Formation Process

Learners' Individual/Collective Identity Formation

This echoes Wenger (1998)'s notion of identity as a mode in which an individual discovers who they are, as they negotiate meanings of concepts while learning. Very important is the process of becoming a positively identified individual by identifiable others in a social field or community of practice. I explain a positively identified individual as a learner who is seen as synonymous to a successful individual in the teachers' tasks. Furthermore it is someone or group of individual whose identity is formed as a result of getting the teachers assigned tasks correctly (successfully). While an identifiable individual is someone or group of individuals who can identify his/herself and others as successful. A successful learning is one who accomplishes the aim and purposes of the task. The individual considerers successful the task assigned by the teacher. Hence, the question of how learners' identity enables sustained participation in a classroom or communities of practice as Wenger (1998) argues emerges. Identities of successes created in the CRIM classroom where culturally-related instructional models are created from beads and beadwork to teach simple and complex organic compounds can be seen a context for the growth of identities of success in the individual and the society.

Therefore confidence in and value for materials that are indigenous to the learners are enhanced in a community of practice that contextualizes how learners can develop cognitively, learn, critically think, imagine and align prior knowledge with knowledge to be acquired in the science classroom. The learning and understanding concepts with culturally related instructional models made from beads and beadwork (cultural artifacts) tends to align with learners cultural background. Also a community of practice that exemplifies the philosophy of the African learners as communal where sharing is a core value; hence, the learning process is a shared negotiated domain between teachers and learners and not just teachers alone as captured on video in the teacher-centered classroom. According to Wenger (1998), the community of practice enhances competence and skills as the learners had different identities at the beginning of the class to the identities formed after been successful at the tasks given. At the beginning of the class lesson, their performance identity here seems to be zero as all learners appears to be wanting to know what is to be taught. While at the end of the lesson, some learners attained identities of positive performance developed as identities of success because they got their tasks correctly. Those who did not get the tasks correctly attain identity of negative performance.

This helps the teacher to discover who the ones with apparently identities of negative performance (those that did not get their tasks correctly and where did the group with identities of negative performance get their understanding of the concept wrong. According to Wenger (1998), along with identity, are three other integral aspects of learning namely, meaning making, practice and community?

As Vygotsky (1997) explained, individual cognitive development or mental functions has sociocultural origins and mediated by tools. These tools are cultural artifacts (beads and beadwork) as used for cognitive learning in the classroom. The sociocultural origins could be experiences, tools and artifacts that are in the learners' lived-world. These identity of success formed by the learners in this study did not only re-invigorate the learners with the identity of success, it enabled other learners access to what seems to be a correct model of experience to imitate as they try to attain their own level of self-efficacy. Could success identity formation be an indicator of learners' success in the classroom tasks? Could self-efficacy be a precursor to learners' identity of success formation also in the classroom? Learners' cultural capital seems to be a catalyst, activator and energizer in the process of self-efficacy and role of identity formation (Turner, 2005) in the learners' cognitive practice. Furthermore, the identity of success formed by the learners seems to generate symbolic capital which other learners become eager to attain at the end of the lesson. The symbolic capital seems to elevate some learners in position of tutors. According to Lave and Wenger (1999) learning is not just acquiring skills but becoming a certain type of individual as stated in the objectives and goals of the lesson. The belonging of a learner to a community of practice is apparently enabled by the capital acquired. It also enhances the symbolic personality of the learner. Apart from the terminal or summative assessment in the life sciences classroom, during formative assessment, collective or individual identities of successes can be markers for positive performance and also for negative performance. Hence the teacher can, in earnest facilitate learning in seemingly less performed groups so that all groups are identified as identities of positive performance or identities of successes in the science classroom.

Summary of the Chapter

From Vygotsky's (1978)'s first generation mediated learning to Leontiev (1985) and Engestrom (1987)'s second generation theory to Engestrom (1993) activity theory, the activity in the life sciences classroom are influenced by factors such as rules, division of labor, subjects (also called agents), objects (goals), instruments (tools or artifacts), community (group pf shared passion). The study shows that the interrelationships of these factors are influenced by learners' interest in the artifacts or tools to be used by the subjects to influence the goals. There also appears to be a shared relationship between the instruments/artifacts (tools) and the community or groups of learners with shared passion. During life sciences classrooms, there are processes enabling the subject's (learners) achievement of the goals in the classroom as seen in the activity theory. Again, there seems to be cognitive enhancing processes embedded in between the objects and outcome in Engestrom activity theory. These cognitive enhancing processes are peer tutoring, peer observation, peer questioning, peer imitation, and peer ZPD, peer assessment and peer identity formation. The object is cognitized to produce the outcome. Cognitization is a process of making an aesthetic object cognitized (capable of aiding learners learning.

Also inherent in this study is the power of cultural artifacts to transform pedagogical practice. The use of cultural artifacts ameliorated the power practice that that seems to exist in the life science classroom. Learners' interaction generated social capital that enhanced their cultural capital (speaking indigenous languages) to understand better the sciences concepts. The social and cultural capital generated symbolic capital and afterwards symbolic capital when learners started to show other learners how to create more complex molecules produce cognitive capital. Hence, the exercise of symbolic capital enhance cognitive capital. Cognitive capital becomes an embodiment of these three because of the power of higher thinking. The acquisition of cognitive capital is also an enablement to becoming an MKO, which is an addition to the age and class differential that Vygotsky (1978) posited. An MKO results from the individual's enablement (capital) of others. This study shows that learners switching from a language to another was a process they engaged in achieving the outcomes of the lesson. Other processes that assist in achieving the outcomes of the lesson include peer-tutoring, peer-assessment, peer-observation and peer-collective identity formation. Individual or collective identity formation appeared to be a marker of successful performance in the science classroom. Self-efficacy seems to be the precursor to attaining learners' identity of positive performance in the science classroom.

According to Chilisa (2012), "in proverbs and metaphors, we discover philosophical and theoretical frameworks in which we can ground research…" (p. 133). Hence, a proverb in the Yoruba language (a major tribe in Nigeria), says 'Bi ile ba sanni, awo la a wo'. 'Ile' is home and 'awo' is condition of the skin. 'Ile' and 'awo' are used metaphorically to indicate the state of affairs of man or the general wellbeing of man. Man is used metaphorically for any category of human being. In essence, the proverb means a person's wellbeing can be confirmed by the outlook of his or her skin. Hence, the learners' collective identity of success formed as a result of the teachers' confirmed learners' performance can be identified by the collective effervescence exhibited by the learners. It appears to be also a marker of successful performance in the life sciences classroom.

Chapter Four

Bridget's African Identity and the knowledge of beads and beadwork as place-based.

Introduction

The last chapter reviewed divergent and discrete works of selected information relevant to teaching and learning within a cultural related pedagogy in the science classroom subsumed within the existing literature. The previous chapter also tends to locate this research work within the existing pedagogical space as well as to acknowledge works of scholars as evidenced in literature (Booth, Sutton, & Papaioannou, 2016). In this chapter, I elaborate on Bridget's unconscious apprenticeship as a habitus accumulator metamorphosing into an embodied cultural capital from her childhood in Swaziland interplaying into a master bead maker and therefore her symbolic capital as she became a professional bead maker and subsequently her African identity as mama Africa was formed. I hope to tell the story from the perspectives of the teller which Manning and Cullum-Swan (1994, p. 465) elaborates further as "an analysis that typically takes the perspective of the teller, rather than that of the society". Her experience on the use of beads and beadwork (Cultural artifacts) was drawn upon and not on account of the influence of her gender, class, intonation, pitch and pauses as lens to the meaning making of the text as Denzin (1989) had explained approached to narratives.

Her experiences in her story on how she began her knowledge of beads and beadwork (cultural artifacts) and how she developed this knowledge to the extent she was identified as Mama Africa was discussed. The epithet "Mama Africa" defined her role in the community where she works and lives in that, as a way of upholding her African epithet, she wore beads every day and defended everything that upholds the African identity. She marveled at the possibility of utilizing the knowledge of bead and beadwork to creating life sciences concepts like cyclic and linear models of glucose, water and carbon dioxide molecules for students to learn in the science classroom and volunteered to construct hers for me to see if fir for pedagogical processes in the science classrooms. I elucidated further on her identity formation as place based and as an

African, she narrated in the interview the generational flow of habituses from her grandmother's generation to her kids. I unpacked her knowledge of bead and beadwork (cultural Artifacts) and found possibilities to create curricular materials as instructional models for teaching and learning in the science classroom. Similar to my learning experience from my father and other siblings which was wholesome, place-based and an "all in one" which enabled my double promotion to a higher class, learning for her was also wholesome, place-based and an all-inclusive education as she was enabled to negotiate her living as demanded by the proxemics of the learning space.

Bridget's Biography

Bridget is a South African mother with three children, whose parents are from Kwa Zulu-natal in Durban; hence her primary language is Zulu. But she is bilingual as she says, she speaks Xhosa and she studied "Swazi" at school. She was home schooled by her grandmother who is also Zulu but she married a Zimbabwean with whom she says "that one, I have no relationship at all''. Perhaps because the Zimbabwean did not live with them (Bridget and her grandmother).This means she lived with her grandmother only without her siblings and her grandmother's Zimbabwean husband. Bridget's paternal side of her biography, she says does not know. She says "And my paternal, I don't know". Bridget's grandmother was a dressmaker. "She used to work a lot with her hands, designs, crocheting" she states. Her grandmother could be said to be capable of expressing her creative thoughts (imagine her design), process these thoughts and express the thoughts in hand made models her granddaughter (Bridget) learnt from. She further states that her maternal grandmother produces handmade swelters, "she was a seamstress". The ability to perfectly use her hands to skillfully weave with her hands created an identity as a seamstress and enabled her as a self-employed individual. One of the skills that made her a seamstress was crocheting. To crotchet means to make a piece of needlework by looping thread with a hooked needle. "With sticks" Bridget continued, "that is how I started designing; hence she started as an unconscious mentee (Piaget, 1970), a legitimate peripheral participator or a cognitive apprentice (Lave & Wenger, 1991). "When I was growing up, I started with Knitting". When I asked how her maternal granny learnt it, she said "I don't know, I never asked but she was self-employed".

The society in a way found channels through which skills are deposited into her grandmother's lived-world perhaps through a more knowledgeable other which could be the grandmother's parents of an older person. In a way Bridget's grandmother had been enabled to be self-employed. To be self-employed mean she worked on her own and made a living from crocheting and dress making. I can also suggest she was a professional seamstress who Bridget lived with and unconsciously developed an expanded role of a more knowledgeable other for Bridget. Bridget did not only live with her maternal Granny but learnt crocheting skills from her (Bridget learnt by observation and practice). Bridget's grandmother's identity as a seamstress could also have endeared Bridget to learning the skills from her grandmother. Bridget says "she used to sew clothing and each time, I come along with her". In coming along with her (granny), Bridget was learning gradually from a pool of granny's cultural skills which accumulated into cognitive capital and enhanced by the interaction (social capital) between them (granny and Bridget). These capitals (social, cognitive and cultural) at a point in Bridget's knowing process, are interchanged from a form of capital to another after which becomes the capital becomes embodied in granny's lived-world and subsequently becomes inherited knowledge by Bridget overtime through socialization and Education (Bourdieu, 1984). The learning space became a social space for learning that seems enhanced by the interaction that takes place (social capital); hence the sociality in the learning process (social capital) seems to be an enabler.

In furtherance of Bourdieu's argument, the accumulation of knowledge and skills can form a pool to be tapped from by the apprentice or legitimate peripheral participator (Bridget) and subsequently could demonstrate one's cultural competence (granny's professional status as a seamstress, dressmaker and being self-employed). Bridget and her grandmother co-existed in a social space whose proxemics seem to be enhanced by the social interaction between them. It appears to be a sort of learning from an adult where responsibilities are shared in gradual amounts perhaps at first from, the more knowledgeable other gets a larger share to both getting equal share of responsibilities and then to the apprentice willing to do a more larger share while the more knowledgeable other getting the smaller share as the apprentice moves towards being a mentor. Bridget continued "that is how I started designing when I was growing up. I started with knitting". From knitting, she developed the beading skill and subsequently designs for the beads. So it seems to be a sort of gradual learning process from the simple to the complex for Bridget. This same knitting was what Bridget's granny did. It was hands–on and a sort of continued practice before Bridget mastered the art of knitting and designing. “No one formally taught me”, Bridget narrated with her face exhuming a sense of pride and confidence in her astuteness in the production of beads. Bridget evolved from a newcomer in the knitting, crocheting and seam dressing business to a master and professional as she went on to a step further-bead making. According to Lave and Wenger (1991), the membership of a community is mediated by the possible form of participation to which newcomers have socially and physically.

By Bridget’s narration, learning for her was wholesome despite not be taught in a formal schooling system. It also resonates with my “home schooling” under the tutelage of my dad and older siblings. My education at home was encompassing that I was skipped the next class and started my formal schooling a step higher in class than my age-group. This learning process seems to be unassociated with the system where the teacher shares all the learning responsibility which enhances passivity in the learners because they do nothing but to listen quietly and perhaps answer a “yes or no” to questions asked. The learners seem to be banks of knowledge (Freire, 1970) where knowledge is deposited and regurgitated as when needed as there seems to be interaction between learners and interaction between learners and the teacher. The social capital appears like a value chain that enables each other into other forms of capital as seen in the generational chain of skill acquisition from Bridget’s grandmother to her and subsequently her kids. She says the “youngest child seems interested”. This knowledge and skills is place-based and indigenous.

According to Ogunniyi (2000), indigenous knowledge consists of knowledge that is wholesome and acquired from previous generations. This confirms the wholesomeness of indigenous knowledge as related to my home-schooling under the tutelage of my parents and other older siblings who I understood as brothers and sisters, the mathematical knowledge of beads in “abacus” and the possibilities inherent the use of beads in creation of instructional models for simple and complex structure of organic compounds in the science classroom. Bridget’s maternal granny did assume many roles (Lave and Wenger, 1998) in bringing up her granddaughter (Bridget) with rules and structures that enables learning from the facilitator. The habituses inherent in the individual (Bridget’s grandmother) has enabled her role as a mother, doctor, guardian, disciplinarian, food provider, lawyer and subsequently as a teacher; hence, Bridget “came along with her whenever a dress has to be sown” as captured in her narrative. Bridget’s learning was place-based and in her "coming along with granny" Bridget learning was mediated with the tools for crocheting, seam dressing and knitting. Bridget's learning process was a form of observation that involved a process of engagement with tools for mediation (Vygotsky, 1978). Vygotsky (1978) further posited that the development of an individual's higher mental process depends on the mediating agents available.

They shared a human endeavor as it was a common activity for both of them and granny aimed at sharing her competence with her granddaughter. In these setting, learning was formal to Bridget. It was a way of learning authentic to the society with granny earning a status of a professional and Bridget being the apprentice (Lave and Wenger, 1998) in a community of practice. According to Bridget, "granny was a designer, fashion professional, and I would see her" (observing and imitating). In fostering an interaction that enhanced Bridget's learning from her granny would surely be implicit rules (Engestrom, 2000) that have enabled her expression of skills. "But I realized that, years later, that oh, ok, probably this is where this (skills) comes from" Bridget professed. Bridget's knowing now became conscious as opposed to the unconscious state she was before and it became a sort of heightened experience for her. I asked Bridget further, No one formally taught you. Bridget answered, "NO!" According to Bridget, "she (Bridget's grandmother) sews the clothing and I take care of the jewelry aspect". It confirms the sharing possibility earlier shared as part of the learning process Bridget went through. It was also a form of division of labor. These rules may not be pronounced but it has allowed and fostered her expression of skills in "taking care of the jewelry aspect" of the clothing granny usually sows. Bridget had graduated from being an observer to "taking care of the Jewelry aspect of the sewed dresses- what Lave and Wenger called legitimate peripheral participation (LPP) while Granny played the role of a More Knowledgeable Order (MKO), according to (Vygotsky, 1999). Could this beading knowledge be shared? I asked Bridget.

Bridget's Knowledge of Beading.

According to Bridget, beads come in different sizes, shapes, colors and materials. "I use glass beads because that is what is available-the trend", she said, when asked the kind of beads she uses. "But we need to as well track back our wooden original beads, our beads made out of bones, as the west came to reciprocate and emulate African beads into glass beads" Bridget said. To her (Bridget) it was a sort of owning back our identity and pride, owning back our artifacts and further sees what we can actually make of the beads for other purposes. One could see the negative emotion in her face describing the extent the westerners has taken claim of our artifacts.

01: Bridget: These beads (glass, wooden, plastic), have holes, you use a measurement, and there is a measurement you need to utilize depending on your neck size and how long you want it (the bead size) to be.

02: Femi: how long you want it to be

03: Bridget: Yes, and the length. Then you use a needle, but because this one is strongish, it's not wobbly. It goes through without a needle, you can just. I don't know in English-suture. Laughs.

04: Femi: it's a form of suturing. Yeah. Doctors do sutures.

05: Bridget: Yeah. Laughs!

06: Femi: but a bead worker does sutures too.

07: Bridget: It is different ways to work with it.

08: Femi: Yeah

09: Bridget: Yeah.

10: Joshua: what are the different ways?

11: Bridget: emm, you can use wires to put it together, you can use a fish rod, it comes in different colors, you can use cotton, yeah

12: Joshua: But these beads have to be added to each other.

13: Bridget: yeah

14: Joshua: to form

15: Bridget: a pattern.

Apart from using a needle to make it strong by "suturing" the threads around the beads hole, the beadwork could be intertwined. (See excerpts below).

16: Bridget: Yeah, I used a piper; I buy material (beads), and then you sew depending on the size, and put materials inside that, you create like a tube. Then you roll, you put beads in a long string, then you roll it around.

17: Joshua: you would have put the beads on the strings.

18: Bridget: Yeah

19: Joshua: and filled up the strings,

20: Bridget: Yes

21: Joshua: you just roll it around, roll around, roll around

22: Bridget: Yes,

23: Joshua: so also the tip here.

24: Bridget: so also the tip

In addition to the "suturing" and the intertwining methods, is the use of safety pins. These tools form part of the materials used in creating beadworks and also forms the methods. (See excerpts below).

25: Bridget: And this is what I have done ((showing me other bead creations she has done)). Eish!, its different ways men. This one.

26: Joshua: Okay, how did you do these also?

27: Bridget: Those are safety pins

28: Joshua: oh pins on the neck?

29: Bridget: Yeah. Safety pins

30: Joshua: aren't those pins harmful to the neck?

31: Bridget: noo!

32: Femi: no,

33: Bridget: no, there is a technique.

34: Femi: you put beads on them

35: Bridget: umm. And then you hang them on another set of beads.

36: Femi: Yeah.

37: Joshua: wao!

38: Femi: it's beautiful.

What are the equipment's? I asked Bridget. We use pliers, cotton, wires, strings, safety pins, measuring instrument (ruler, etc.)

39: Bridget: These are strings. These, it's like fish strings.

These tools appear to be mediators in the learning process of knitting, crocheting and seam dressing and further, in the beading learning process. The beads are rolled on the strings to form shapes of desired beads structure. Sometimes, we use cotton or needle. You using needle, cotton and thread through the holes so that the beads are not dangling. The uses of these tools elaborate more on the methodology or rule and structure in the use of tool to mediate learning in the science classroom. The desired bead structure also has colors. According to Bridget, the beads come in different colors (red, blue, black, pink, white and any other color) and they form a crucial part of the bead making process. "I am more of a color person" Bridget said. We have to bring these two aspects" (forming the shape of the beads along with the color of the beads). "You choose your own color for what you want to create", Bridget continued. (See below excerpts)

40: Joshua: How do you know the type of color that would go with these?

41: Bridget: I have done color theory.

42: Joshua: What do you mean by color theory?

43: Bridget: I have learnt about colors. I have done decoration. That's how you know. Yeah.

44: Joshua: the type of colors you need. (Joshua looking at other beads she created). They are beautiful beads.

She (Bridget) was enabled by the capital to own her learning process and which perhaps had allowed her to further learn color theory to enhance her design prowess. Should learners be allowed to ownership of their learning thereby allowing the sharing in the learning process as opposed to the traditional teacher centered process where the learners are passive while the teacher becomes the only active member? Bridget's conversation continued in the excerpts below.

46: Joshua: Okay, how did you do these also?

47: Bridget: Those are safety pins

48: Joshua: oh pins on the neck?

49: Bridget: Yeah. Safety pins

50: Joshua: aren't those pins harmful to the neck?

51: Bridget: noo

52: Femi: no,

53: Bridget: no, there is a technique.

54: Femi: you put beads on them

55: Bridget: umm. And then you hang them on another set of beads.

56: Femi: Yeah.

57: Joshua: wao!

58: Femi: it's beautiful.

Beautiful beadworks are enhanced by the pattern of colors and shapes which makes the creation adorable and adorn-able. These patterns form part of Bridget's creativity. According to Cooper and Warren (2008), the ability to identify patterns in learning is fundamental to the cognitive development of some science concepts. The school system should apply instructional methods that resonate with the learners learning culture as learning styles reflect how student approach different tasks (Cooper & Warren, 2008). Pattern formation while forming structures as models for science learning could also appeal to learners with different learning style. Perhaps a recognizable learning pattern might resonate with learners learning style and therefore form a sort of identity to the learner. According to Bridget, our identity as Africans can be enhanced by the use of beads which perhaps resonates with the aesthetic characteristics but because of its spiritual relation to some people and it creates cultural and social awareness according to Bridget. Parsons (2008) reported Boykins (1978) posits spirituality as one of the seven Black cultural ethos (BCE). Furthermore, Bridget says "it makes me aware of life around me". According to Goduka (2005) indigenous knowledge comprises a system that is rooted in people's worldview, spiritual being and ancestral knowingness which in this case can be represented by beads. As Africans everything around us is living-the soil, grasses, mountains, water, fire. African peoples make relation to creatures and creations (relational ontology by Goduka (2008)) as Africans live in a communal universe (Mosha, 2000). The African axiology in the use of beads is enhanced by the pattern of colors formed as in Bridget's case. In finding other aspects of Bridget's world enhanced her learning curve in the use of beads Femi asked "you are a visual person" (See excerpts below).

40: Femi: you are visual. You are a visual person.

41: Bridget: yes

42: Femi: you take that knowledge of being visual and you create something. And like you said, something unique. One of a kind

43 Bridget: umm

44: Femi: so you modify other designs, so when you see something, you come back home,

45: Bridget: Yes

46: Femi: then you put your own together

47: Femi: Something you have seen

From Femi's conversation with Bridget, visually, creativity, and re-modification are three constructs Bridget acknowledges to have enhanced her learning- curve towards being a professional bead designer. Learning styles of learners becomes important during the learning process as confirmed in Bridget's learning process and instructional materials should provide for these various learners with different learning styles. Visual learners somehow appreciate colors as natural beautiful realities that they can also make connections with. According to Goduka (2006), African people make connections with nature (relational ontology) to make meaning to a socio-cultural phenomenon. To visualize could in other terms mean to create an image (imagination) by seeing something. While to re-modify could mean to first see, create a mental picture of the material and then re-create the visuals into your new mental image. The act of visualizing and remodifying are central to being creative- all in a social space which Bourdieu (1994) called field or social space. According to Bourdieu (1994), creativity depicts imagination in action and it develops from the need to create a new endeavor- re-modification as in Bridget's case. She has the need to be original in her life style; hence her words "I just fell in love and then made a decision that I want to be involved with this (beads and beadwork", "I still want to know how to start from creating my own (beads)" and "to produce my own glass beads or original beads”. The motivating factor in Bridget’s continuous learning process is the will to “own”. Could this will be also a motivating factor for the learners as they take their learning responsibility into their own hands? These were some of Bridget’s needs. “Original beads”? Femi asked Bridget, “yes original beads” Bridget answered. Bridget continued “Because I have seen, I don’t know how in Zimbabwe they do theirs (Bridget’s relational ontology), but they are beautiful! Bridget confirmed she was creative. (See excerpts below)

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48:  Bridget: it’s more. I regard myself as a creative person
49:  Joshua:  okay
50:  Bridget: I think it comes from my creativity and just being aware
              of what is around me.
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According to Bourdieu (1994), creativity is based on our brains ability to combine previous elements of past experiences and use them to generate new behavior. The brain combines elements of the old to produce a structure (the new) which is the basis of creativity. Bridget learnt the skills from her granny unknowingly and over the years, this has accumulated gradually to become a capital. Bourdieu (1994) argued that the experience does not develop at once, but very slowly and subsequently re-modifies from simpler forms to more complex ones. This experience was gathered over time from reality (her mum’s learning space) in a social space coupled with her ability to imagine (create a mental picture) has enhanced Bridget’s creativity. All things that imagination creates are based on elements taken from the individuals’ previous experience and create more and more different and increased levels of combination (Bourdieu, 1994). This resonates with Bridget’s past experiences with her granny as she states that her mum did not necessary do beads and beadwork. When Joshua asked, “and she was the bead woman, the one that use beads to do the dress”? Bridget answered, “No! She, she was a dress maker”. Joshua continued further in the conversation, “yeah, a dress maker, but the beading part, putting all those into the dresses”. Bridget answered, “I used to”. Femi continued, “To do that for her”? Bridget answered, “Yeah”. (See excerpts below)

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51:  Joshua:   so it is more like you got it from your granny or your
               granny enhanced it somehow like that.
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52: Bridget: laughs, yeah, she was self-employed, my mum is not into. She did not do beads; my granny, she, she. Used to sew clothing, and I will come with her.

53: Femi: yeah

54: Bridget: and I will take care of the jewelry aspect

55: Femi: but I am saying mum may know some, something about how granny, how her mother, you know,

56: Joshua: but it was the granny that was the basics

67: Bridget: Yeah

68: Joshua: granny, because no matter how we imagine, our imaginations come from realities.

62: Bridget: nmm

63: Bridget: you know what? It's from my maternal side. My granny. And my paternal. But I don't know, she did not work with beads. But she used to work a lot with hands. Designs, crocheting, I guess maybe.

64: Joshua: what's crocheting?

65: Bridget: its production of these.

66: Femi: Sweaters and.

67: Bridget: but hand made.

68: Bridget: you know, when growing up, you know as I said, my mum is natural. But she would often, when she does her braids, would have the beads around the hair. (Bridget demonstrating with her hands the position of the beads on the head).

This seems not an actual training in Bridget's perspective but this is an example of one of the ways of knowing for indigenous learners – observational learning (Chilisa, 2010) and hand-on minds-on practice (Mpofu, Otulaja, & Mushayikwa, 2013). Parsons, Travis and Simpson (2005) argues that indigenous learners participate in a range of diverse, highly stimulating hands-on opportunities as they engage and build up social relationships among each other. Bridget confirmed she goes along with her to sew dresses, but not beadwork. Seam dressing, crocheting, fashion design coupled with mum's decoration of her hair with beads formed a rich experience fertile enough for the mental picture (seed) of a professional bead maker could grow. According to Bourdieu, the richer a person's experience, the richer is the material that imagination (mental picture) has access to. For further elucidation, Bridget's creative ability (to be able to imagine) depended on the richness and variety of her previous experience because the experience of dressmaking, crocheting, fashion designing provided her the material from which the numerous beadworks (creations) were constructed. Bridget's social and cultural capital has enabled her cognitive development; hence, her creative ability was enabled by the social and cultural capital. In a relational case, building a relatively strong foundation for indigenous learners' creativity to learn science, teachers and curriculum implementers have the responsibility of widening the experience and provide for the child-a space to explore. Curriculum continued allusion to the learners' social and cultural capital can also be an enabler for learners' better understanding of science in the classroom.

To Bourdieu (1994), all forms of creative imaginations possess a form of affection. These affections depict the internal processes occurring during the cognitive processes that result in expressive constructs. Evident in Bridget's facial expression was the willingness to narrate her story to me, her laughs and smiles, positive emotional energy (Collins, 2004) that radiated from her. This summed up to produce a positive interaction as she showed me so many pictures of beadworks she created. On her neck was a beautiful bead creation. Bridget's capital (social, cultural) is afterwards translated to symbolic capital; hence her epithet-"Mama Africa". (See excerpts below)

69: Bridget: Yeah, you know what? I just love everything that is African. That's just me.

70: Joshua: so the Europeans cannot lay claim to beads as European

71: Bridget: Noo, they copy us, they envy us.

72: Joshua: laughs

73: Bridget: it's unfortunate that we don't see the beauty in us.

74: Joshua: hmnn

75: Bridget: you know what, I often say and this is what, I went schooling, I started in Swaziland. And people will often say to me, are you from Kenya, and are you from Zimbabwe? But I rarely took it in. I never for once said I am not. I always say I am the daughter of the soil.

76: Femi: yeah.

77: Bridget: whether you say to me, am I this or that, yes, I am an African.

78: Joshua: beads made your identity as an African stronger.

77: Bridget: yes. And they call me Mama 'A'. Mama Africa.

78: Femi: okay.

79: Joshua: Why did they call you mama Africa?

80: Bridget: Because I am authentic, natural, I only wear beads. Beads are African.

Before, she could be identified as "Mama Africa" by her colleagues and associates in the social space, her symbolic capital has distinguished her and gave her the identity. Bourdieu (1993) connotes symbolic capital as a degree or level (in my own terms) of competence and recognition accumulated over some time. It is also the amount of prestige a person holds within a social structure. The epithet "Mama Africa" is recognition of Bridget's dexterity in performing the task (creating bead creations). Bridget's symbolic capital was built at a cost. Bridget's granny had accumulated cultural capital (dress making), passed on to Bridget as she observed unknowingly as both of them interrelated (social capital) and later metamorphosed into Bridget's symbolic capital. This symbolic capital created a sort of identity for Bridget. Identity is being modified through cognition and emotional experience according to Geijsel and Meijers (2005). I assume the process between the formation of Bridget's symbolic capital and identity formation involved both intrinsic and extrinsic structures. First, she was proud to be associated with the creations she made. She was successful in her endeavor - beads and beadworks (cognitive), coupled with the affection (emotional experience) that comes with successful tasks accomplishment like smiling, laughing and confident body posture which enhanced her pride as an African.

Bridget's charisma as an African woman was developed and maintained by the beads she adorns and has become an African symbol especially in a multicultural space. Geijsel and Meijers (2005) elaborated on identity formation as "the ever-changing configuration of interpretation that individuals attach to themselves as related to the activities they participate in (p. 423). They argue that positive response leads to identity formation and vice-versa which resonates with Bridget's identity formation as a result of her series of successful creation of her designed beads and Bridget's competence in making more beautiful beadworks. According to Geertz (1973), culture is a historically transmitted pattern of meaning embodied in symbols, expressed in symbolic forms by which the people communicate and develop their knowledge. This resonates with Bridget's Narration because the art of beading was gradually passed on and historically transmitted to her by her granny, which over the years has formed a pattern of meaning embodied in her over the years and expressed in symbolic forms; hence her name "Mama Africa. This symbolic capital (as I pointed out earlier) assisted in Bridget's negotiation into various spaces.

Bridget's knowledge of bead and beadworks (cultural artifacts) illuminated my understanding on how create models of structures (linear and cyclical glucose structures, fructose structures, maltose, glycine and lysine and fatty acids as instructional materials in the science classroom). Her knowledge of patterning, numeracy, color theory, groupings, sizes and shapes of beads, bonding and other mathematical concepts coupled with the methodological context associated with learning beading such as social and cultural capital associated with mentor-mentee, master-apprenticeship group interaction. Can the knowledge of beads and beadwork be conveyed towards enhancing learning in the science classroom? Yes! Beads and beadworks aesthetic attributes extended to cognitive learning as instructional models was created from beads and beadworks and the representational attribute of beads and beadwork became pronounced in cognitive learning. Learners became aware of the potency for cognitive and pedagogical practice which negated the belief that indigenous people's knowledge can be also relevant to learning in the classroom as western artifacts. This also enhanced the possibilities of other artifacts to be used for teaching as their teachers, weeks and months after the learners created the beads, said "Do you know that these learners never forgot those structures? The excellence and potency in black culture has been underrepresented and in a way misrepresented.

As stated earlier in chapter one of this study, the teachers went through a professional development and training seminar where they created their own models of simple molecules like water and carbon-dioxide before proceeding to more complex structures such as glucose (linear and cyclic) and fructose structures before proceeding to the classroom after acquiring the knowledge. In the professional development and training seminar, the teacher's social capital became valuable as the teachers shared experiences among themselves. Such models created by the teachers are as seen below.

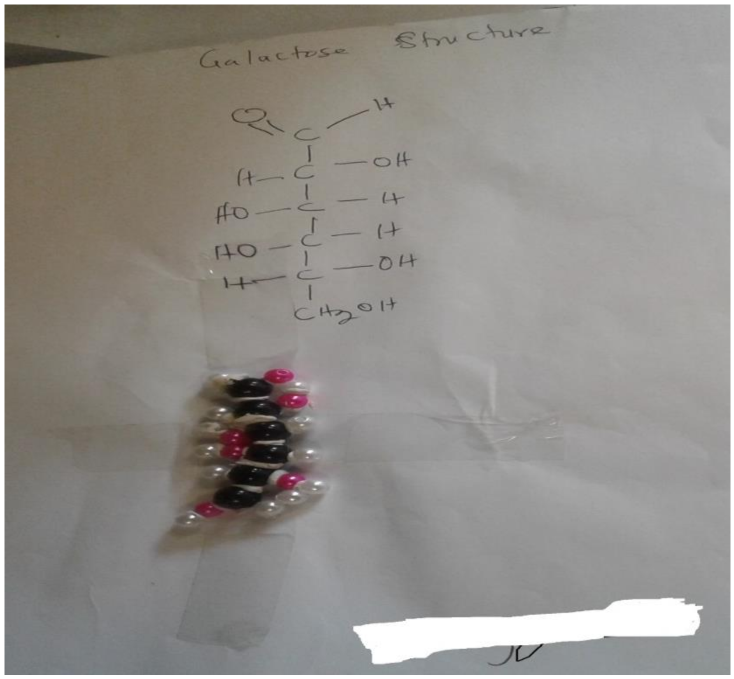


Fig. 7 – Mr. Kagiso's linear Structure

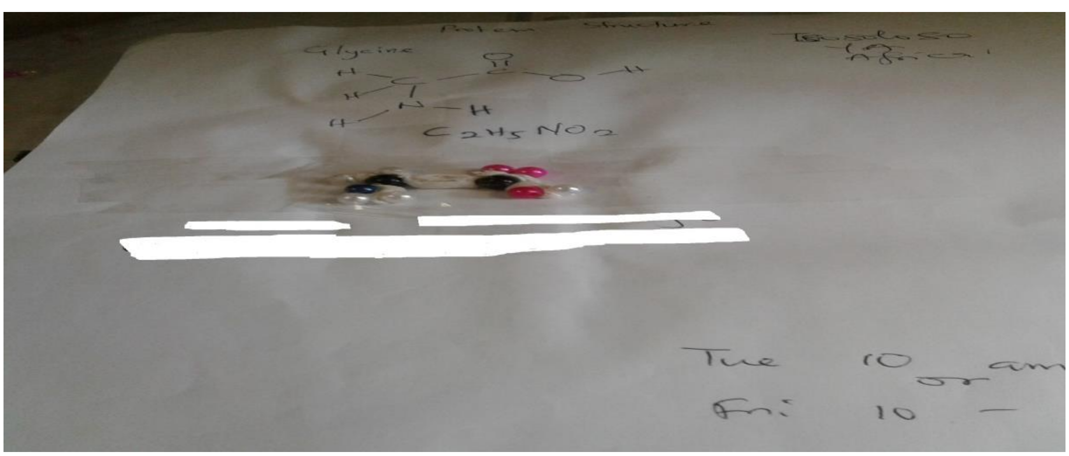


Fig. 8 – Ms. Mbali Glucose Cyclic Structure

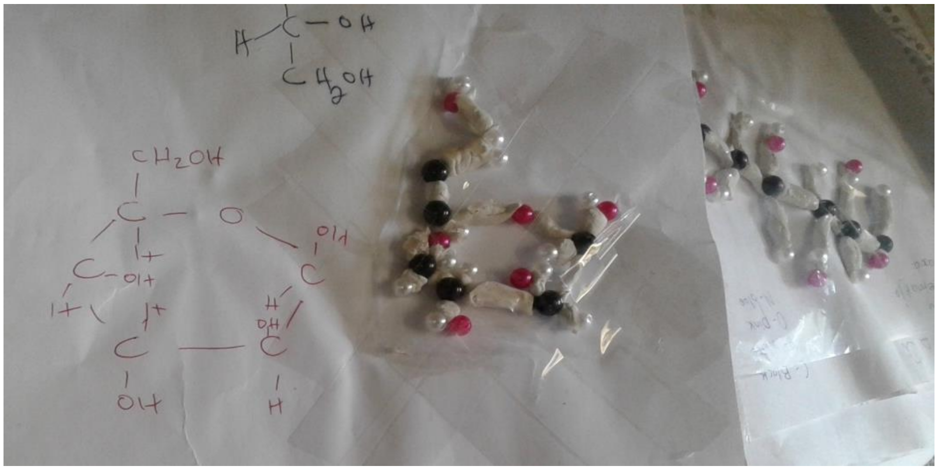


Fig. 9 – Ms. Karabo's cyclical Glucose Structure

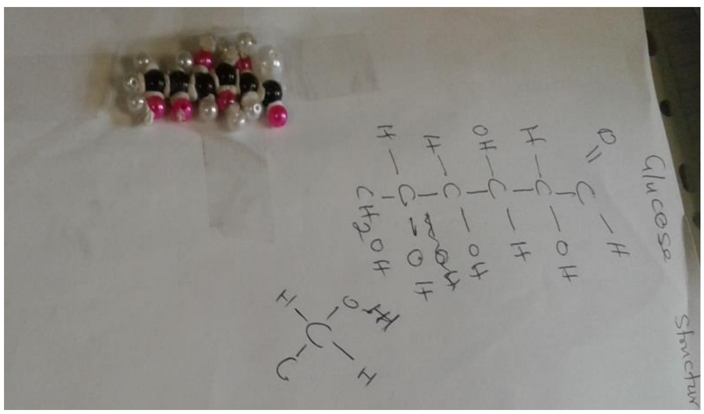


Fig. 10 – Learners Linear Glucose Structure

Figure 1 represents the galactose structure created by one of the teachers in a high school, while Figure 2 represents a glycine protein structure from the same professional development and training session with teachers. Figure 3 represents the cyclic structure of the glucose compounds and figure 4 represents the linear structure of the glucose compound. All four models are representative of what the teachers created. Can the learning approach that Bridget went through (master-mentee or master-apprentice) be employed in the classroom teaching? This approach pedagogical approach seems inhabit the potential that will help learners to relate school science to their home settings as stated in policies implementation in chapter two (2). In the next chapter I will describe the learners' cognitive constructs as affordances enabled by the use of beads and beadworks (cultural artifacts) in a learner centered classroom as captured in the four teachers' classes.

Chapter Five

A Descriptive Presentation

Introduction

In chapter one, I recounted moments of childhood learning as enabled by locally based materials (place-based) and also recalled how some local based materials enhanced learners' learning of science concepts in their science classroom. Chapter one also took account of the frameworks I employed in the research study as well as method of data collection and analysis in this study. In chapter two, previous related literatures were taken account of and elaborated as chapter three took account of Bridget narratives on the knowledge of how she created her beadworks as aesthetic and symbolic materials as a professional bead maker. The knowledge of bead and beadwork as narrated by Bridget was applied and used to create instructional models for the teaching and learning of simple and complex organic molecules. According to Nieuwenhuis (2007), the process of data analysis commences before data collection even started as it entails framing a research question or problem, knowing the various theoretical positions available for the topic chosen, finding blind spots or gaps in literature, knowing one's preconceptions and bias, and making sure sampling was purposeful. On account of Nieuwenhuis (2007) stance on the process of data analysis, the process (data analysis) continues.

The knowledge of beads and beadworks as coined from Bridget's narratives hatched into the knowledge modified to create instructional models of simple and complex organic compounds from beads and beadwork (cultural artifacts). Spawned from Bridget narratives are the knowledge of patterning (there must be patterns formed), Numeracy (the number of carbons, hydrogen, oxygen), color theory (carbon- black, Hydrogen- white, Oxygen- pink, Nitrogen- Blue), grouping (molecular groups), Sizes and shapes (round beads and a medium-sized bead). Bridget's mode/philosophy of learning how to create beadworks such as mentor-mentee relationships or master-apprentice relationship, group interactions (communal) also provided a philosophy to relate to while teaching in the classroom. Learners were in groups which enhanced their individual access to their social, cognitive and cultural capital. It also resonates with indigenous knowledge people's ways of knowing (Boykins, 1994) as seen in chapter 2. This knowledge was transferred into creating instructional models for teaching and learning science concepts from bead and beadwork (cultural artifacts). These models were used as samples for the teachers learning in their professional development and training seminar and subsequently reproduce and gradually modified by the teachers. The modification was continued along the teaching process in the classroom as needs arose by the teachers.

Understanding the Data.

As explained earlier (i) the professional development training of the teachers; (ii) the classroom interactions of the teachers during traditional ways of teaching (teacher-centered teaching) and (iii) the classroom interactions between the teachers and learners with the use of beads and beadworks (cultural artifacts) to create instructional materials as models for the teaching and learning of simple and complex organic molecules, was captured on video for analysis. The reason for capturing on video both classroom sessions (teachers traditional teaching classroom and the classroom facilitated with models created from beads and beadwork (cultural artifacts) was to establish a baseline so as to show how the use of models created from place-based materials may affords learners' understanding of simple and complex organic compounds as against the classroom without the use of culturally related instructional models (CRIM). In addition, it was also meant to figure out what difference or effect the use of beads and beadworks (cultural artifacts) has on the pedagogical practice (teacher and learners) in the classroom. Bridget's narrative on how she created beadwork as (cultural artifacts) was captured on an audio-device. Bead creations were photographed for both record and analysis. Co-participants' experiences were also gathered with the use of semi-structured questionnaire sometimes during and most times after the classroom learning these simple and complex concepts with beads and beadworks (cultural artifacts). Again, the created models (artifacts) were also collected from the teachers and learners to study and discern the misconceptions as seen emerged from the artifacts. All these are part of ensuring the quality of the data in preparation for triangulation.

Triangulating the Data

The different methods of collecting data enabled me to member check and triangulate as, to ensure quality of the data in the study. Trustworthiness of the study was enhanced and the collection process that was made transparent to the participants. Denzin (1970, 1978), Kimchi, Polivka and Stevenson (1991); Patton (1999), enumerated four types of triangulation, namely; triangulation of theories, multiple investigators, multiple theories and multiple sources of data. According to Merriam (2002), while triangulation of theories is rare, the most common is the triangulation of methods and it is repeatedly found in qualitative researches. Further elaboration on the triangulation of data sources, the researcher utilized multiple methods to collect data (interviews, observations and document analysis). According to Chilisa (2012), triangulation is a strategy for enhancing credibility of a study which has other constructs that describes the issue of trustworthiness such as transferability, dependability and confirmability. To Chilisa (2012) triangulation types includes methodological triangulation, investigator triangulation, triangulation of data sources and theoretical triangulation. She also went further as Denzin (1978) did, to posit that methodological data refers to data collected by various means. Means here as described by Chilisa (2012) denotes "data from structured interviews, talk circles, observations, diaries, documents, oral literature, storytelling, songs, language, proverbs, metaphors and artifacts" (p. 167). In explaining the triangulation of data sources, Chilisa (2012) posited that "it is based on the importance of varying times during which events are observed, space where they are observed and participants in the study".

Polyvices

Another form of triangulation of data sources may involve the use of a wide range of informants. A range of documents may also be employed as source materials according to Shenton (2004). In this study, methodological triangulation was employed as data from unstructured interviews of teachers and some classroom observations of the teachers' traditional (teacher centered) classroom was captured. The observation of the classroom where the use of beads and beadwork (cultural artifacts) took place with unstructured questionnaires of both teachers' and learners' experiences as well as field notes was also captured. Artifacts from both teachers and learners were collected and observed. Furthermore, I engaged the use of multiple recording devices (MRD) such as cameras and audio recording devices for each observation in each classroom.

The use of multiple recording (data collecting) devices in observing a phenomena is called Polyvices. The use of multiple devices was to ensure that the most salient activities (learners-learners, teacher-learners' group) interactions in the classroom was captured. Also important was the power dynamics existing between the learners and their teacher were captured. Learners were involved in ensuring the learning process in the science classroom became more meaningful. Learners' interactions became inclusive as teachers and the environment because resources for learning. I had to capture the classroom observation with multiple cameras at different positions at the same time in the classroom. Therefore I had multiple (four) versions of the same classroom activity both for the teacher-centered classroom and the classroom with the use of beads and beadwork (cultural artifacts).

In capturing the video data, I used four cameras for each classroom (4 cameras in 1 classroom). I transcribed each of the four versions; hence I had four transcribed data from four cameras of the happenings in the same classroom. Thereafter, for the activities in each classroom, I compressed the four different versions of the cameras into an A4 size paper with four columns where each camera transcription was placed in a column such that it looks like this. See below.

Table 1. Camera Transcription

Mbali (camera 1)	Mbali (camera 2)	Mbali (camera 3)	Mbali (camera 4)

Thereafter, I assigned colors (red, blue, green and yellow, pink, light blue…) to code the voice transcription of each participant in a classroom. Each participant or group has a color code. The teacher as a participant and each groups of learners as a group. For example, in a life science class (I), the teacher was also represented by color red. Group (A) members were represented by color green, group (B) members was represented by color blue, group (C) members were represented by color yellow and so on. In cases where there were group interactions, the group was coded with the same color while each group members involved in the group interactions were labelled (L1, L2, L3) in a group of three and (L1, L2, L3, L4) in a group of four participants.

Table 2. Camera Transcription with Tables

Mbali (camera 1)	Mbali (camera) 2	Mbali camera 3	Mbali camera 4
Teacher : Make sure you don't lose the beads (00:02) Look up (00:09) Look up the teacher says we should look up((group (A_{L1}) member talking to group (A_{L2})) (00:10)	Teacher : Make sure you don't lose the beads (00:02) Look up (00:09) What I did the teacher just say? ((group C_{L1} member talking to group C_{L3} (00:14)	Teacher : Make sure you don't lose the beads (00:09) Look up (00:09)	Teacher : Make sure you don't lose the beads (00:09) Look up (00:09) Give me the pencil please, let me draw ((group B_{L1} talking to Group B_{L4})) (00:12)

If group A comprises three learners, all group A conversations will be coded in color green and at the end of each conversation, the member of group (A) involved in the conversation will be labelled (L1) as a subscript of group (A). The second member will be labelled (L2) as a subscript of group (A), while the third and fourth member will bear L3 and L4 as a subscript of group (A) respectively. So across the four columns (camera 1, 2, 3, 4) of the same class, the teachers words was coded the same color as well as all groups and group members.

Again, I numbered every word of every participant in the conversation. This is to ensure the right conversation when compressing each participant's conversation. Another reason for numbering each word was because in some part of the participant's conversations, I found out that some words were not very clear in a camera and clearer in another or sometimes in other cameras. In essence, the numbering of the words ensured that the correct word followed the last word transcribed. At the end, I compressed the four columns into just one. This means, each participant had a member checked version.

Table 3. Compressed Camera Transcript

Mbali (camera 1)	Mbali (camera 2)	Mbali (camera 3)	Mbali (camera 4)
Teacher : Make sure you don't lose the	Teacher : Make sure you don't lose the	Teacher : Make sure you don't lose the	Teacher : Make sure you don't lose the

beads…..1 Look up …2	beads…..1 Look up ….2	beads…..1 Look up……. 2	beads…..1 Look up…… 2

Table 4. Color Coded Camera

Teacher	Group A	Group B	Group C
lose the beads…..1	Tell me the meaning of that double bond (L1)	Glue the black beads (carbon) together please (L2)	I need six white beads (L1)

After color coding each participant, labeling each participant of a group, and numbering each conversation of each participant in the group, I compared the four transcriptions of each camera, arranged in columns (cam 1, 2, 3, 4), and I discovered that, some words were made clearer in one camera while in other camera, it may be faint. So after comparing the words in the four cameras, I ended up with a correct version of what words the participants said. This is an advantage of Polyvices. Afterwards I had separate A4 paper for the conversations of each participant in the classroom. (The teacher and the four groups). In essence, I collated each participant conversation into a data set for each class and each school. For example, all group (A) conversation in grade 10 (I) was compiled into a booklet. I did the same for group (B), (C) and that of the other teachers' conversation. (See below)

Table 5. Group Conversation Compiled

Teacher
The black beads represent carbon, the white beads represent hydrogen, while the pink beads represent oxygen.1 You get it?...2 It is not like this , it is like that ((teacher talking to group A))…3

Table 5A. Group A Conversation

Group A
Tell me the meaning of that double bond (L1) talking to (L2) Hydrogen only attaches to one carbon….(L2 answering L1)

Table 5B. Group B Conversation

Group B
Glue the black beads (carbon) together please (L2) talking to L1) Ok, I have given it to him (L3) answering (L2)

Table 5C. Group C Conversation

Group C
I need six white beads (L1) please, bring them for us so that we can construct our bonds(L3 talking to L1) Kanjani ((how did you do it)) L1 asks L3

The numbers were removed and colors for different participants were also removed. I had all teachers conversations vetted, as well as all other conversations per group. This was done to fully understand the conversations in group and see if there are patterns forming. Transactions such as learners gestures (eye contacts, bodily contact with hands and legs), were captured in a column on the transcription paper. Classroom interactions (learners-learners, learners-teachers, learners-environment) were captured. By learners- environment interaction I mean interactions with someone on the corridor or interactions with the camera boy in the classroom. In some cases where there is more than a classroom to video-capture at the same time, I took permission from the teacher to assign the duty of using the camera to a student from the same classroom or from a student from another classroom to video-capture the classroom interactions (Tobin, 2005).

Using just a video-capturing equipment (camera) in the classroom might deprive the research study the rich and thick capture from the classroom. In classrooms where the learner to learners interaction becomes vital and also in cases where the teachers conversations with a group farther from the chalkboard needed to be captured, it appears there is the need for multiple video-capturing equipment to capture simultaneously the classroom interactions. In the four versions, there were words that a camera captured clearly and in another camera, the words were captured faintly. I captured transactions between members in a group, conversations between members in a group and another/other member of another group, and transactions between a group and the teacher individually. I proceeded to compressing the words into a single conversation as I said earlier. Also in the classroom teaching and learning, conversations occurred simultaneously of each other. When the teacher converses with the whole class, some groups could also be interacting with each other or while the teacher explains to a group, other groups were busy teaching each other.

These interactions occurred sometimes at same time other interactions occurs and also at varying times from when other interactions occur. For example in a class, all captured conversations in the classroom (between the teacher and all groups at the same time and between the teacher and a group while other groups interact at the same time.

Table 6A. Ms. Mbali's Classroom Recompiled

Mbali (the teacher)	Group A	Group B	Group C
Make sure you do not lose the white beads otherwise you will not have enough beads representing hydrogen molecules (00:12)	Yes (00:13) Chorus	Yes (00:13) Chorus	Yes (00:13) chorus
			Ma, we do not have these beads ((learners referring to hydrogen beads)) 00:14
The white beads representing oxygen are here, come and pick the number of beads you need. ((teacher replying group c members)) 00:16	Listen , the teacher is explaining 00:16	The double bond is like this (00:16)	How many carbon atoms are here (00:16)

In generating a framework to make sense of the data and identifying categories and themes (Creswell, 2009) the all-class conversation was created on a page containing four columns. After ensuring I have the co-participants conversation transcript, I compiled all conversations in columns with the goal to make it easier to read so that conversations that occurred at the same time were always together with conversations that occurred at different time as buffers. See below.

Table 6b. Ms Karabo Classroom Recompiled

Miss Karabo's class IIB			
Teacher	Group B	Group C	Group D
Look at the chalk board please. (00:11)	Look up {L2 tells L1) 00:11	And the two oxygen (L1 tells L2) 00:11	That is what we are going to do. 00:11

The conversational style enabled sense making of the data as patterns of expression became clearer and themes evolved from categories (Corbin & Strauss, 2007). In cases where the teachers have more than one class, the classes were named class A or B or C and each class conversations were represented on an A4 paper. From these conversations, I coded for words of participants and afterwards coded for patterns of expressions that began to appear.

From all that I have alluded to in previous paragraphs or section, each class had its own conventional sheet. From the conversational sheet, codes were formed from which categories emerged. Related categories formed themes. Further engagement with the data showed trends of recurring patterns that reflected the learners' affordances with the use of beads and beadworks (cultural artifacts) to learn in the science classroom. As part of what Merriam (2015) posited earlier, the process of analysis depended on how the data was gathered, the researchers view and choices. I found it imperative to explain the "how" of what role the participants played in the study. Bridget (Chapter Three) unpacked the knowledge of beads and beadwork (cultural artifacts) to be used to create instructional models for teaching and learning of simple and complex organic compounds. The teachers had to first learn the use of beads and beadwork (cultural artifacts) to create instructional models from the professional development and training seminar before the teachers helped learners facilitate their learning of simple and complex organic compounds. The learners participated in the classroom pedagogical practice with the use of beads and beadwork (cultural artifacts) to create instructional models. Subsequently, I allowed research participants access to the interpretations of data afterwards and granted them the responsibility of vetting both the written description and analyze. The goal was to member check the interpretation of data to determine if it resonates with what they intend to mean during the classroom interactions. By doing this, I extended the validation process to the research participants (Creswell & Creswell, 2017). Validation of the various narratives in the study preceded the articulation of what happened and why it happened.

Influence of Bridget's Narrative

Earlier in the study, Bridget's narrative on the knowledge of beads and beadworks (cultural artifacts) enabled me to adhere to the processes, when creating instructional models on simple and complex organic compounds from bead and beadworks (cultural artifacts). Enacting these instructional materials made from beads and beadworks (cultural artifacts) in the classroom highlighted how culturally relevant materials could be utilized in enabling the learners' science concepts learning in the science classroom. As highlighted in the literature review, Gloria Ladson-billings (1995) argued that culturally relevant pedagogy evolved from various terms used by researchers advocating for teaching learners while alluding to the learners' culture. Researchers such as Mohatt and Erikson (1981)'s use terms such as "culturally congruent, Cazden and Legette (1991)", Mohatt and Erikson (1982)'s used the term "culturally responsive" to make evident the push for a teaching and learning method that involves the allusion that learners' lived-world is a place-based resource. According to Gloria Ladson-Billings (1995), Vogt, Jordan and Tharp (1987) used the term "culturally compatible" when explaining the success they had with Hawaii children. Gloria Ladson-Billings (1995) further posited that scholars used these terms to describe language interactions that are harmonious with linguistically diverse and Native American students (all indigenous to their communities).

They (teachers) should observe the learners' lived-world and be willing to inculcate some aspects of the learners' lived-world with classroom science teaching. These studies were also particular about the language interaction patterns between the teacher and the learners in the science classroom. To encapsulate a more expansive term that will bridge the gap between learners home culture and the school culture, the term CRP was articulated as well as other terms like culturally responsive teaching (CRT) (Gay, 2000) and cultural aspects in learning science (Aikenhead, 1997). In the case of this study, I allude to the use of cultural artifacts (bead and beadwork) to create instructional materials to enable learners learning as a cognitization process. The reason for this is that culturally related materials are used to enable learners learning in the classroom.

Based on this study, culturally related learning does not only entail the inclusion of policies that advocates integrating materials from the learners' cultural environment into their learning in the classroom but a curriculum that accommodates the learners experiences (lived world). The learners' lived world includes their philosophy (African), relational ontology, learners' axiology and cosmology (Goduka, 2005). In addition, teachers can allude to patterns of interactions between learners and teachers in the classroom. By African philosophy, I mean teachers show understanding of how African learners think. I explain relational ontology as "the nature of the learners being". Goduka (2005) further explains relational ontology as how the learners see the world, which also impacts the learners understanding of science concepts. By learners' axiology, I mean the nature of the learners' values as this enables the teacher to know what value do the learners place on a scientific thought. Learners' thoughts are interconnected and interdependent within their environment (Goduka, 2005). The learners are surrounded with their culture, if so, what part of the learners culture can be alluded to in the classroom pedagogical practice by the teacher. Hence I wish to assert the term culturally relevant learning as a term that reflects learners learning with the use of materials in the learners' lived world.

The transfer of Bridget's knowledge of beads creations to the science classroom as instructional materials to create models for learning in the science classroom became valuable in actualizing the dynamics in the creation of bead and beadwork models. As enumerated earlier, the teachers produced their replica models of glucose, fructose, lipids, protein that was given to them as examples during the teacher development and training program. In this study, the learning moments of four life science teachers and their learners were captured; while emphasis is made to ensure confidentiality and anonymity. Pseudonyms were used in place of proper names except in the case of Mr. Brighton who wanted his proper name to be used and for which he signed an agreement.

After the teachers (Ms. Karabo, Ms. Mbali, Mr. Brighton and Mr. Kagiso) created these instructional materials, one of them, a life science teacher, unconsciously uttered "Wao! This is beautiful"! At first, before she signified her willingness to participate, her facial expression indicated a look of "what is the relevance of beads to life science"? This resonates with the views Onwu (2009) that posits that "some teachers have the perception that indigenous knowledge is outdated, degenerated, demeaning and not in harmony with modern or current thinking" (p. 25). These teachers wondered how beads could be used to teach in a life science classroom. Furthermore, all teachers involved in the professional development and training seminar indicated their unawareness of the curriculum stance on the use of beads and beadwork (cultural artifacts) to teach simple and complex organic compounds. Teachers were subsequently taught on how to develop the models as well as represent the simple and complex organic structures with models to enhance learners understanding of the science concepts. The teachers were subsequently taught how to write lesson plans on the use of beads and beadworks (cultural artifacts) to create models of simple and complex compounds in the classroom. This was because three of the teachers signified that they don't know how to write lesson plans generally, let alone writing lesson plans for the creation of models from beads and beadworks (cultural artifacts). Again, the learners' use of beads and beadworks (cultural artifacts) also revealed the different mental representations of bonds holding these organic structures. Below are some cases where the misconceptions (Fig 1, 2, 3, & 4) of learners became glaring as they (learners) represented their knowledge of bonding differently which might not have been made clear to the teacher if these structures were not made much more concrete.

Learners Bonding Preconceptions and Misconceptions

The learners' representations in the Figures below revealed the learners preconceptions and misconceptions about the bonding concepts in simple and complex organic compounds. It also represents the learner's thoughts in relation to chemical bonding in simple and complex organic structures. To the teachers, it showed the reality of learners' thoughts and conceptions of bonding concepts in organic structures. I selected the artifacts of few groups in the classrooms based on the differences on how the learners conceptualized their knowledge of bonding. The group of learners that created the model in Figure 1 noted that "the organic molecules are directly attached to each other by the bonds". While the second Figure I selected said the model they created (Fig 2) depicts that "the organic molecules are attached to each other by bonds that are at length from each other and which were represented by lines in between molecules-these lines are imaginary". The third group of learners represented by the artifacts shown in Figure 3 noted that bonds are, as they look in the textbook-they are like a long thin line holding two or more elements together. This is how the bonds look physically. The fourth (Figure 4) represents a cyclical structure of glucose whose molecules are held together by long lines. The fifth (Figure 5) simply represented the bonds as imaginary lines holding the molecules together and Figure 6 represents compounds attracted to each other because of the electrons affinity according to the learners.

Misconceptions arose from the teachings in the classroom and these misconceptions where corrected as the teachers (Ms. Karabo, Ms. Mbali, Mr. Brighton, and Mr. Kagiso) in their different classes had to teach the learners the nature of chemical bonds. It was an eye opening for the teachers to discover the learners' 'Achilles heel" in learning the bonding concepts. Learners had been taught that the chemical bonds are forces of attraction that held atoms together and as a matter of fact, the bonds are shared between two atoms. The teacher continued, bonds are formed when electrons are shared between two atoms. For example, if two hydrogen atoms (H^+ and H^+) are combined together to form a bond, each hydrogen atom has a share in both electrons. This electron share can be represented as 2 dots (H:) or a single dash (-). In cases where there is a double or triple dash, the dash becomes double and triple. At the end of the lessons, the teachers became aware of the misconceptions that learners while trying to understand various concepts in the classroom. To the teacher, without the representations the learners made, the learners' misconceptions will not be discovered.

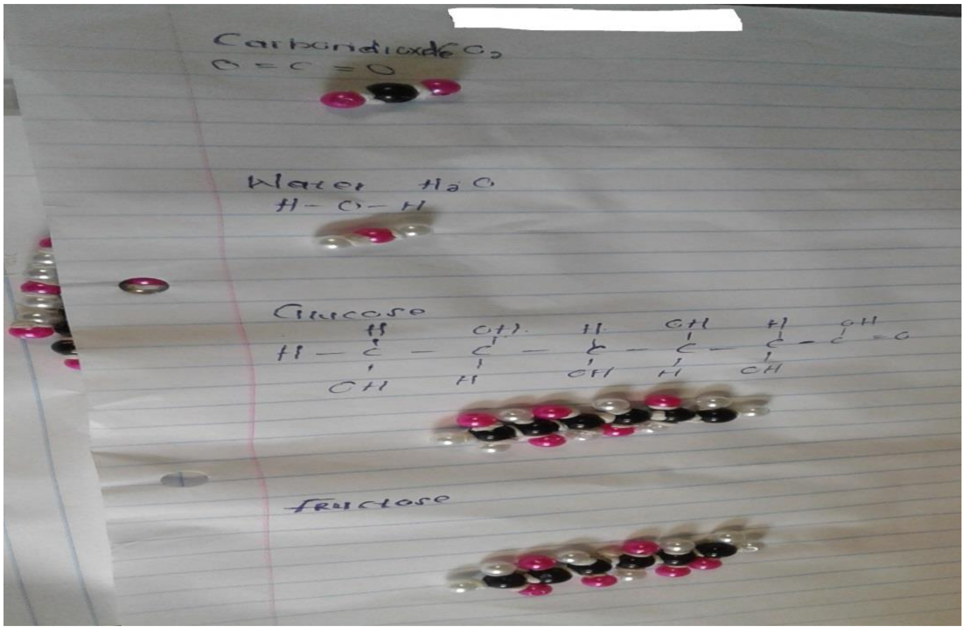


Fig. 11 – Learners' Water and Carbon Dioxide and Linear Glucose Structure

Figure 11 shows the representations of simple molecules (CO_2 and H_2O) and the complex molecules of linear glucose structure and the fructose structure.

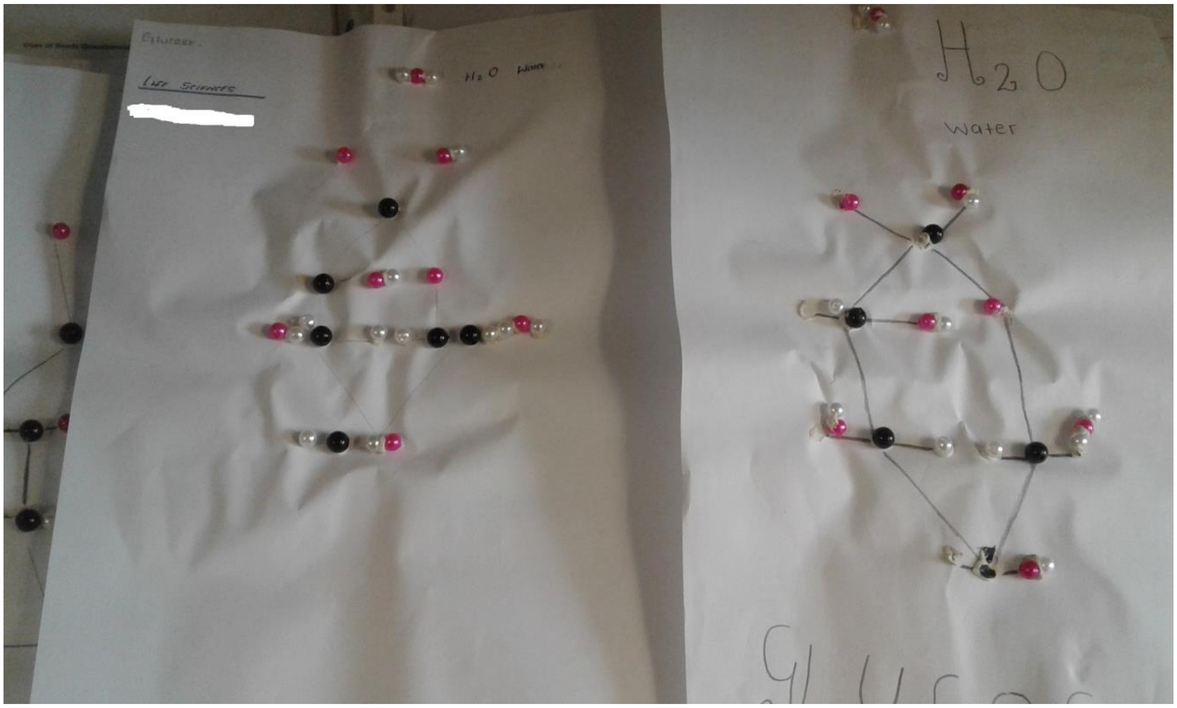


Fig. 12 – Learner's Water and Carbon dioxide and Cyclical Glucose Structure

Fig. 12 represents the simple structures of H_2O and the complex cyclical structure of glucose.

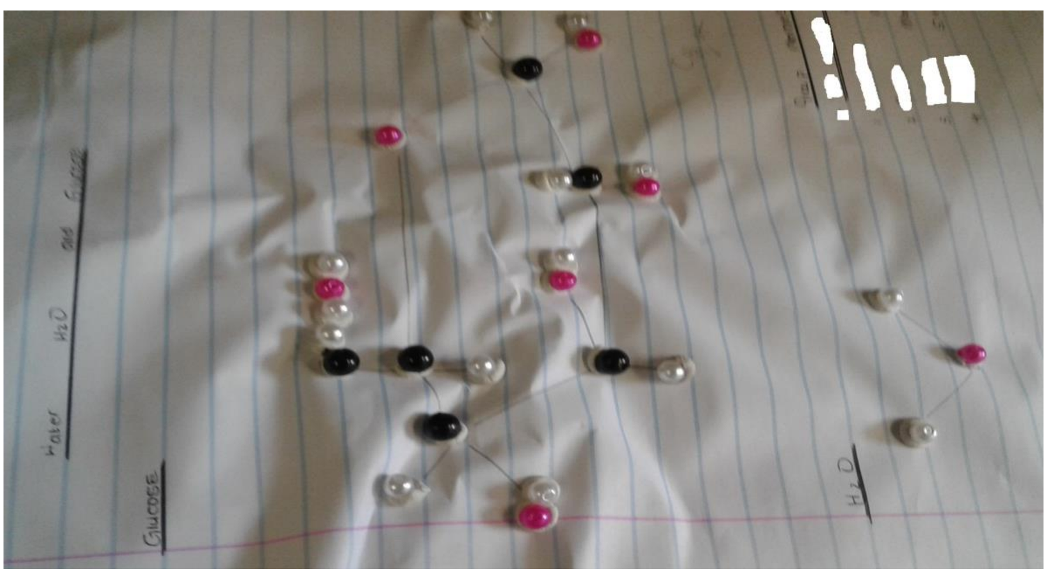


Fig. 13 - Learner's Cyclical Glucose Structure

Fig. 13 represents the simple structure of H_2O and CO_2 and the complex cyclical structure of glucose.

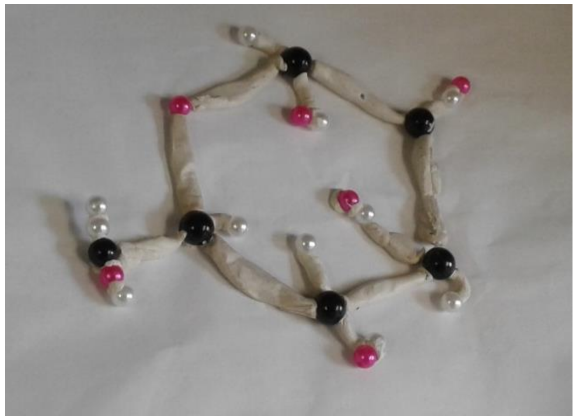


Fig. 14 - Cyclical Structure of Glucose Compound

Fig. 14 represents the cyclical structure of glucose compound.

Fig. 15 – Water and Linear Structure of Glucose

Fig 12 represents the simple structure of water (H_2O) and the linear structure of glucose.

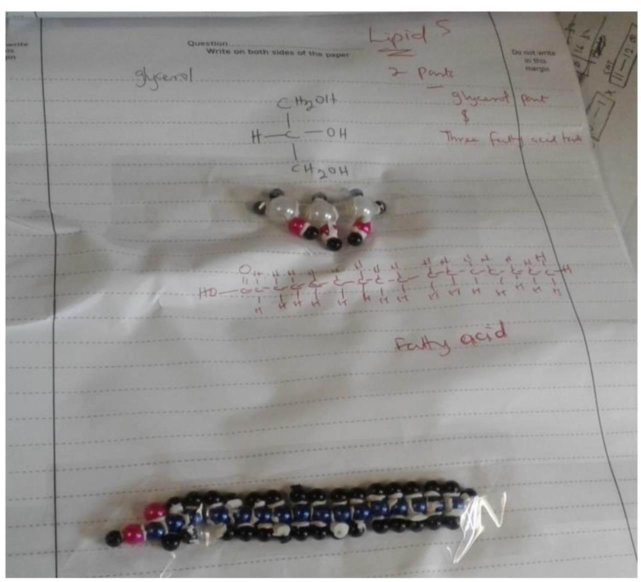


Fig 16 – Glycerol and Fatty Acid

Fig 13 represents the structures of glycerol and fatty acid respectively. Each teacher had different form of expressions and opinions on the use of beads and beadwork (cultural artifacts) to teach in the classroom and I think it is necessary to discuss each of the teachers' narratives as it happened in both of their classroom.

Who are the Teachers?

Short biography of Ms. Karabo. Ms. Karabo is a South African female who had been teaching life sciences for three years; she is relatively new in the profession. In my discussion with Ms. Karabo, she claimed to have been born and bred in a village. She also claimed to have been trained in the school of Education in one of the metropolitan University. She teaches in a peri-urban school where she was responsible for teaching life sciences to grade 10 and grade 11 learners. She also teaches grade 10 natural Sciences natural sciences classes. There are on the average fifty learners in each of her classes. Ms. Karabo was recommended to me by the Head of Life sciences department and subsequently, I invited Ms. Karabo for a dialogue. Ms. Karabo's school was one of the three schools selected for carrying out my research study. The dialogue was to explore the idea of possibly using beads and beadwork (cultural artifacts) to create instructional models of simple and complex organic compounds. It was also to establish a working relationship with her and ascertain the time for her lessons as well as free periods for both the professional development and training seminar and the classroom practice with the use of beads and beadworks. At first, she was skeptical about the use of beads and beadwork (cultural artifacts) to teach these organic compounds (carbohydrate, protein and lipids) in the classroom. After the dialogue, she began to see the possibilities of creating the organic compounds for teaching in, not just the life sciences classroom but in the natural science classroom. I examined her classroom pedagogical practice in relation to the affordances the use of beads and beadwork (cultural artifacts) enabled her learners and to explore how the use of bead and beadwork helped her learners understand science better in the classroom. Below is an excerpt from Karabo and me during the professional development and training.

Ms. Karabo asked if we could teach all her classes and I obliged. Ms. Karabo was the first out of the ten teachers (both life sciences and natural sciences teachers) to attend the professional seminar; she was always punctual and inquisitive, wanting to know if it (creation of instructional models from bead and beadworks) could be used for pedagogical practice. All teachers including

Ms. Karabo stunningly told me they were not aware the use of beads was stated to be use in the curriculum. At first, my supervisor and I were not also aware of the use of beads and beadworks (cultural artifacts) to teach the learners the structure of organic compounds as stipulated in the curriculum. We just discovered after searching through the literature and the South African curriculum. Perusing the curriculum with Ms. Karabo, she said the curriculum did not tell us how the beads would be used to construct instructional models for science teaching. Perhaps the teacher would use needle and thread or other stuffs, "we don't know?" Ms. Karabo further told me that her students will be excited to be engaged with the beads and that it could make them learn more. Ms. Karabo created her model and proudly wrote her name on the model (glucose and fructose) she created. She showed enthusiasm and was willing to encourage other teachers who were at first skeptical in the use of beads and beadworks to teach science in the classroom. Other teachers saw the enthusiasm in her (Ms. Karabo) and the positive emotional energy what radiated which in a way became infectious to other teachers ; hence, their willingness to create models from beads and beadworks (cultural artifacts gained momentum and it became a sort of "I can also do mine" among the teachers. My interaction with Ms. Karabo continued (see excerpts below). The teachers' creation of models afterwards increased the teachers' value on the use of beads and beadwork (cultural artifacts) as beads can is now seen to be able to be used cognitively and not only aesthetics. It also made the teachers' value for their indigenous knowledge increase. Our discussions continued. See excerpts below.

Joshua: Can the students find it easy while doing it?

Ms. Karabo: Yes

Joshua: Do you find it tiring

Ms. Karabo: No, but now if you make the hydrogen (beads) smaller and the carbons (beads) bigger because we have to attach the hydrogens (beads) to the carbons (beads) on four sides. It's hard for me to connect a whole lot of big beads to the smaller one. *((It seems the beads were bigger than each other, at first))*

Joshua: These white ones (beads) are smaller beads.

Ms. Karabo: Okay, okay, yeah, yeah, I think that would work much better.

Joshua: yes

Ms. Karabo: Try using the big blacks (beads). The big black beads. Okay

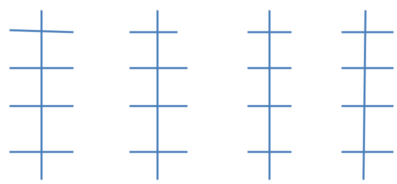
Joshua: You know what, I don’t want to kids to feel of think that the carbons (beads) are bigger in size than the hydrogen (beads). You never know what they can think of.

Ms. Karabo: {laughs}, Maybe you remove the big ones (beads), those white ones (beads). The pink one is oxygen, so the oxygen is attached to the hydrogen……. {Pause}. So how would they learners be able to identify the double bond?

Joshua: Anywhere you have that single pink (beads); it will be a double bond. ((*This was my way of representing double bond))*

Ms. Karabo seems to see opportunities for better learning for her learners with the use of beads and beadworks (cultural artifacts) to create instructional models such as glucose, fructose, lipids, and protein in the classroom. She also rendered her suggestions on how to improve the creation of the model using beads. Her ontological shift towards the value of the use of bead and beadworks (cultural artifacts) to teach and learn in the classroom seems obvious. Ms. Karabo noticed a possible difficulty in representing the double bonds with the Bostic glue, as we constructed the glucose structure. I tried to explain to her Ms. Karabo how I conceptualized the construction of the double bond in the glucose structure from what Bridget in chapter 3 narrated. However, drawing on her pedagogical practice, Ms. Karabo seemed not convinced. She noted that the learners may find some ways to articulate how to construct the double bond in the glucose structure. Ms. Karabo saw an opportunity to enhance her life science learners’ understanding of simple and complex organic compounds as she became more curious in finding the right approach to teaching her learners how to construct a glucose molecule using beads and beadwork (cultural artifacts).

As noted earlier, Ms. Karabo’s traditional centered class was captured on the video. Her learners’ class sitting arrangement is in rows and columns. Perhaps by default, taller learners sat at the back of each shorter learner. Hence, the classroom arrangement was like ‘a descending order from the tallest at the back to the shortest at the front. There are fifty learners in her classroom. Each learners desk was arranged so close to the next learner in front such that there was no space in between a learner's desk and the next learners chair in the same row. In between columns, there were walkable spaces; hence movement between rows is allowed while movement between columns is restricted.



The whole classroom space was apparently divided into the teachers and learners space. The space around the chalkboard and the learners' front desks seemed like the teachers' space while the space arranged in rows and columns seemed like the learners space. The teacher (Ms. Karabo) spent most of the lesson teaching and classroom management of the 'learners' space' from the 'teachers' space' in front of the classroom. Ms. Karabo hardly moved into the learners' space throughout the lesson. Learners were neither allowed to talk nor interact unless instructed by the teacher. Perhaps, the traditional sitting arrangement favors Ms. Karabo's teaching method as she taught the learners while they were somewhat quiet.

In Ms. Karabo's classroom with the use of beads and beadwork (cultural artifacts) to create instructional models for simple and complex organic compounds, her learners, by instruction arranged themselves in groups. Groups were in three's, four's, five's and in somewhat of a circular form, thanks to the movable desks and chairs in the classroom. How the learners chose themselves was not clear to me. Hence, there were eleven to twelve groups of learners in the classroom. After a few minutes of introduction and explanation of the lessons intricacies to the learners, the teacher went from group to group to attend to the learners' challenges as they arose. Teachers' selection of whom to attend to, during classroom teaching was sometimes based on the learners' call for attention and other times, based on the teacher's ability to discern a challenged learner or group of learners as the lesson progresses. Learners voice in the classroom was raised as they were seen interacting with each other. According to Harvey and Kenyon (2013), sitting arrangements influence learning significantly. Harvey and Kenyon (2013) further states that, the sitting arrangements in the classroom influences teacher/learners communication, peer/peer engagement. In Ms. Karabo's classroom, teacher/learners engagement, teacher's learners' physical mobility was also evident as well as peer-instructional engagement in the classroom.

Furthermore on the happenings in Ms. Karabo's teacher-centered classroom, there were no instructional materials (charts, drawings, models) or other presentation materials for the learners in the life sciences classroom. No mediating artifact or model to be used by the learners but the teacher had a note and textbook with her in front of the classroom. Perhaps the more reason learners had to focus on the teacher as the sole source of information for the learners. Learners were somewhat attentive and quiet while they were taught by the teacher. The teacher being the sole source of information to the learners feasibly may have resulted in breeding learners' seemingly total dependency on the teacher to understand these science concepts. Hence, the workload weighs down the teacher and gets tired shortly. Especially when the teacher has other multiple lessons to take for the day, the teachers' productivity decreases. As the lesson went on, the learners' responses to the teacher was one-worded. Sometimes the learners did not answer the teacher when asked questions. This non-response perhaps tells the teacher the learners do not understand what she is teaching the classroom. Questions that required higher order thinking questions were ignored while questions that required just a 'yes and No' was answered. (See below excerpts)

Ms. Karabo:	Digestive system, Reproductive system. Those are some examples of system, Right
Learners:	yes *((chorus))*
Ms. Karabo:	And then the organism is…. Yourself, other animals. So now, we have a flower; a plant and those are:
Learners:	No response
Ms. Karabo:	The flowers, leafs, stem are. They are organs. You get them now? What functions are the leaves involved in?
Learners:	No response
Ms. Karabo:	Cos now we are talking about the leaves specifically right? These are some of the organs and we are going to be focusing on the leaves. Right, can somebody tell me something that the leave can hold?
Learners:	No response
Ms. Karabo:	They make life for photosynthesis. For photosynthesis right?

Learners: No response *((chorus))*

Ms. Karabo: What do they have that makes it possible to produce sugar?

Learners: Chlorophyll; Chloroplast *((chorus))*

Ms. Karabo: What else do they do? They are involved in cellular respiration. What do they do in the process of gaseous exchange?

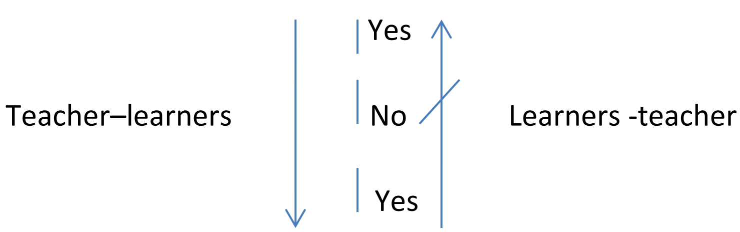
Learners: No response.

Ms. Karabo: This sugar that is produced is also called glucose. That is the structure we are to study this morning.

Learners: Yes Ma'am. *((chorus))*

Again, questions the learners did not respond to were re-explained by the teacher. The non-response by the learners could possibly be a communicating signal to the teacher to say 'please re-explain'! It could possibly also occur as a result of learners being conditioned to knowing that, the teacher will answer the questions she asks, if not answered. It could possibly also be because the learners do not understand the answers to the questions asked; hence, the learners were not involved in their learning process. There was always a chorus response (yes) from the learners.

Communication in Ms. Karabo's classroom was a sort of one–way interaction, from the teacher to the individual learners and learners back to the teacher.



Occasionally, learners responded with a one-word answer (yes and no). Learners were not encouraged to interact with each other and share knowledge. The teacher fails to recognize that the communication is supposed to be a two-way stream. Her lesson depicted a classroom where the learners were only allowed to talk when the teacher permits the individual learner to speak and perhaps respond only to the teacher; hence, the 'yes' and 'no'. This could possibly be on account of the teachers' African context, premised on that saying that respect is demanded.

Culturally, younger ones must not speak when the elders are involved in a discourse. Similarly, learners must not speak when the teacher in the classroom teaches unless the teacher acknowledges the one who raises the hand. Multiple hands may also be raised up and the teacher choses to acknowledge few of the hands. For the rest of hands that the teacher did not attend to, it may be demotivating if this non-acknowledgement (hands) is repeated. The act of non-acknowledging the hands could be subconscious, but because of the workload, learners' population among others, the teacher becomes exhausted. The teachers' state of debility at the end of the lesson or the teachers' will to cover the lesson being taught in time may account for the teacher, raising his/her voice in the class even while asking questions. More often, the intonation and facial expression of the teacher while asking "any question" engenders the seemingly default in the classroom indicating that learners are not supposed to ask questions and that learners are supposed to understand anything the teacher says without having to ask the teacher any question.

These rules could have conditioned the learners to have responded a 'yes' or 'no' when asked questions in the classroom. In essence, the nature of questions the teacher asked required longer answers and in some cases the learner failed to respond to the question. A reason could possibly also be that they may have been conditioned to giving a 'yes or no' answer. Or because of time constraint on the teachers' part, the teacher may not have given the learners time to think through. It could also possibly be, because the learners are afraid to give a wrong answer on account of the learners prior experience there the teacher has not been kind to them. (See excerpts below)

Ms. Karabo: Now on the next page? Page 122 we have the structure of the fructose and glucose which is produced in the leaf. So this structure will take us through the whole glucose structure. And it will show us what it is made up of and what other members of the monosaccharide, disaccharide and polysaccharide we have. Right! So on the next page we have the structures of other family members, we are going to study and discuss. Then from there we shall know what specific types they are involved in. Before that, let me ask you what where is sugar/glucose produced in the plant?

Learners: No response

Ms. Karabo: leaves right! The leaves of angiosperms are usually made up of leaf blade or lamella, so the lamella is the whole leave which is attached to the leave base of the plant or the leaf stalk or petiole. Now, when you have a leaf, can somebody bring what I can use to wipe the board? When you have a leaf, or a tree as a whole. And there are ways in which the leaves and other branches are connected to that stem right? Now, Let us see if these are the small steps. There will be smaller ones that connect the leaf to the stem. Right? Those are called a petiole; they are responsible for connecting the leaf to the stem. They do have branches. The structure of glucose is *((she draws the structure on the chalkboard))*

Learners were somewhat quiet and despite the class being seemingly quiet, some learners tend to whisper to each other in a manner oblivious of the teacher. While some learners had their eyes gazed at the chalkboard some others had ways to communicate with their peers with other body parts such as eye contacts and body contacts. For example, a learner who seem to look at the board while the teacher teaches, is captured communicating with the next learner in from with his legs as the learner steps on the other another. So the teacher tends to monitor the learners to enhance his/her classroom management. However, in as much as she (Ms. Karabo) tries to keep a monitored classroom, Ms. Karabo still ends up complaining about learners not listening and been restless. Perhaps being that quiet is at variance with the nature of indigenous learners. It appears like learners are under a context not enabling to them.

As soon as Ms. Karabo's lesson time was up, she left the class and went to her next class. "We shall see in the next lesson" Ms. Karabo said. Learners were seen interacting actively with each other the moment the teacher left the classroom. This, they were not allowed to do and be involved in during the lesson. The learners showed other bodily interactions such as gesturing, smiling and laughing as well as talking to themselves, perhaps reflecting on what was taught. Perhaps they were let loose of the quiet, 'no talking' condition they (learners) were subjected to by Ms. Karabo. The learners' communication was minimized to largely support the teacher's stance as the controller of the learners' learning. It was observed that Ms. Karabo's was interacting more with those who sat at the front row in the class and less interaction with the ones at the middle while those who sat at the back of the classroom enjoyed little attention. Can teachers provide a context that allows learners to get more involved in their own learning by creating an enabling environment for active engagement?

Ms. Karabo, at the end of the professional development and training workshop on the use of beads and beadwork (cultural artifacts) to create models of simple and complex organic molecules for teaching and learning, suggested that the use of beads and beadwork (cultural artifacts) would enable the learners to critically think in the classroom. Ms. Karabo could possibly be suggesting what could fill a void/gap in her pedagogical practice in the classroom. (See excerpts below)

Joshua: Is it interesting?

Ms. Karabo: Yeah, very, very

Joshua: Can you recommend it for students to learn

Ms. Karabo: Very well

Joshua: Can you use this cello tape to stick it down with the paper? Yes. Hope it was not boring?

Ms. Karabo: Nooo, Laughing. You get to think, the learners don't think a lot about these things (structures of Organic compounds) when they write them down. So now they got to think I need so many numbers of oxygen, so many numbers hydrogen and so many numbers of carbons and then next time they know that alright six black beads for carbon.

I asked myself, why would the learners be inhibited from interacting more in the classroom if the learners' learning is paramount? In essence, the teacher's practice inhibits learners from interaction. Perhaps because the content is deposited in the learners' memory and they are told not to forget. The learners are not enabled to critically think in a traditional (teacher-centered) context such as that of Ms. Karabo's teacher centered classroom? Perhaps because the power structures in the classroom have placed the learners in a state of disempowerment; and making inactive as their learning were not learners to actively participate in their own learning. That made them inactive as their (learners) learning was not in their own hands but in the hands of the teacher. According to Boykins, (1986, 1994) indigenous learners exhibit the following black ethos characteristics: communality, verve, spirituality, affect, harmony, orality and expressive individualism embodied in them. Creating an enabling environment for these learners to exhibit these characteristics could enhance their learning because these characteristics are those of indigenous learners when enhances by culturally relevant materials.

The professional development and training. "Let's go teach my learners" Ms. Karabo said. Ms. Karabo and I proceeded into the class to teach the learners. And sitting in the classroom was a learner wearing beads as a body ornament who Ms. Karabo spotted right away. "She is putting on beads" Ms. Karabo said to me. Ms. Karabo's awareness became heightened. This strengthens the availability of culturally related materials in the learners' lived-world. Not only are the beads being in the learners' lived-world but learners bring them into the classroom. These beads are inexpensive to acquire and environmental friendly (Bostic) as opposed to some western instructional models made from materials that are expensive and unfriendly. The western instructional models are not readily available, or seen in the learners' lived-world. It also makes a case for cultural capital as embodied in the objectified state in the learners' lived-world. Embodied in the sense that, it is part of the learners' way of life; and hence, they wear them (beads) everywhere they go. In chapter two, I enumerated that some African women even wear beads on their waist for some purposes and often do not remove the waist beads even when taking a bath. On getting to the classroom with the use of beads and beadwork (cultural artifacts), Ms. Karabo told the learners to arrange themselves in groups, whether in group of three or four. This means she wanted a classroom where learners would be able to interact and relate to themselves. Surprisingly, I had not given her any rule she was to use in the classroom, even the professional training and development she was involved in, all teachers sat individually, and here, she tells the learners to sit in groups. Could the sense of communality be embodied? The teacher, despite been western trained, was raised in the cultural norms and the cultural norm became embodied in her (Ms. Karabo)

Communalism is an African cultural ethos (Boykins, 1986, 1994) and this sense of communality was exhibited by Ms. Karabo without prior information or instruction. Like every other African, according to Chilisa (2012), she says "I belong to the bantu people of Africa, who live a communal life based on a connectedness that stretches from birth to death, continues beyond death and extends to the living and the non-living (p. 3). She continues to say that the issue of relatedness and connectedness is not unique to the Bantu people of Southern Africa but to all indigenous peoples especially in Africa. Communalism embodied in her (Ms. Karabo) in form of habitus has helped her negotiate the cognitive field (classroom) and these learners, without hesitation gathered themselves without much instruction and arrangement as if it was always a practice in the classroom. The learners may have been accustomed to the communal practice in their homes where they may have been used to gathering in the homes when they cook or dish out food (Goduka, 2005), tell stories to one another, play games and all other sorts. This does not happen often in the classroom. Apart from the sense of been in groups the learners exhibited, the learners entrained themselves in the group learning mode, smiling and talking to themselves. Perhaps the learners were saying "We are working in groups today" that's lovely!

One could see the positive energy building up in the learners as Ms. Karabo went around in between each group to instruct the learners on what they were going to be doing during the lesson. Learners were already interacting among themselves, laughing and excited which became evident in their verbal and bodily interactions. "They are happy" Ms. Karabo said, as she noticed perhaps a change in their affect which is different from the affect that the learners exhibited in her traditional teacher-centered classroom. The use of beads and beadworks (cultural artifacts) to create models of simple and complex organic compounds as instructional models to teach the structure of these organic molecules (glucose, fructose, lipids and proteins) in Ms. Karabo' s life science class, I believe enabled the learners to become responsible for negotiating their own understanding of these science concepts. The learners exhibited more than just responding to the teacher in a one-word "yes and No" answer but interacted with the teacher and created channels unknowingly through which they could learn better. The learners expanded their constructs from learners responding with a one-word answer to actively involved in the science classroom.

This could be as a result of these learners finding themselves in an environment that favors the learners finding ways to express themselves in the classroom. The power dynamics in the classroom was also on a balanced scale. By balanced scale, I mean that the learners and teachers shared the pedagogical responsibility. They both shared the classroom spaces, and attention given to every learner. This was an eye-opener for Ms. Karabo as she reflects that her learners were not critically thinking enough in her traditional teacher-centered classroom. She also reflected that her learners not contributing enough and perhaps not always provided the enabling environment for learners' better learning of science concepts**.** From the themes, the research work showed that Ms. Karabo's learners' translanguaged among themselves but when they were to interact with the teacher, they spoke in English-the language of the colonizers which is now accepted as the language of teaching and learning. These learners translanguaged from English to their various languages (isiZulu, Setswana, Tshonga, and Pitori (Street language). Interactions between groups were closely examined as similar constructs were discovered across all classes. Themes formed are: (1) Peers' zone of proximal development (ZPD); (ii) Peer tutorship; (iii) Peer collective identity formation; (iv) Peer translanguaging; (v) Peer-teacher questioning; (vi) Peer self-Assessment and evaluation; (vii) Peer questioning; (viii) Peer teacher imitation/mimicking; and (ix) Inter-group questioning /assessment.

After the lessons Ms. Karabo learners were said to love the use of beads and beadwork (cultural artifacts) to teach in the science classroom perhaps because it is part of their lived world. Students enumerated how the beads can be useful to them in the classroom as: (i) helping them to understand the bonding concepts; (ii) sharing of electrons; (iii) life sciences organic structures; (iv) representations of atoms; (v) molecules; and (vi) Lewis dot diagram in physics. The learners also advocated for the teacher's use of beads and beadwork cultural artifacts to teach in the science classroom. Statistics from the learners' response shows that, fifty percent of the learners said it makes them understand more, twenty five percent said it makes them never forget what they have learnt while six point three percent (6.3%) said it helps visual learners perhaps because of the different colors. Twelve percent (12%) of the learners did not give a specific reason while another six point three percent (6.3%) said it will help them know the purpose of beads more. Would teachers not allude to using resources that: (1) enhances learners' retention of learnt concepts; (2) enable learners with different learning styles; and (3) enables easier understanding of science concepts. Further exploration on the use of beads and beadwork (cultural artifacts) led me to the learners in Ms. Mbali's life sciences class.

Short Biography of Ms. Mbali

Ms. Mbali, from the same school as Ms. Karabo, teaches a grade 10 class, two natural sciences and one Agricultural sciences class. She indicated that she teaches grade 10 learners across the sciences simple and complex organic compounds yearly. She also mentioned that these learners experiences difficulty in understanding these concepts (structures of simple and complex organic compounds). Ms. Mbali is a female, black, South African teacher. She is energetic and somewhat strict with her learners. I described her as been strict because, she won't allow you to talk or murmur unless she gives the permission to do so. She created her glucose model during the professional development and training workshop as she indicated she wanted to construct the seemingly hard model (galactose structure) which she did afterwards. She said afterwards that she would be happy if I could facilitate the creation of the Aldo ring and keto ring with the beads (for her Agricultural Sciences class) and I promised to do that on my next visit. It was not part of my plan to teach this Aldo and Keto rings. She noted that she was not aware of the use of beads to teach in the classroom nor was she aware of any teacher who has used it (bead) to teach. She maintained that her class is overcrowded and she was battling with teaching all of them as well as making them understand. The use of beads and beadwork (cultural artifacts), she said would help her learners' learn better simple and complex organic molecules. Ms. Mbali continued when I asked her if the learners will enjoy using the beads to learn in the classroom, she declared "I think they will, Instead of us just talking about it; that this, the galactose, carbohydrates structures, now, they can see and do them and they won't forget".

Her reasons for thinking the learners will enjoy using beads and beadwork (cultural artifacts) to learn, speaks volumes on the fact that most teachers just speak, and deposit the content into the banks of the learners (Freire, 2000). It is an occurrence the teacher and learners may not want to pass through again hence, the teachers wants what these learners can see and do (Hands-on, Minds-on) as reported by Ms. Mbali in the professional training and development workshop and which as a result of this make them remember all over again. I did not teach her this, neither did I suggest to her the result of seeing and doing at the same time. She continued further as I asked from her "why do you think the learners will be happy to use this (beads and beadwork as models to learn)? She replied "hmm, I think, to them, it might be fun; because in the classes we just talk and talk and talk". Ms. Mbali, alluded to the earlier comment that they just talk! This seems to be challenging as she repeats the 'talking syndrome' in the classroom. "So that's why it is something they are willing to do as you can even tell them to do it as an assignment and bring it back to the classroom the next day" Ms. Mbali continued. Yeah, I agreed with her and asked if she had finished creating hers. Afterwards, I asked her to self-access what she had done. "You are done; right! beautiful" I guess, I asked Ms. Mbali. Her response was a positive "Yes" she said. "Can you grade yourself?" I asked further. She said, a "10/10". She seemed happy and enjoyed what she had created. “But this is different from how we teach in my normal class”, she said. “What is the difference”? I asked Ms., Mbali. “In my normal class (traditional teacher-centered classroom), the learners are not allowed to talk because they will make noise, the class is also boring”. Hence, I asked if I can be part of her normal class and she obliged. Her connotation of the class being normal is that of a teacher-centered classroom. For learning responses to a quick post teachers’ survey, see appendix D for Teachers responses.

Ms. Mbali’s Traditional Class

Before Ms. Mbali’s introduction of beads and beadwork (cultural artifacts) to her learners, I asked if I can video–record her traditional teaching class and she obliged. I wanted to discuss her pedagogical practice with her and thereafter discuss how her pedagogical practice would have been enhanced and her learners learning in the classroom. Ms. Mbali started her teaching with learners by revising what she taught them in the previous lesson about the relevance of traditional technology to the immune system. (See excerpt below)

Ms. Mbali:	What is passive?
Learners:	Murmuring
Ms. Mbali:	That’s the one that develops in another organism and then they inject you with an antibody, neh!
Learners:	Yes *((chorus))*
Ms. Mbali:	Does it have..? What about the second one? Active neh? So active also has two part Right? What is the first one? Natural infection. So that when our body produces antibodies or it battles this microbe; what is the microbe again? It is bacteria or viruses that can cause illnesses, neh? What is the second one? It can either be the natural infection or the artificial, and what happens when they vaccinate you? One person? What happens when you get vaccinated? They give you a weaker form of the virus so that your body can produce antibody to be able to defend itself. So

when you get the virus gain you are not infected. So the second one which I want us to do is boosting the immunity system using traditional technology. So write there boosting the immunity system using traditional technology *((she told the learners to write it in their note book))*. We have talk about all these other different ways. We have said that they can inject you with antibodies; you can also go for vaccination. But now we are going to talk about traditional method right? So just write boosting the immunity system using traditional technology. Using traditional technology, so some of us still have grandmothers right!

Learners: Yes *((chorus))*

Ms. Mbali: so ever you have a cold, what does your grandmother do to you? Or if ever you have eaten too many sweets, what did they say would happen? So our grandmothers and family members, most of them do tell you that you should drink this plant, eat this, when you get flu and they give you this other thing. Which is not part of traditional medicine, so they give us alternative, so the other plant and other …..We can say it plants that actually help us to boost out immunity systems, neh! So for example if they say you have this stomach upset they can say you should drink something that actually heals. So, aah, that is what we are talking about now. Rosemary plant, thyme and ginger are powerful antiseptic and tonics. They are powerful antiseptic and tonic. This one you done usually get it from the doctor but at home they tell you to get dome ginger with some water and eat up

Learners: yes *((chorus))*

Ms. Mbali: Antiseptic and tonics. So there are three main plants that you as grade 10 you have to know about, there is the African potatoes. There are three natural plants that can boost. That can boost our immune system. The first one is the African potatoes. Number 1 is the sutherlandia. The second one is the .And the devils claw. Hmm, sutherlandia. So there is the African potatoes, the sutherlandia and the devil claw. It is not as bad as it is very good for you .And then, devils claw. Claw as in claw. Devils claw. So with African potato; let's describe African potato, when you were doing cancer. There were different ways to treat cancer. The surgery, chemotherapy and radiotherapy. So these other plants can also help in terms of people who are suffering from cancer, neh! So we only explore the traditional medicine. But there are also plants that can help people that have cancer. So, it has been used. Let's start with the African potato. The African potato- it has been used by indigenous people of KZN and Pondoland, Pondo, Pondoland, as a laxative, so they use it as a laxative. If ever you have eaten too much in your stomach or if ever during the holiday you ate too much candies. Then secondly also scientist have also found. Scientist have also found that the African potato. The African potato is rich in natural resources of steroids. Steroids, I am pronouncing it so that you are able to write it down, and steroids boost the immune system in our bodies, so, they boost the immune system in our bodies, and the second part is that since the scientist has discovered that it has a lot of natural resources, and it is being introduced to traditional medicine. It is now been used to increase the body's natural resistant to diseases, neh!

Learners: Yes *((chorus))*

Ms. Mbali: And it has been proven that it slows down the progress of HIV/AIDs, TB, cancer and arthritis and a-r-t-h-r-i-t-i-s *((she spells it for the learners))* So now we can appreciate all plants that we have , So these plants they can actually help you if you are suffering from HIV/AIDS , And also cancer, neh! So the sutherlandia. I wanted to do this before we move on because during June and December, they might put this in as an essay. And you are told to explain how traditional technology helps with our immune system. These immune systems are energized by the energy in the cells. This energy can be from carbohydrate, proteins and lipids which are called organic compounds. The structures of these organic compounds are on the chalk board *((she draws the structures on the chalk board))*.

From her class teaching, the learners only responded while replying the teacher in a one-word answer; 'Yes'. Ms. Mbali did nearly all the talking in the classroom as indicated in the excerpts above. It was also a situation she (Ms. Mbali) complained about earlier as evident in the length of talk compared to the learners' one-word answers. Even when she asked questions from the learners, the learners did not respond, perhaps they had again understood that the teacher will provide answer to her question herself. Ms. Mbali was a strict woman, not allowing the learners to talk to themselves or interact because she wanted the learners to listen to her while teaching. Learners seem to be listening but not responding to her questions on the immune system even when she switched over to the simple and complex organic structures. She seemed to have made rules that kept the learners seemingly quiet. She often would say "don't talk while I am teaching; again, "you don't move for any reason". These rules seem to hinder social and cognitive interactions between teacher and between learners in the classroom. Those learners who break these rules are labelled stubborn. The supposed stubbornness in the learners may be tantamount to apparent suppression in the learning transaction. Some learners who feel suppressed by these rules tend to challenge them. It is not also part of the black ethos (verve, affect, communality) and not part of their capital, so they will resist it.

Post observation discussion. Upon further discussion on how the lesson went, I noticed she did not write a lesson plan for her lesson. She indicated that they do not write lesson plans and even do not know how to write a lesson plan when she I asked to see a copy of her lesson plan. So I volunteered to guide her in writing a lesson plan. I informed her that, I observed that her she barely moved from one spot in the front near the chalk board into the lesson. She was just talking she did not make illustrations on the chalkboard. I informed her that some learners were standing because they were without chairs and desks. They stood throughout the lesson. I counted fifty learners which seem to be a large class to manage; hence, she seemed to speak louder than normal for the whole class to hear her. After the observation, we arranged to meet again for her lesson on the use of beads and beadwork (cultural artifacts) to create models for learners to learn organic macro molecules.

On the appointed day, we went to the classroom together for me to observe her lesson when she taught learners how to use beads and beadworks (cultural artifacts) to create simple and complex organic molecules. Learners seemed happy to welcome us with beads in the classroom. The learners were wondered what the teachers were to use this (beads) for. Before entering the classroom for the use of beads to teach simple and complex compounds, Ms. Mbali had told me that she has not seen other teachers teach with these beads-a similar response as Ms. Karabo indicated earlier. This is despite the directive in the caps document to use beads to teach organic macromolecules structures in the classroom. Ms. Mbali was not even aware it was even in the CAPS document–as MS. Karabo also just as Ms. Karabo was also not aware. Going to the classroom to teach the learners on the use of beads and beadwork (cultural artifacts) to create models of organic macro molecules in the classroom, I asked Ms. Mbali, "How do you think learners will respond to the use of beads and beadwork (cultural artifacts) in the teaching of life sciences? She replied "I think in a positive manner". Ms., Mbali's response revealed the confidence she gained towards the use of the beads and beadwork (cultural artifacts) to teach these organic structures in a science classroom after the professional development and training workshop she participated in the science classroom. It showed positive emotional energy which was at variance to her disposition before she also attended the professional development and training workshop.

We proceeded to the classroom and asked the learners if they like beads. Forty seven (47) out of Ms. Mbali's fifty–two (52) learners responded with an overwhelming "yes" which also translates to ninety percent of the classroom, while the four remaining (4) learners which translate to 7.7 percent replied "No". Out of the four learners, a learner did not respond as she was sick while another learner just answered "NO" without given the reason for not liking beads. The two other responses are (i) "because beads are mostly weaved by girls and if you are a boy and you wear beads, people will think you are gay or something". This view seems to resonate with the challenges of integrating indigenous knowledge with western science as the learner attributed feminism to the role of beads in the society. After using the beads in the classroom, learners view changed as he said I never knew it could be used to learn in the classroom. Another response said the beads are "somehow not related to my career and interest", this learner seem to only see the cultural role of beads in the society but his view changed at the end of the lesson on the use of beads and beadwork (cultural artifacts) to create simple and complex organic structures as instructional models.

A quick survey of the classroom indicated that 54.7 percent of Ms. Mbali's learners loved beads because it was part of their tradition and cultural heritage. Another reason given by a learner on why he loved beads was "because my father was given beads by my mother for engagement and I am planning to do so". This response explains the depth of value these learners place on cultural artifacts. Fifteen point four percent (15.4%) said they loved beads because it would enhance their creativity in the way they learn. Perhaps the learners had more often had boring lessons or way of learning. Twenty three point zero percent (23.0%) loved beads because they would use beautiful materials to learn in the classroom which also speaks more on boring nature of the teachers' lessons to the learners. 3.8 percent loved beads because of its decorative abilities which also add to the creative and beautifying nature of the beads and beadwork (cultural artifacts) while four percent (4%) of Ms. Mbali learners acknowledged the mathematical enhancing characteristics of beads. These were their responses before the use of beads and beadwork (cultural artifacts) to create models of simple and organic molecules for teaching and learning in the classroom. If the views of the learners are to be valued, then teachers should because of these reasons, allude to the use of beads and beadworks (cultural artifacts) to create instructional models for their pedagogical practice.

As Ms. Mbali proceeded in her teaching, she informed the learners to arrange themselves into groups of four or five learners each. She went around the classroom to see the groups are arranged as instructed by her. Ms. Mbali did this without my interference or instructions as the same that happened in Ms. Karabo's class. Ms. Mbali gave other instructions on what each color represents each atom and distributed the environmental friendly glue (Bostic) to the learners, group by group. She tasked them to decide on the number of beads they needed and come forward to get them from her. Before this task, she pasted a larger diagram of the structure of glucose and fructose, galactose (drawn on a big white sheet of paper) and pasted on the chalk board so the learners could easily count the number of carbons, hydrogens and oxygens in the glucose and fructose structure and come forward to get them from the teacher. At a time during her teaching, a group mentioned a different number of carbon (beads) for creating the glucose structure while another mentioned another different number of carbon, (beads). Ms. Mbali, immediately noticed it and asked the class "a group says seven and another group says eight, why? She asked. To me, the teacher has directed the questions to the learners in the whole class while she guides them to know the required number of the carbon atoms (six) in the glucose molecules as opposed to her traditional class where she tells them the answers after she asked the question herself.

In her class where she taught the use of beads and beadwork (cultural artifacts) to teach the simple and complex organic structures, the learners seem to be actively participating in their own their learning process and they had a re-think of the number of beads they needed and demanded it again from the teacher. This time, they got the number of carbon, hydrogen and oxygen molecules right. During the lesson, I asked Ms. Mbali "how and where in her subsequent topics in life sciences can she modify or adjust to includes the use of beads and beadwork (cultural artifacts) to teach? She answered " I think I can use it for a cell organelle diagram, organic molecules, DNA and RNA structure and if possible with the variation of colors so that they will remember which bead for example is the vacuole and the function of it and it will be easier for them", she responded. Learners who participated in the classroom teaching with the use of beads and beadwork (cultural artifacts) were able to express themselves more other than Ms. Mbali's teacher-centered classroom where they just answered "yes or no" in responses to the teachers' question.

These learners expressiveness is what I presume to be "expanded constructs" as they (learners) expanded the way they learn and how they learn, taking cognizance of the large number of learners in Ms. Mbali's class (fifty two). The learners were also enabled to be involved individually in their learning process without depriving the learners of a conducive learning environment. After the classroom teaching, Ms. Mbali's learners advocated for further use of beads in teaching and learning in the classroom because the instructional models enabled them (the learners) to: (i) make them understand what it takes to learn; (ii) helps them not to forget easily; (iii) making life sciences lesson more practical (hands-on, minds-on); (iv) helps in understanding some mathematical concepts like counting and other calculations; (v) helps to identity what compound is constructed; (vi) to represent these structures with concrete items; (vii) it helps to maintain concentration; (viii) helps to create a sort of experiment in the classroom ; and (ix) helps the color blind in the classroom. The learners also created and explored channels through which they carried out their learning. These forms of expressions are what I call expanded constructs.

Themes that emerged include: (i) peer tutorship (peer instruction); (ii) peer-division of labor; (iii)peer-role distribution; (iv) peer questioning; (v) peer excitement; (vi) intra-group assessment; (vii) peer- trans-language-ing; (viii) peer identity formation; (ix) peer assessment/evaluation; (x) peer teacher imitation; (xi) peer ZPD; (xii) peer-teacher reflection; and (xii) teacher-peer compliment. In the next section, I discuss Mr. Brighton's class as I have just done with Ms. Mbali.

Short Biography of Mr. Brighton

Mr. Brighton is a Zimbabwean black male teacher with more than fifteen (15) years of teaching experience as he narrated. He teaches two grades 10, one grade 11 and one grade 12 life sciences. He has always been willing to engage in the research processes as a co-participant hoping to improve himself but has not been opportuned to. He was always willing to assist at every opportunity. During the professional development and training, Mr. Brighton constructed both the cyclic and linear glucose structures while other teachers constructed the linear glucose structure or/and the galactose structure. He says "This is linear and this is cyclic, so so ... I want to do it cyclical so that it is different from the linear one''. Mr. Brighton acknowledged that he was color blind (he could not recognize certain colors except black and white), hence told me to get him the beads color by color. He will call the color I will get it for him. "Unfortunately, I am color blind; so you have to show me which one" he repeats. "This is white, white (beads) I could tell, this is pink (beads); oh it's pink not blue; no not blue; Okay. This is black; black (beads) is for carbon; then this blue; you put them together" he continues to tell me as I pick the beads for him. Although he doesn't look color blind because as I picked the beads for him, he got the colors right, however, he said he was color blind.

The professional development and training on the use of beads and beadworks (cultural artifacts) to create instructional models of simple and complex organic compounds somehow became an intriguing process as Mr. Brighton created his models in a way that depicted he would enjoy teaching these kids the use of beads to create instructional models in the science classroom. As he picked the black beads (carbon), he pronounced the number so loud and there was synchronization between his voice and his counting procedures of the number of carbons, hydrogen and oxygen needed for the glucose structure. He started to create the first carbon to the sixth carbon (beads) as he explained, "this is the first carbon, that's first and second. We are going to the third carbon; the third carbon is this one (pointing to the third carbon). We use this one, this is oxygen, right! *((showing the pink colored bead to me))*, that is oxygen, so oxygen is pink, we supposed to make it bigger" *((referring to the size))* he suggested. This is the same concern expressed by Ms. Mbali. Perhaps the beads were somewhat smaller and they fall off from the hands. It was a sort of curriculum material development as I took note of the amendments. When we (Mr. Brighton and I) were to go to the classroom, I took much bigger beads along with us.

He continued, "Each one will have oxygen, the C-O-C bond here, is what we call glycolytic bond, Mr. Brighton started to explain to me as he creates the cyclic structure. "That's the one present in carbohydrates, it is only found in carbohydrates, Glycolytic linkage, so here we have got a carbon, and we attach it to that; to the oxygen "he stopped and continued after 'a five seconds' pause, he wanted to self-evaluate and assess what he has done to see whether he was correct or not. He continued his explanation "then we have got the skeleton of the cyclic". By skeleton, he means the carbon cyclical chain without the hydroxyls and hydrogen attached to the carbons. Mr. Brighton started to explain how to create the cyclic bond. "The first one here we have two hydrogen and oxygen and another hydrogen, so what color is the hydrogen-white. Hydrogen is white, so we must have hydrogen. They are not joined together in the actual fact. Then next one we join this one here to, one of the hydrogen (beads) to oxygen and then another hydrogen (beads), oxygen is… pink (beads). Oxygen is pink which is this one *((Mr. Brighton was showing me the structure he was creating))*. Then we do it *((construct the model))* like this, to this oxygen (bead) it is combined to another hydrogen (bead), It means, that one is fine. Brighton continued to explain to me the process of creation and representation. On hearing the conversation between Mr. Brighton and me, another Agricultural teacher *((Mr. Mpho))* join the discussion. "This is beautiful", Mr. Mpho said. Seeing that another teacher has joined the conversation, Mr. Brighton said "Don't worry my degree was biology and chemistry." In Zimbabwe where I come from I was teaching chemistry while I teach biology in South Africa.

He continued the content discussion, "For the hydroxyl, I join them together, put them here. Carbon atom is there, the last one we start with white on the outside which is hydrogen". He wanted to show me he has the required knowledge or to re-assure me that I am in a competent hand to teach the learners the use of artifacts. He continues to count "1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, Let me do it again. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13; No there is a problem, somewhere I think it's on this side". Mr. Brighton created the model and self-assessed himself. "CH_2OH, the hydroxyl, I have seen the problem, that's it. Now this is glucose cyclic". He had assessed himself, and corrected his mistakes. When I asked if it was good for the learners to learn in the classroom, based on his vast experience from Zimbabwe to South Africa, Mr. Brighton answered by saying, "it aids their (learners) understanding because they are actually playing and seeing how the bonds are being formed between elements and atoms". To actually see and touch in tangible form depicts making abstract concepts real which influences learners understanding of what exists (Wilson 2001). "So it is actually good for them (learners), because the moment they have done these (created the structures), they are very unlikely to forget", Mr. Brighton states. This resonates with the suggestions of Ms. Mbali and Ms. Karabo on the use of beads and beadwork (cultural artifacts) to create instructional models of simple and complex organic compounds. The activity in the learners' classroom enabled a fun-filled learning process. It was also afforded the learners to play and enabled them to visualize the concepts being taught in the activity based classroom. Without these activities, the learners do not seem to enjoy the abstract nature of life science teaching. Mr. Brighton continued his suggestions towards the curriculum material development; "they will have done it themselves", he said. He continues to say, "Let me give you an example", "I am forty- two (42) years old. I have not tasted alcohol. When I tell my learners they say that is not possible". Mr. Brighton explains the importance of making abstract concepts concrete. He continues "For me to tell a person what alcohol does to the individual, when I have not tasted it is a problem". "I have to ask those who have tasted it before; how does it feel"? "Any reactions whatever and sometimes I have to observe those who are drunk, so that I am fully equipped to explain". "So, if they do it, it gets into them *((they understand))* because this is practice and it helps them assimilate". Mr. Brighton did not stop at this explanation, he continued.

"But I am saying the content, *((organic compounds, carbohydrates, proteins, lipids))* that is in grade 10 lessons, and they have to see this *((make learning concrete))*". "It will help them a lot for grade 12". He continued to suggest the concepts of life sciences that can be constructed with beads and beadworks (cultural artifacts). "We have to look at the structure of DNA for example; with that one we can do *((we can create with beads))"*. Mr. Brighton continued, "RNA, DNA, and maybe even the nucleus and maybe the nucleus to show them". "We can also represent what is inside the nucleus, the chromatids network and how the threads of chromosomes are arranged there; and that [what] they are having in DNA. “I think that can be done (created)”. “I am thinking reproductive systems *((creation with beads and beadwork))”*. “Yeah, that can be done *((it can be also created with beads))*. “Then gametogenesis, especially the female one; if we go to gametogenesis, we are supposed to be looking at that”. “I am looking at the reproductive system of the female and how we have to show them *((learners))*.

Mr. Brighton continued, “with beads, we can construct the structure of the fallopian tubes and ovary system in different colors and when the rupture opens in one ovary, and we can actually show them that an ovum is being released into the fallopian tubes; and we show them the uterus and how the endometrium is. We use, maybe red, if we have red beads”. Mr. Brighton’s suggestions are based on his experience in teaching and learning in the classroom. He literally has reconstructed the curriculum with this suggestion to enhance better teaching of life sciences concepts. (See excerpts below)

> We can also indicate the increase in the endometrium in preparation for the implantation; and we show them the virgina with the use of beads and beadwork (cultural artifacts). When we are teaching them human reproduction, they (learners) tell me “teach us the theory”. The practical we already know even better than you *((the learners referring to the teacher))*.
>
> And they tell you that, ‘yes!’ They tell me that, because I have always told them I want you to understand. You are my learners. You don’t have to be shy. None of you is my wife, here. So, I am only your teacher; and you have to be as free as you can be to the extent that when I teach them, the male reproductive system, I tell them it is called the penis, combined with the scrotum. It is testicular. In my Shona language, we call it ‘*machete*’. Then they tell me; can we tell you what we call it in isiZulu language?

I was surprised at what extent he could visualize what we can be created with the use of beads and beadwork for models to learn. "He continued further, in isiZulu it is called *'Mazembe'*. Then they say 'Mazambe' and 'Machte'; it is almost the same". "This is Shona and isiZulu; so, let's move on". I asked from Mr. Brighton, if there are concepts in natural science grade 9 that can be done with the use of beads and beadwork. "Do they do this also? *((Referring to the suggestions he had given before))*. I asked him and he answered, "they do it" *((the aforementioned suggestions))*. "It is basically introduction to a more advanced learning in higher grades but not as deep as we do in grade 12 and organic compounds, the food types, and gaseous exchange" (other suggestions). "I think that one we can come up with a model especially for breathing in inhalation and exhalation, and also for gaseous exchange in the alveoli, we can come up with something to tell them this is how this is the capillary, the pulmonary vein which is carrying oxygenated blood after exchange-all with the use of beads". After these suggestions by Mr. Brighton, I sought for his views about whether his learners will be willing to learn with the beads and he said an emphatic, "Yea"! Brighton's learners were asked how many of them has seen beads before, all of his learners signified they have seen beads. This confirms the availability of beads in the learners lived world.

When his learners where asked whether they loved beads; Seventeen of eighteen of his learners confirmed their love for beads while one said a "No ". And when he asked the learners did not like it, he said it seems to be harmful to children. That was his learners view and when I asked how is it harmful to the children, the learners said because they are small. It also resonates with Mr. Brighton's apprehension on the size of the beads as small and I had to increase the size thereafter. Mr. Brighton went on to teach the learners as I video-recorded his lesson. Mr. Brighton told another colleague (Mr. Steven)[2]; apart from Mr. Mpho[1] (*(whom he invited for the professional development and training seminar))* to come along to the classroom to see learners creating instructional models with the use of beads and beadworks (cultural artifacts) for simple and complex organic molecules. He informed Mr. Steven to draw a sketch of linear glucose structure on the chalkboard while he, Mr. Brighton, draws the cyclical structure on another side of the chalkboard. The teacher, Mr. Steven, said he has forgotten how to draw the linear structure on the chalkboard. Mr. Brighton proceeded to draw the structures (linear and cyclic) on the chalk

[2] One of the three other teachers invited to participate but was not involved in the research

board as the learners try to model the organic structures drawn on the chalkboard. It appears that by Mr. Brighton inviting two separate teachers to see the construction of the simple and complex organic molecules, he inadvertently empowered those two teachers who eventually participated in the professional development and training in progress *((Knowledge sharing)).* Before going into the classroom with Mr. Brighton to teach simple and complex organic molecules using instructional models created from beads and beadwork (cultural artifacts), I suggested attending his traditional teacher centered classroom.

Mr. Brighton's traditional teacher centered classroom. During Mr., Brighton's traditional teacher-centered classroom observation, learners responded with a one-word answer-Yes or No. The teacher did most of the talking in the classroom as the learners listened. When the teacher asked questions from the learners, he most often answers the questions himself. As I enumerated earlier, this could be because the learners are either conditioned to knowing that the teacher will answer the questions himself; hence, there is no need to answer the teacher. It could also be because the learners do not understand the concepts; hence, they are silent. When the teacher discovers that the learners do not answer, the teacher volunteers the answers to the questions himself so that the lesson can progress. This resonates with what happened in the two previous teachers' teacher-centered classroom (Ms. Karabo and Ms. Mbali). In the teacher-entered classroom, the learners seem not to actively participate in their learning since the teacher volunteers the answers to his own questions as it reflects in the learners attitude towards learning. It appears the teacher does most of the teaching and learning in the classroom. They tend to accept the teacher as the epitome of knowledge and therefore the learners are not encouraged by the traditional pedagogy to learn themselves. The excerpt below, from Mr. Brighton's life science classroom on organic structures is an example.

Mr. Brighton: In the carbon dioxide and water, carbon dioxide and what? Water *((he answers himself))*. Now these are required so that we can convert these simple inorganic molecules or compounds into simple organic compounds. Which is what? Which is what? Glucose *((he answers himself))*. Then glucose is later converted to what? *((he answers his own question))*. To starch. Come let me ask you a question. Why should glucose be converted to starch? Why should… Yes, yes, yes. Let me get ….. What he is saying, my question is. Why should glucose, which is what? , by photosynthesis be converted to…starch, the reason why I am asking this is because we have done organic compounds .Isn't it?

Learners: yes *((chorus))*

Mr. Brighton: and what do you know about glucose? It is a monosaccharide *((he answers himself))*. And what do you know about starch, it is a polysaccharide *((he answers himself))*. What other polysaccharides do you know from carbohydrates? Haaaa! Cellulose *((he answers by himself))*. And what other monosaccharide do you know? Fructose and galactose *((he answers himself))*. And what? Galactose *((he answers himself))*. Then the disaccharides are sucrose, maltose, is that okay?

Learners: yes *((chorus))*

Mr. Brighton: yeah, these are what? Disaccharides *((he answers himself))*. Now, the disaccharides are soluble in water. Are what? Soluble in water *((he answers himself))*. Because they are soluble, they cannot be used for storage. They cannot be used for what? Storage *((he answers himself))*.

It is evident from the excerpts above that Mr. Brighton did most of the talking in the life sciences classroom. Mr. Brighton spoke a total of 190 words and the learners spoke on two words in the excerpts above. The learners were already conditioned to being quiet; hence, if a learner asks from another learner in the classroom without the teachers' permission, the learner who was asked the question reports to the teacher and the individual who asked the question is chastised. Proceeding to Mr. Brighton' class to teach the learners the structures of simple and complex organic molecules with the use of beads and beadwork (cultural artifacts) to create instructional models, he entered into the classroom with Mr. Steven-the life science teacher that he invited to his classroom where he anticipates to teach the use of beads and beadwork (cultural artifacts) to create instructional models of simple and complex organic molecules in the life science classroom. He introduced the guests, Mr. Steven, and myself to the learners and the decision to use of beads and beadwork (cultural artifacts) to create instructional models in their classroom. Mr. Brighton asked the learners if they loved beads, and all the learners said and overwhelming "yes". He started by drawing the original glucose and fructose structures on the chalkboard. He explained to the learners how the colored beads represent each molecule. For example, Black beads represent carbon while white and pink beads represent hydrogen and oxygen respectively. As the learners saw the beads, it was visibly noticed from Mr. Brighton's facial expression that they (learners) were astonished. When he turned around from drawing the structures, they (learners) started clapping for him. Mr. Brighton was surprised that the learners where clapping for him and asked subsequently asked them "You must be very happy today. Is it because we are using beads and beadwork (cultural artifacts) to teach these structures? Mr. Brighton's learners continued to clap for him; and Mr. Brighton turned around to tell me, "these learners are happy today". Could this be a ripple effect of the positive emotional energy contacted from the professional development and training workshop? Could this be that the learners sensed that he was going to teach differently? Mr. Brighton, after the lesson where simple and complex organic structures was taught with instructional models created from beads and beadworks (cultural artifacts), repeated to me, "these learners are happy today. Imagine, they were clapping for me".

The learners were also asked by Mr. Brighton in a questionnaire if beads and beadworks (cultural artifacts) can be used to further teach in the classroom. All learners responded with a definite "Yes". In the same questionnaire learners were asked why they think the beads should be used to further teach concepts, they all responded that: (i) it helps them understand the science concepts better; (ii) it helps to make learning easier by representing and constructing organic structures which seems hard to learn; (iii) for learning mathematical concepts; (iv) for creativity and design; (iv) it enables learners to show what they have learnt and also enable them to explore further; (v) it helps to understand and check how far they have understood; (vi) it enables our imagination and visualization; and (vii) it helps to show us representations of these abstract structures. After the class where beads and beadwork (cultural artifacts) were used to create simple and complex organic compounds, Mr. Brighton self-assessed and reflected on his pedagogical practice in both classes (the class with the traditional teacher-centered class and the class with the use of beads and beadworks (cultural artifacts) to create instructional models from simple and complex organic compound). He concluded and said, "In this class, *((class where he taught the simple and complex organic compounds with beads and beadwork ((cultural artifacts used to create models))*, "I discovered that some of them where dancing, smiling, speaking to each other, they were happy at what they did".

“I saw excitement; they were alert”. It kept their attention span and you see these learners were brilliant. All of Mr. Brighton‘s learners suggested that the use of beads and beadworks (cultural artifacts) to teach in the science classroom as instructional models would be a good teaching tool in the science classroom. Mr. Brighton says “and the beauty of it *((the use of beads and beadwork))* is that those smart learners can also assist those who are less gifted (peer tutorship and distributed leadership). Furthermore, Mr. Brighton said, “We are activating so many senses, senses of touch and visual senses, you know. “Those are the main senses and they are so important as far as learning the concept is concerned”, Mr. Brighton said.

The use of beads and beadwork (cultural artifacts) became an eye-opener which translated into a state of heightened awareness for Mr. Brighton; hence, he began to see possibilities to enhance his pedagogical practice in the life sciences classroom. He also posited possibilities to enable learners enjoy their learning experiences. Furthermore, perhaps the learners clapping for their teacher (Mr. Brighton) became a sort of energizer and motivator to teach better; hence, he became amazed as they continued to clap for him after teaching in the science classroom. “It has never happened before” he said. The professional development and training also enabled him to teach his learners better than before which was acknowledged by his learners. The training activated some positive energy in him which he unknowingly transferred into the life science classroom and infected the learners who became surprised and amazed. The learners’ amazement may be because they (learners) were perhaps expecting the usual traditional teacher-classroom practice. On getting to the life sciences classroom the learners saw it was a different context mediated by the use of beads and beadwork (cultural artifacts) hence, they were happy, smiling, interacting and at the end, clapping for their teacher. When I went back to the schools to further interview the teacher, he was given the opportunity to see what happened and why what happened, happened, using video stimulated recall. Mr. Brighton said ‘see, “those learners never forgot the simple and complex organic structures. Mr. Kagiso’s life science classroom was the next class to observe. He is also an experienced teacher.

Emerging constructs from the learners’ interaction with the teacher and artifacts are: (i) peer-self assessment/evaluation; (ii) peer-shared responsibility; (ii) peer-vicarious experience; (iii) peer compliment, questioning and correction; (iv) learners “AHA” moment; (v) peer tutorship; (vi) peer collective identity formation; (vii) peer-teacher imitation/mimicking; (vii) peer ZPD; (viii) translanguaging; (ix) Peer content demonstration; and (x) peer critique.

Short Biography of Mr. Kagiso

Mr. Kagiso is a South African male local teacher. He is the head of department of science and often acts as a vice principal. He participated in the professional development and training with the other teachers from the sciences, in his school, in learning to create instructional models of simple and complex organic compounds using beads and beadwork (cultural artifacts) during the professional development and training workshop. He constructed the glucose and fructose organic structures as he followed the instructions on how to create instructional models from beads and beadworks (cultural artifacts). "Do you understand it now?" I asked Mr. Karabo. "Yes" he replied. "You know it's not joined to the carbon, the oxygen is separate, and this one is separate ((hydrogen molecules)), so how do we do it; ((construct the double bond in the glucose structure)). "Ok…" he discovered he seemed to have a better understanding of the concepts of bonding. "I now understand" he continued. "So, I should do this one", he asked from me. He wanted to create the fructose structure after creating the glucose structure earlier on. "Umm, these beads, hydrogen is white (beads), two white *((he counted the beads)),* he continued. "Is it *((construction of the fructose structure))* difficult?" I asked and he answered "No it's not". I asked further, "do you think the learners can do what you are doing now"? "Yeah" he answered. "It's not difficult, but you know some" *((he was referring to learners))*. "They know that carbon is black (bead), for hydrogen they will use white beads. And we use pink beads for oxygen". "Is it showing what you are doing; that's the skeleton of the carbon" *((Mr. Karabo showed me))*.

I asked further, "why do you think we should use beads to teach"; and he further answered that "I think it's better for learners to understand more when they are hands-on than when they are just being taught orally so at least it they are hands-on". "They can see, so this is the bonds which they are talking about, others will remember what they did from hands-on". "So they will always remember that okay, in this glucose, there is a double bond. So we have the O-H, the O-H which are six, we have carbon which is six (6) so meaning the hydrogen is two times the oxygen and also the carbon", he replied. As the professional development and training proceeded, his facial expression continued to reflect that of a surprised teacher who wondered if these beads can ever be used for teaching apart from their aesthetics uses. This is similar to that of the three previous teachers where they were all surprised that beads and beadworks could be used for teaching and learning simple and complex organic compounds in the classroom.

I proceeded to ask if he knew that the national curriculum stated that teachers should use beads to teach simple and complex organic compounds to the learners. I asked him, “You know in the caps documents, it was written there that teachers should use beads to create models of simple and complex organic compounds for teaching”. He replied, ‘No’. He went further to explain. “Sometimes the obstacles you can find in the classroom is that there is no resources. For example, those beads are not in school. I have not seen the beads in the school”. I asked, “who do you think is to provide the schools with the beads? And he answered, “I think the department should provide the beads since the department is the one who provides the text books. So they should also provide it for them so that they *((learners))* will be able to understand more hands-on, not just for life sciences but also for other subjects”. As we continued the conversation, I asked, “so if the Department of Education had provided it *((beads))*, don’t you think they have to teach teachers how to use them to teach the learners?”, “Yeah”, he answered. “I think that’s a very good one because you cannot go and teach something you do not have any idea about for example as I was doing here”. In representing the double bond in the glucose structure, Mr. Kagiso found a different way to represent the double bond with the glue *((Bostic))* and suggested other concepts that can be taught with instructional models created from beads and beadwork (cultural artifacts). Mr. Kagiso further stated that these instructional models will enable the learners to think critically.

Mr. Kagiso said, “it helps to let the learners think on their own. okay! “Sometimes this teaching is not all about talking and talking but letting the learner’s modify their own ideas and see what they can come up with”. He continued: (See excerpts below)

> “You can never know some of them can come up with something you did not think could happen. You feel learners should explore their own ideas. They should not feel limited to only their teacher who is to tell us to do this and this and this”.

Mr. Kagiso's statement of heightened awareness enables him to value the power of imagination in learners when allowed to make their own meaning. One could feel the curiosity reflecting from Mr. Kagiso's facial expression as that of someone searching for ways to improve his learners' learning through the process of creating an enabling environment for learning; and had just found one. The expression captures someone who is excited and at the same time willing to explore ways of learning with his learners. The will to create a cognitive space that enables critically thinking among learners was evident in Mr. Kagiso's expression. Mr. Kagiso went further to suggest genetics as a topic to be taught with beads and beadworks (cultural artifacts). "I think genetics, genetics", he said. Then I asked "What part in genetics?" He replied, "I think genetics, since we know that the learners get a little bit confused when they get to the homogenous and heterogeneous part of genetics". He continued:

> If you can remember, so we have the homogenous genes and heterogeneous genes which have the same alleles for example it can be two dominant which will be for example RR and a Rr [rr] representing the recessive allele; so we can do this in a way that for the big R, both of these can be same color of beads and the dominant and in the recessive can be represented by big bead to show it is dominant on the recessive. Since it is the one that appears in the phenotype. And then for this one, we use a small bead. We can also use the same color to show it is the same character. For an example, if this one is yellow, and also, for the… there is this guy from …Eish! I forgot the name, there is this diagram of sex-linked disorders where you can see the ancestors, where you got the disease from. So, we can use it also in this case.

He suggested the concept of incomplete dominance. "We have incomplete genetics whereby… for example; a white flower and a yellow flower give birth to a white flower. So the phenotype is not like the father or the mother". These words of Mr. Kagiso suggests more use of models created from beads and beadwork (artifacts) as to help retention of what was taught in addition to having fun to learning. As I did with the teachers, I asked Mr. Kagiso if I could observe his traditional teaching class, and he obliged. He introduced me to his class learners and lesson began. The learners only responded with one-word answers as usual. The teacher (Mr. Kagiso) spoke for most of the classroom time and the teacher answered the questions he asked from the learners himself. (See excerpts from the classroom below).

Mr. Kagiso: So, we say under conducting tissues we have two tissues which is the xylem and the phloem. Are we together?

Learners: Yes *((chorus))*

Mr. Kagiso: So, we have the xylem and the phloem; we shall be looking at the xylem. The xylem consists of four cells which are: No 1, we have the xylem vessel; No 2, we have the xylem tracheid; No 3, we have the xylem sclerenchyma; And lastly we have the xylem parenchyma, Right!

Learners: Yes (*(chorus)*)

Mr. Kagiso: So, our xylem sclerenchyma and our xylem parenchyma, it works in exactly the same way as the ordinary parenchyma and the sclerenchyma. What is the function of the xylem sclerenchyma? What is the function of the xylem sclerenchyma? What is the function of the sclerenchyma, Yes, Provides mechanical support. *((He answers it by himself))* if the sclerenchyma provides mechanical support then what is the function of the xylem sclerenchyma? It is also the same. Since it is similar then it means it does the exact same thing and the exact same function *((he answers it himself))*. Are we together? So let's look at our xylem vessel first, our xylem vessel. These are dead cells which are long and cylindrically shaped, Cells are in cylindrical shape, as you can see, just think of the straw of a bottle of cold drink. Are we together? You can see that (language) it's like this. And then, coming to the xylem vessel, it has cross walls. It has cross walls which are perforated, and you say perforated it means, they have holes, since they have holes, why do they have holes. To allow water to pass through so they are perforated or sometimes they are usually absent ((he answers it himself)). As you can see here they are usually absent. We are together right? So they have no living cells. It means cells are dead. If you can look at this structure, so this is our xylem vessel right? It has walls. These walls are thick, and then I said these walls are thick because it is found between these tissues. The xylem is found between which tissues? The sclerenchyma or the parenchyma, And the sclerenchyma consist of which substance that makes it to be strong, the what? It consists of the lignin *((he answers it himself))*. Are we together, so the lignin is the one that gives the xylem to have the big walls so that it may be able to give support to the plant, we are together right?

Learners: Yes *((chorus))*

Mr. Kagiso: And since I said the xylem has thick walls, the xylem parenchyma is the same as the xylem vessel, But the difference now is that cross walls are always present and their always perforated. Can you see? The xylem vessel and the xylem tracheid, both of them have cross walls which are perforated. And for the xylem tracheid, sometimes are usually absent. But then in this matter, the cross walls are always there. Are we together?

Learners: Yes *((chorus))*

Mr. Kagiso: And they are narrow. As this structure like this; they are narrow at the top part. They are narrow as you can see, here, Are we together class? In our next lesson we are going to be talking about the phloem. So the first thing before we go to the phloem. What are the main two functions of the xylem that they transport? Water and mineral, and the other what? *((He answers it by himself)) and the other one?* To give strength to the other, the sclerenchyma and the parenchyma as you know, also gives strength. The xylem also give strength. *((he answers it by himself))* Are we together. So, we are going to be talking about in the next lesson phloem. So since we know phloem; it transports food. Are we together? And it also has four cells. You hear right? First one, we have the sieve tubes. Second one, we have the companion cells. Third one, we have the phloem parenchyma. And the phloem sclerenchyma. Can you see that the xylem and the phloem, It has sclerenchyma,

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parenchyma, and then the other one it has sclerenchyma,
parenchyma, I can say they are similar. Are we
together? So in the other lesson we are going to be
talking about the sieve tubes, the companion cells,
phloem parenchyma and the phloem sclerenchyma. Thank
you for the lesson.
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Mr. Kagiso did most of the talking in this lesson. Learners only responded four times with a one-word answer which they chorused while the teacher spoke six hundred and eighty words. The proxemics of interaction showed that teacher taught the learners in a position in the front of the classroom. The learners seem inactive in the teaching and learning process. The next time Mr. Kagiso and I met, he was to teach using beads and beadwork (cultural artifacts) to create models of simple and complex organic compounds. From the questionnaire to elicit learners responses on the use of beads, when the learners where asked if they loved beads; all twenty- two learners responded positively indicating love for beads. In the same questionnaire, they were asked if the beads can be used for learning other concepts, the learners also responded an overwhelming "Yes". In addition, they suggested that the use of beads and beadwork (cultural artifacts) to create instructional models will enable them: (i) to represent structures of various elements, molecules, saccharides, disaccharide, polysaccharide, monosaccharide, and other formula in science, generally; (ii) will enhance their ability to learn to do new things, make designs and experiment in the science classroom; (iii) teachers should continue to use beads and beadwork (cultural artifacts) to teach learners in the science classroom because it enables learners to be creative, to understand and make learning easier. Taking cognizance of these learners' suggestions, that would enhance their learning and also since teachers are in school because of the goal of enhancing learners understanding in the science classroom, instructional materials that have the above attributes should be provided in the science classroom.

Proceeded to his two life Grade 10 classrooms, he said we shall only teach the use of beads and beadwork (cultural artifacts) to create simple and complex structures in a class and not the other, because the second class learners were stubborn. I asked why he classified these learners as stubborn, he said, when you teach them in the classroom, they always talk in the classroom while teaching, teacher shout and shout as the learners are adamant to correction. I objected and told him we shall not deprive the second class of the knowledge that might be passed across. He taught the first class and I facilitated the second class. As teaching and learning commenced in both classes, Mr. Kagiso said he gave the learners instructional duties to carry out, such as, picking the number of expected beads for each organic structure and grouping of learners in groups of three, four or five. Mr. Kagiso also assigned two of the cameras to two other learners for video-capturing of the lesson. He gave another learner the task of distributing to the learners the beads they were to use, and perhaps by this act, learners were occupied with knowledge enhancing activities.

The “stubborn learners” became so occupied and engrossed that they did not want to be left behind by other learners in the creation of simple and complex organic compounds from beads and beadwork (cultural artifacts). The so called “stubborn ones” became entrained in the lesson engagement and did not want to become distracted from the lesson in the classroom. “These learners are busy” Ms. Karabo told me when I came to observe what and how he was doing in the science classroom. “They seem not to be concerned about me. What has the beads done to them”? Ms. Karabo asked. Ms. Karabo’s noticed the change in the learners attitude as they were busy constructing their models. The learners were engaged with the construction of beads and beadwork (cultural artifacts); hence, a sustained attention. Perhaps the stubborn learners had the goal of getting the task right as no child seems to want to fail. Perhaps the learners do not want to be identified by their peers as negative learners in the classroom. By negative learners I mean learners who are not smart and not willing to be smart. The positive attitudes of these learners also seem to address the fact that, when the learners are active in the classroom, they would not spend their time on frivolous activities; hence they were engaged. As soon as the learners finished their tasks, they beckoned to the teacher to assess their work. The teacher response was to their task was positive and subsequently the same ‘stubborn’ learners were asking for more. Seeing the obvious differences in the learner’s attitude while creating models from bead and beadworks (cultural artifacts) and the usual attitude of his leaners during the teacher-centered traditional classroom, his awareness of a different pedagogical practice became heightened. Perhaps it further spurred him to suggest other areas where beads can be used to teach and learn in the life science classroom. “These beads are useful” Ms. Karabo said. They can be used to teach other concepts in Agricultural science and chemistry. In chemistry, it can be used to teach the topic organic chemistry. In Life science, we can use it for cell organelles.

From Ms. Karabo's classrooms, constructs formed are: (i) peer –peer instructions/ peer assistance/ peer-correction/ peer questioning/ Learners –teachers questioning/ peer excitement; (ii) peer tutorship; (ii) peer-division of labor (distribution of responsibilities); (iv) peer volunteer/ peer-peer content demonstrations; (v) peer-self-evaluation/assessment; (vi) peer trans-languaging ; and (vii) inter group discussion/ inter-group questioning. These constructs resonate with those of other teachers' classes (Ms. Karabo, Ms. Mbali, and Mr. Brighton). In the next chapter, I will discuss the comparative study on the themes in the four classes.

Summary of the Chapter

In conclusion of this chapter, the teachers' professional development and training workshop, attended by the teachers was a sort of enablers to improving their pedagogical practice in the life science classroom. It was a sort of preparatory class for what the teacher would teach in the lessons on simple and complex organic molecules; hence the need for thorough teachers preparation in methodology and content before going into the classroom to teach the learners. At first, the teachers were skeptical of the use of beads and beadwork (cultural artifacts) to create instructional materials for the teaching and learning enterprise in the classroom. The professional development and training further enabled the teachers' confidence to teach the learners; hence, the learners full engagement during the lessons. The enhanced teachers' pedagogical practice with instructional materials created from cultural artifacts in a way influenced the learners' interactions during learning. There was increased communication between learners and also enhanced communication between learners and teachers.

Interactions among learners in the classroom seemed to be enhanced by the teachers' pedagogical practice which engaged the use of instructional models made from cultural artifacts for learning. This is not the case in the teachers' traditional teacher-centered classroom where instructional models were not engaged with at all. The teachers' pedagogical practices, after the professional development and training, encouraged interactions with peer learners and also with instructional materials made from cultural artifacts. This seems to enhance and sustain positive emotional energy (Collins, 2004) in the life science classroom. The teachers' pedagogical practice also in a way enabled a context that valued the black learners' quintessence such as communalism, affect, verve, in the life science classroom. Hence, the change in learners attitude positively; as learners were seen smiling, willing to ask each other questions, willing to peer tutor each other as well as assess their own learning. Learners were willing to engage with the instructional materials made from cultural artifacts as their interest in learning science concepts seemed to be enabled and sustained. This is at variance with the happenings in the teachers' traditional teacher-centered teaching method where learners were answering in a one-word answer while the teacher did most of the talking in the classroom.

Chapter Six

A Comparative Analysis

Introduction

In the last chapter, I discussed the experiences of four teachers (Ms. Karabo, Ms. Mbali, Mr. Brighton and Mr. Kagiso), before, during and after the professional development and training. I described the teachers' classrooms in relation to the teachers' traditional (teacher-centered) teaching method on organic compounds. And I also discussed the teachers' classrooms where beads and beadwork (cultural artifacts) were used to create instructional models of simple and complex organic molecules. I further described the learners' views, perceptions and constructs on the use of beads and beadwork to create instructional models of simple and complex organic molecular structures during the classroom teaching of organic compounds. This chapter (Chapter Five) elaborates further on the comparative analysis of constructs as evident in the activity happening in the life science classroom. I also unpacked the constructs as narrated by the learners in both learner-centered classroom aided by beads and beadwork (cultural artifacts) and the traditional teachers-centered classroom. Lastly, I compared the teacher as a learner in the professional development and training workshop with their own learners as they taught these learners in the life science classroom.

Juxtaposing Learning Roles

In the professional development and training, the participating teachers in a way participated as learners during the learning of how to create instructional models from beads and beadwork (cultural artifacts). Their interests in the learning process (creation of instructional models) and content (simple and complex organic compounds) seem to also motivate each other (teachers) to learn how to use beads and beadwork (cultural artifacts) to create models of simple and complex organic compounds. Looking at how learners learned in the traditional teacher-centered classroom of the same teachers who are acting as learners in the professional development and training workshop, their learners do not seem to have opportunities to engage in discussions while the teachers were teaching. Hence, learners seemed to be less interested in the learning process in the life sciences classroom of these teachers when they taught using the traditional teacher centered method. There also appears to be less interest in the learning process in the life science classroom.

Teachers as learners in the professional development and training workshop interacted with each other during the workshop (Something they do not afford their own learners prior to the use of bead and beadworks (cultural artifacts) in creating instructional models in the Life sciences classroom). Perhaps, they interacted with each other because they seem to be able to access the cultural capital each of them brought into the professional development and training workshop. It may also be that they feel that as peers, they could explain better the content knowledge to each other in their local language; hence, they understand better. The teachers learning process was enhanced by the interaction similar to what happened with Bridget's learning process as a mentee. Interactions between her maternal granny (mentor) and Bridget (mentee) resulted in interactions with shared passion between both of them. Interactions also enhanced the generation of social, cultural and cognitive capital between the learners (mentee) and their teachers (mentor). It also enhanced the teaching and learning in my high school life sciences learners. Interactions again enhanced the learning processes between my dad, my siblings and I in a home schooling context as I posited in Chapter One.

It seems that the power dynamics in these contexts seemed collapsed to enable learning to take place. The teachers in the professional development and training workshop, now acting as learners, further seem to identify with the practical aspect (hands-on, minds-on) of their learning process. The teachers were active (physically and mentally) in their quest to discover knowledge as they constructed instructional models from beads and beadwork (cultural artifacts) as well as in processing this knowledge cognitively. The teachers seemed to be actively engaged in the practical process in their learning. This practical process seems similar to the process I introduced previously in my life sciences classroom as discussed in Chapter One where learners constructed instructional models representing the nutrient cycles using paper Mache. It also seems to resonate with the practical processes Bridget went through while learning from her maternal granny, as the skills she learned was from a hands-on, minds-on experience. In the traditional teacher-centered classroom, the learners, apart from sitting and looking and sometimes responding to the teacher in a one-word response, the learners seemed not physically or mentally involved in the learning processes.

The learners in the four teachers' classrooms seem to also enjoy the practical process in their learning of simple and complex organic compounds in the classrooms taught by the same teachers who were involved in the professional development and training workshop. This practical process appeared not to be available in the teachers' traditional teacher-centered classroom where the teachers appeared to read and explain verbally the lesson content to the learners. After the workshop, the teachers used the knowledge gained (how interaction enables learning, enabling learning through generation of activities to show case how cultural artifacts can be used to teach and learn science, the collapse of power structure to enable learning) to teach their learners simple and complex organic compounds with culturally related instructional models (CAIM) created from beads and beadwork (cultural artifacts). In the post intervention interview I had with the teachers Mr. Brighton said:

> This one where we use demonstration and experiment ((the class where beads and beadwork (cultural artifacts) were used to create instructional models for simple and complex organic compounds)). Is good for learners to understand concepts, after they have practiced and done them themselves. They will always remember what they were doing. It quickly makes them assimilate the content and it also captures even the less academic less gifted. And the beauty of it is that those smart can also assist those who are less gifted. That is this method. Because we are activating so many senses. Senses of touch and visual senses. You know, those are the main senses and they are so important as far as learning the concept is concerned. But then we had not done a model so they are now excited at seeing it for real. They are excited to see how it looks like in terms of real structure. They were stimulated because they know glucose was a monosaccharide. But they were even more excited because they are seeing how it looks like for real. Whether it is linear or cyclic. They were seeing the real structure.

Learner's expressive individualism. The teachers in the professional development and training seminar also talked, interacted and also made productive 'noise' in and after the teachers' pedagogical practice in the classroom. The interstitial space between the professional development and training workshop and the classroom where the teachers taught the learners how to create these instructional models from beads and beadwork, the teachers were observed discussing and asking each other question. After the lesson, the teachers were seen asking each other questions related to what and how they did the task given to them in the workshop as they were not restricted in their interaction during the workshop. This strengthens the fact that interactions among learners seems to enhance knowledge exchange among learners. As what was learned becomes epistemic objects that foster continued dialogues among learners when learners are enabled to interact with each other. These same teachers in their traditional teaching practice often constrain learners from interacting with each other; hence, they literally disenable learners from learning from each other.

This then indicate that when enabled, learners of any category enjoy talking to each other, they enjoy asking questions from each other make bodily contact, smile with each other and make "productive noise" with each other in the life science classroom (Boykins, 1986, 1994). Learners should be allowed to do this in the science classroom to enable learning. Even though the teachers consciously disenabled the learners from interaction with each other in the classroom, they subconsciously used the medium of interaction in the workshop to enable their own learning. The teachers as learners in the professional development and training were allowed to move to any group or person in the classroom (there was no restriction of movement) as seen in the traditional teacher centered classroom. They were permitted to ask questions from the (facilitator) teacher and themselves at any time as the hands-on activity progressed.

These happenings are at variance to the traditional teacher centered classroom where learners' movements are "restricted". The teachers' form of expressive individualism (Boykin, 1986, 1994) in Chapter Two which appears to be what the teachers call "noise" in a traditional teacher-centered classroom seems to resonate with the learners' way of interacting in the life sciences classroom taught by the same teachers after the teacher development workshop where they constructed models from bead and beadwork. Expressive individualism is a characteristic of black ethos (Boykin, 1986, 1994). This also appears to be part of the classrooms where instructional models were created from beads and beadwork (cultural artifacts). Expressive individualism seems to be aided by individual verve and learners seem to depend on each other to maintain the verve being expressed in the classroom. The inter-dependency of each learner in the life science classroom appears to strengthen the learners' cultural capital as a resource for learning in the science classroom. Boykins studies posited that, high level interactions aid the cognitive performance of indigenous African American learners while it has a negative effect on European American learners (Allen & Boykin, 1991; Boykin & Bailey, 2000). This is despite both learners (African-American and European-American) being taught in the same context and by the same teacher.

Learning in a practical and pragmatic process. With these apparently firsthand experiences of teachers on the structures of simple and complex organic compounds, using culturally related instructional models such as those made of beads and beadwork (cultural artifacts); the teachers became aware of not only the knowledge of creating instructional models with beads but also the significance of creating an enabling classroom for learning science while interacting. Learning in the life science classroom, if it is, to be reproduced by the teachers in their various life sciences classes, would demand teachers making learning more practical and pragmatic. By being practical and pragmatic, I mean the use of beads in producing structural representations of macro molecules generated firsthand experience for learners with high level productive discussion and learners' movement of in and out of groups. Teacher's preparation for a more practical and pragmatic lesson can enable their anticipation of learners' cognitive strengths and weaknesses during classroom teaching. The teachers seemingly learnt that the creation of culturally related instructional models (CRIM)[3] from beads and beadworks (cultural artifacts) under a context that enabled active participation allowed learners' access to each other, and as repertoires of knowledge in the workshop. This seems to be similar to how teachers access each other as they learn together during the professional development and training workshop. Similarly, this echoes the learning process I went through with my dad and siblings in the home schooling context and how my life sciences learners learned in the life sciences classroom.

[3] CRIM means culturally related instructional models which are cognitized models used for learning in the classroom.

Furthermore, it resonates with the way Bridget learnt from her maternal grandmother as well as the learners in the teachers' four classrooms with the use of culturally related instructional models to teach in the classroom. This is against the practice by the same teachers in their traditional teacher-centered classroom where learners' interactions with each other and the teachers themselves seems restricted. In the traditional teacher-centered classroom, peer interaction and learners' interaction with the teacher seemed to be seen as an act of resistance to the teachers' authority and/or insubordination to the teacher. The teacher in the African culture is highly respected regardless the age of the teacher. As discussed in Chapter Two, In the African culture, learners do not respond or interfere until allowed to. And as such, if learners express their views while the elders do the same at the same time, it is considered as interruption and hence, the individual is seen as less cultured. In this study, the use of instructional models created from beads and beadwork (cultural artifacts), a form of cultural capital, collapsed the apparent power structure; hence, the teachers seem not to feel disrespected when the leaves assume the role of co-teaching in the classroom. Rather, the teachers seem motivated to facilitate learners learning in the life science classroom. The culturally related instructional models naturally found a way to collapse the power structure in the classroom as both teachers and learners seem to feel motivated to teach and learn in the life science classroom. The lack of pragmatic and practical-based activities in the teacher-centered classroom left room for didactic teachings enhancing a seemingly abstract lesson in the life sciences classroom.

The lack of pragmatic and practical activities in the traditional teachers centered classroom is at variance with the practical expression and assessment with my indigenous life sciences learners (Chapter One) whose learning was enabled by making abstract concepts practical with models created from culturally related materials such as beads and beadwork. The practical processes I employed to assess the learners understanding of the life sciences concepts was enabled by the way they expressed their thoughts as enabled by cultural artifacts. I knew they learnt because of how they expressed their thoughts and then I approved. The practical enablement of cultural artifacts in my life science classroom (Chapter One) and that of the learners in this study is in resonance with Bridget's learning experience in Chapter Three. For Bridget, learning the art of crocheting was not in the abstract form likewise was the knowledge of patterning, numbering, groupings, color differentiation as well as multiplication, division, addition and subtraction. It was hands-on, minds-on. Bridget learnt this knowledge by unconsciously been enabled by the use of cultural artifacts and as a mentor-mentee relationship. She learnt from a more knowledgeable learner. The happenings in these three situations are at variance with the happenings in the traditional teacher-centered classroom where indigenous learners are also taught life sciences concepts.

In addition to the learners' one-word responses, the teachers (in the four different teacher centered-classes) asked questions collectively from the class and not from individual learners. Learners equally answered the teacher in a chorus. The learners' collective responses in the traditional teacher-centered classroom seem not to enhance the teachers' ability to decipher the learners' strengths and weaknesses. Although for, a class of 50 learners or less, it seems difficult for a teacher to monitor the learning progress of each learner in the science classroom. The more reason a learning context enabling the use of culturally related instructional materials to teach and learn in a life sciences classroom. In a learning context that enable structures that allow teachers to individually access learners. In the same vein, the answers the teachers received were also chorus answers in form of a "Yes" and "No". In few cases especially in Mr. Brighton's class, the teacher needed to call a learner to respond to the questions the teacher asked. In this case, the teacher answered the question himself as the learners either did not respond or did not respond correctly. The apparent non response from the learners may not necessarily be because the learners were not interested in responding but because there was no repertoire from which the learners can allude to, and answer the teachers' question. It is when the learners have understanding of what was been taught, then they can store what has been understood and thereafter give feedback from the repertoire that has been stored. There seemed to be less teacher-learners interaction and engagement between the learners and teacher. In the teachers' teacher-centered classrooms, the learner's seemed tasked to memorize and regurgitate the specific content being taught in the classroom.

Learners' emotional energy: learners as "hotspots". In the traditional teacher-centered classroom, some learners tend to find some aspect of the learning process (memorization and regurgitation) boring and not exciting and they are not easily excited especially when learning life sciences. They tend to view as an abstract subject and I concur with this view. However, the abstractness of life science is as a result of the way "we" as learners were taught and how life sciences concepts were presented to "us" (the learners). The learners tend to receive the message (content) given to them by the teacher, and because of its seemingly boring nature (life sciences), the learners seem less motivated to actually learn in the science classroom. This is diametrical to the excitement and positive emotional energy (Collins, 2004) evident in the classroom where the use of culturally related instructional models (CRIM) created from beads and beadwork (cultural artifacts) to teach simple and complex organic compounds occurred. It seemed not just momentary positive emotional energy but a sustained one as the learners were captured on video smiling, talking to each other as well as exhibiting gestures that confirm verbal expressions such as “Let’s do this”, “we got it”. As they arrived at a correct answer, they erupt into collective effervescence such as “hurray”! “Yeah! We got it” The emotional energy seemed distributed among the learners. Whereas in the traditional teacher-centered of the four teacher before intervention, the teacher seems to be the only “hotspot” the learners seem to gain energy (knowledge, emotional) from. Literally, a hotspot is a physical location from which individuals may obtain internet access (energy). In this study, hotspot appears to mean a location where learners can access capitals/knowledge/resources/energy to further enhance their understanding of science concept.

In the classroom with the use of beads and beadwork (cultural artifacts) to create models of simple and complex organic molecules, the various groups became learning “hotspots” for the teachers and learners to access. A learner can decide to access capitals from his or her own group, same learners group, adjacent or far away from his/her current group; hence, inter and intra group. Accessing the hotspots could occur when a learner overhears a discussion from another group without necessarily moving from his/her original position to enhance his/her understanding of the concept being taught/discussed. In this context, movement of learners is not restricted as the learners shift position to have a better access to the hotspot. In the traditional teacher-centered classroom, the teachers’ space at the front of the classroom seems to be the only hotspot to knowledge or resources as capitals. Other supposedly hotspots are not enabled to thrive; hence the learners total dependence on the teacher for knowledge access in the life sciences classroom. In the classroom where culturally related instructional models were used to create simple and complex compounds from beads and beadworks (cultural artifacts), learners can access the teachers’ hotspot in front of the classroom and other individual or group. Hence, the learners understanding is enabled by different access points (hotspots) to knowledge and resources.

In the traditional teacher-centered classroom, more often, if the teacher comes into the classroom (life science) with low positive emotional energy, since there is less interactions among learners, (conductors of energy) the energy tends to remains low. Hence, the hotspots from which the learners seem to receive knowledge/energy/capital/resources from, remains not efficacious enough to enable learners understand the content of the lesson. This same class (traditional teacher-centered classroom) seems to lack enough energy required to energize the classroom unlike the classroom with the use of beads and beadworks (cultural artifacts) where apart from the teachers "hotspot" at the front of the classroom, there are other learners "hotspots" from which learners can access knowledge/energy/capital. Also, because of the interactions between learners and teacher(s), and the artifacts (artifacts becomes energizer), the conductors of emotional energy seem to entrain each other, thereby enhancing the increase and sustainability of positive emotional energy in the classroom.

Since each group seems to represent a "hotspot" of knowledge, an individual learner can decide to get energized/capitalized/resourced from any group (location) in the classroom. The positive emotional energy radiating in the classroom is also not dependent on the teachers, as appears in the traditional teacher-centered classroom of the four teachers. The influence of this positive emotional energy also enhanced life science learning in my high school learners as the positive emotional energy that was developed enabled social bonding and afterwards endeared the weaker learners to the hotspots (cognitively stronger learners (MKO), Vygotsky, 1978)) in the classroom. My high school learners eventually became the ones suggesting to me what in their environment can be used to teach certain life science concepts. The influence is also seen in Bridget's narration of the influence her maternal granny had on her while learning as a mentee from a mentor (LPP), Lave & Wenger, 1998)). From her narration, both Bridget and her maternal granny had a very close relationship as their social bonding and connectedness may have helped Bridget to access the knowledge of beading from the hotspot (her maternal granny).

Learners' sitting arrangement. The sitting arrangement in the classroom where beads and beadwork (cultural artifacts) were used to create instructional models of simple and complex organic molecules, had learners siting in groups, facing each other. Sitting in groups seem to encourage the communal nature of indigenous learners as they interact with each other and actively engage themselves. This style of sitting arrangement seem to appear as a cultural style as seen in the cultural institutions in African societies. It also appears to showcase the African concept of “I am because we are” (Ubuntu; omoluabi concept (Ogunniyi, 2004). When stories, proverb, songs, myths and metaphors are to be passed across to the younger ones, the communal philosophy is most often employed (a gathering connected with social and cognitive bonds) (eZiko concept; Goduka, 2005) as a framework for constructing epistemologies (Chilisa, 2012). This is in contrast to the traditional teacher-centered classroom where learners sit behind each other in rows while they are not allowed to interact even in columns/rows in the classroom. The sitting arrangement in the traditional teacher-centered classroom may be embodied by Rene Descartes (1637) well known adage of “I think; therefore I am” (an individualistic concepts), translated from the Latin philosophical proposition and in French, je pense, donc, je suis (an individualistic concepts). Here, the focus and aim of the philosophy is to push for an individual decision making in the science classroom. This sitting arrangement and philosophy affects interactions in the classroom, as seen in the traditional teacher-centered classroom, where the learners are seemingly constrained from interacting with each other.

In a proxemics analysis of the classroom space (Otulaja, 2010), the classroom also seemed to be divided into the teacher’s space and the learner’s space. The teacher’s space is usually in front of the learner’s space to the position of the chalkboard while the learners’ space is the space where the learners are sitting behind the teacher’s front position. More often than not, the teacher in the traditional teacher-centered classroom seems not accustomed to moving into the learners’ space; hence, if peradventure, the teacher moves into the learners’ space, the learners perhaps know the teacher is there to unleash symbolic violence on the learners; not often out of affection or to check what they are doing. It is unusual to find the teacher enhancing learners’ understanding of the science concept from the learners’ zone. Unlike the classroom where learners were taught with culturally-related instructional models (CRIM), such as those created from beads and beadwork (cultural artifacts) to teach simple and complex organic molecules. In such classrooms, the whole classroom space becomes that of both the teacher and learners (community space) as learners were seen, sometimes moving to the chalkboard arena and the teachers were also captured on video moving to the seemingly learners space with ease. The learners appear to be conscious that the teacher moving around in the learners’ space was to help them learn better and that it becomes usual because the power structure between teacher and learners is collapsed to enable learning to take place. The learners accessed the teachers’ capital as well as the other;

hence they seem to interact better than the traditional teacher-centered classroom; hence expanding the hotspots and allowing the leaves to interact better. Most times, the explanation the teacher gives to the groups seems to enhance the understanding of another group by just hearing what the teacher tells the group s/he is explains to.

The active engagement as a result of an enhanced mobility in the classroom between the teacher and learners enhances social bonding and social connectedness. It also enhances learner-teacher interactions, interactions among learners themselves, teacher-learner interaction, learners and teachers interactions with the instructional materials/model (CRR) and the environment and entrainment of positive emotional energy[4]. Interactions seem to re-structure the power dynamics in the life science classroom. In the traditional teacher-centered classroom, the teacher seems to be seen by the learners as the "know-it-all" and all powerful. He decides what happens, who asks questions and who does not. He also decides if there is going to be questions to be asked at a time or not, as well as how and what the learners learn. The teachers seem to perceive the learners as ones who are not capable to navigate and negotiate their own learning hence, the need for classroom control. The teachers seem to achieve the lesson goals in their (teachers) own way rather than the learners discovering how best they can learn. Learners, therefore remain inactive until motivated to get involved in the pedagogical process. In the classroom with beads and beadwork (cultural artifact), the teaching and learning responsibility seems to be shared (distributed learning/leadership); hence, the change in power dynamics to accommodate the learners in the pedagogical process. The teaching and learning process is shared in a sort of structure that transforms teachers (facilitator) and learners role (co-teachers) allowing the learner to participate actively and permits a sort of multiple-way of cognitive interaction in the classroom.

This structure (distributed empowerment) is enacted to empower the learners to become active in the pedagogical process in the classroom and to actively participate in their own learning. As evident in the classroom with the use of beads and beadwork cultural artifacts, the learners felt unrestrained to ask question from the teacher as well as from their peers without fear of being chastised. The context in which to ask questions was not determined by the teacher alone as was

[4] CRR means cultural responsive resources which are culturally related instructional models cognized to enhance learning in the classroom.

the case in the traditional teachers-centered classroom where who could ask questions, the type of questions to be asked and when to ask such questions is determined by the teacher alone. Also in traditional teacher centered-classroom, the teacher controls what happens in the classroom from the teacher space whereas in the classroom where beads and beadwork (cultural artifacts) were used to teach simple and complex organic compounds, the proxemics of interaction allowed the co-mingling of teachers and learners in ways that affect learning through hands-on, minds-on activities. The teacher does not control but facilitate the happenings in the classroom where beads and beadworks (cultural artifacts) were used for teaching and learning.

Peer Translanguaging.

Language as a cognitive artifacts/tool. As described in Chapter Four, the learners in the classrooms spoke multiple local languages (isiZulu, Tshivenda, isiXhosa, isiNdebele). Some even spoke local street languages when they wanted to explain instructions to each other. English was a second home language as their first home language is their mother tongue. It is suffice to say that all learners spoke more than one local language. Learners tend to speak English language mixed up with local language in addition to a Pidgin language (Pitori). Hence, the learners learn in a multilingual context. The learners in the classroom of the four teachers where cultural related instructional models (CRIM) was used to teach simple and complex organic molecules seen to actively engage each other as they spoke their local languages (linguistic science discourse) in the life sciences classroom. According to Cummings (2008), the use of multiple languages to learn can be an asset and resource to the learners during their lesson. Linguistic science discourse forms a novel opportunity for cultural and language encounters in the sciences classroom. At other moments, the learners who spoke English language, especially when they wanted to talk to the teachers who seem to premise English language above local languages.

Surprisingly, the teachers also use local languages at moments in the life science classroom to explain further to the learners concepts they perceive as difficult for learners to understand when English language is used to communicate such concepts. Teachers tend to discourage the learners from speaking in their local language in the classroom but learners and teachers spontaneously use it to convey the depth of knowledge. Learners' thoughts, manners and judgement are impacted by the learners' home languages (Chilisa, 2012). Chilisa (2012) further posits that, language gives all its demonstrations form and texture. By texture, I mean the finesse the indigenous learners need to deeply understand the science concepts they are taught using English language, which is not the learners mother tongue. Hence, the learners, after engaging local languages in their learning, in return, they seem to gain a deeper and more understandable version of the same lesson content the teachers was teaching them. This process is formerly known as code switching (Bloomberg, 2004) is now referred to as translanguaging (Chilisa, 2012). The same learners in the traditional teacher-centered classroom did not exhibit these characteristics. It is not that the learners could not exhibit the transformed characteristics demonstrated in the cultural artifacts mediated life science classroom. It is obvious that, the traditional methods of teaching constrained them.

The learners, after instructions and explanations has been provided by the teacher, speaks English language to the teacher, would turn to their colleagues, and speak their local language to each other in enhancing better understanding of the science concepts. In essence, the learners negotiated their learning by translanguaging. All of the languages different languages spoken by the learners in the classroom where culturally related instructional models (CRIM), models created from beads and beadwork (cultural artifacts) were used to teach simple and complex organic compounds are predominant languages spoken predominant around the location of the schools that participated in the study. Each of these local languages became adopted as the first home language of each of the schools that participated in the study. South Africa is a multilingual and multicultural society (an aim of the South African policy on Education, 1996) and it is mandatory for South African grade 10 to grade 12 learners, in addition to been first language, to learn, other languages in the school as a second home language. This is a language in Education policy (1996). Also the policy of language in Education in terms of section 3(4) of the National Education Policy act, 1996 (Act 27 of 1996), learning of more than one language should be a general practice and principle in our society.

According to the Department of Basic Education (DBE), schools are mandated to organize learning and teaching with a minimum of two language levels. The home language and the first additional language and there could be the possibility of adding a second additional language (DBE, 2011). Garcia and Wei (2014) posit that situations where learners allude to multiple languages as language resource/tool to enhance their learning can be called translanguaging practice.

Learners' language as a meaning-making tool. In a science classroom, where the medium of teaching and learning is English, learners spoke to themselves (the learners) in their local language and also in English, despite English language being the language of instruction in science classroom and seemingly the language of science (Karlsson, Larsson, & Jakobsson, 2018). In this study, and in the classrooms where culturally related instructional models (CRIM) was used, more often, the learners spoke English to the teacher but spoke their local language among each other (learners) and turned back again to speak English language to the teacher in the classroom. In essence, the learners negotiated between the border crossing of English and their local languages as they made meaning in the science classroom. From a perspective, the teachers seem to represent western science and not the indigenous science to the learners. Perhaps from another perspective, the learners see each other as an embodiment of indigenous knowledge; hence, they spoke their indigenous language to explain the teachers' westernized science to themselves.

This could mean that the learners found the local languages a channel through which they could negotiate their learning of science concepts. It also seems to provide avenues for learners to access scientific understanding (Brown & Spang, 2008). Warren (2016) posits that second language learners who are allowed to utilize their first language in the teaching and learning in the classroom tends to enhance their conceptual subject knowledge to greater extent than students who are not offered this opportunity. Hence, the learners where (CRIM) was used to teach simple and complex organic compounds, alluded to the use of their local language to understand the simple structure and subsequently went to attempt the more complex molecules on their own. This did not happen in the traditional teacher-centered classroom as all of the participants (teacher and learners) spoke in English language during classroom lesson. The nature of conversations when interpreted to English also revealed that learners conversed in their local language, the content been taught in the life science classrooms. Perhaps the bead and beadworks (cultural artifacts) in a way ushered in the classroom, the learners' home context. The home context in the classroom perhaps enabled the learners' entrainment in the cultural context to enable learning.

Learners' language as banks. According to Chilisa and Preece (2005), languages are banks where knowledge is stored and retrieved from, as an information repertoire. Language as a bank or repertoire of knowledge seems to justify one of the reasons why learners resort to their language to mediate science content knowledge with the use of their local languages. Perhaps, the local language provides the learners with deeper meaning of what is been taught. In addition, Canagarajah (2011) posits that language is a repertoire that can be accessed for learners communicative purposes as they construct their own meaning based on their home and community experiences. To these learners, language became a bank where communicative accessories were drawn from, to enhance science understanding in the classroom. From the two elaborations (that of Chilisa (2012) and that of Canagarajah (2011)), language use can enhance a more comprehensible meaning of western science concepts to the indigenous learners. According to Wallace (2004), for learners to understand science better, there is the necessity for learners to contextualize science as well as relate seemingly abstract subjects such as relating life sciences to their own lived-world.

Again, when learners' language (which is part of their cultural knowledge and experience) is valued as a resource for learning (Tan, Barton, Turner, & Gutiérrez, 2012), there is increased motivation, commitment and engagement towards the learning of the subject matter (Gutierrez 2012). The learners also understood when to speak the language of instruction (English) to the teacher and the local language to each other. When an outsider (an individual that is not part of the classroom at the moment) comes into the classroom, the learners tend to switch to the language of instruction (English Language). The transcriptions of classroom activities revealed that when learners wanted the teacher to make them understand a concept more, they asked the teacher in the local language that the teacher understands, because the teacher may not understand all the local languages in their society despite English language being the only accepted language of instruction in the life science classroom. Learners also spoke their local languages to the teacher when the teacher explained some science concepts to the learners in their local language and which will need the learners to reply the teacher in the language they were taught with. The teachers also seem to be individuals accustomed to the local language despite being western trained. Learner's deliberate use of local languages for better understanding of the science concepts tends to spiral up their discursive capacities and hence facilitate the learners understanding of scientific concepts (Nygård-Larsson, 2011).

Translanguaging context. Further studies on language use in the life science classroom have either called the phenomenon code-switching or translanguaging. Studies of Jamshidi and Navehebraim (2013) explained code-switching as an act of switching between two languages within a single discourse, sentence, or conversation. Macaro (2005) defined code-switching as an "asset and a valuable addition to the array of communicative strategies" (p. 63). Co-participants (learners and teachers) valued the use of language as an asset to be accessed to enhance their learning in the life sciences classroom. Since language is cultural, and language seems to enhance learners understanding of science, then science ideally is culturally based (Harding, 1998). During science teaching in the life sciences classroom, (CRIM) the use of such as those created from beads and beadworks (cultural artifacts) seems invaluable to the understanding of western science concepts by the indigenous learners. Also Bloomberg (2004) alludes to code switching as the interchanging of two languages while speaking. Numan and Carter (2001) also define the term as "a phenomenon of switching from one language to another in the same discourse" (linguistic science discourse) (2001, p. 275). All these definitions seem to elaborate on the switch between two or more languages in the science classroom (linguistic science discourse). Translanguaging is explained as the use of multiple languages between each other (Canagarajah, 2012). The studies indicated above seem premised in a linguistic literacy discourse to enable better understanding of concepts of the concepts being explained.

Although Bloomberg (2004) and Numan and Carter (2001) studies were conducted in the language and literacy context of classroom of language development, this study conducted in life science classroom where the language of teaching and learning in an African context is English Language and where learners engaged the use of their mother tongue to communicate among themselves their meaning making and understanding of science concepts aided by (CRIM). While the teachers use English to teach indigenous learners' scientific concepts and subconsciously code switch to local language when explaining difficult science concept. The expectation from the teacher was that learners must use English language in their communication of science concepts with the teacher and among learners. Learner tended to resist this unconscious hegemonic tendency on the part of the teachers by adhering to using their local language when communicating among each other aided by (CRIM).

According to Lowyck, Elen, and Clarebout (2004), when teachers fail to translanguage in the science classroom, by not allowing learners to access their local language, as observed in the traditional teacher-centered classroom, teachers are inflicting symbolic violence on learners' especially in the indigenous context. Teachers are in essence constraining learners to access a cultural resource using (CRIM) that would enhanced their science understanding. The excerpt below demonstrate learners' use of translanguaging in a (CRIM).

Mr. Brighton's culturally related instructional models (CRIM) class.

Group A

L1 Ekae Bostick *((Sotho))* (where is the Bostic?) O-H, radihlakanisa? (Oh we join them?) *((They now understand it))*

L2 Odiriletshe kea (how many did you do?) *((Members of group A interacting))*. 1, 2, 3,4,5,6 *((L2 from group A counting))*

L3 deyi six (it's six) *((L3 telling other group A members))* Deyikae ''C''? And 3, 4, 5, 6*((they are counting))*

In Mr. Brighton's traditional teacher centered classroom, the learners either answered in a one word answer or did not answer at all. See below excerpts from his class.

Mr. Brighton: is it? *((Brighton wants to be sure))*

Learners: *no response*

Mr. Brighton: you want me to do it? You want me to do it?

Learners: *No response*

Mr. Brighton: Its C, CH, here and OH and here H. Then OH, H, Then, C, H, OH, C, OH, H. Come to this one, C, *((Brighton draws the cyclic structure on the chalk board))*. What do we have here? H, No cos there is supposed to be a double bond. *((Teacher draws the* *linear glucose structure on the chalk board.))* ((*Learners imitate the C. H. OH that the teacher says)).* C, double bond O. Yeah! First, count the carbon atoms *((to assess whether what he has drawn is correctly done)).*

The happenings in the Mr. Brighton's traditional teacher-centered classroom as shown in the excerpts above is in the same manner as the ones in other groups because they are in the same class and there were also no groups in the traditional teacher-centered classroom.

Group B

L1: Anqi, understand, manje makuyi double bond? Sizo faka ama bead ayi two*? (I don't understand, if it is double bond, what must we do? put two beads?* Cos it's a double bond?

L2: Ihlobai one (there will only be one here) *((pointing at the black beads))*

L3: Ekae cellotape? Faka, I Bostic ayikho icello tape (Where is the cellotape)? (Rather use bostick because there is no cellotape) Beselena injani ke? (How is this one? O-H) *((L3 asks L1)) ((They continue to tell group A to discover yourself)).*

Group C

L1: Iso? (Is it like this?) *((She pointed[5] to the beads))* ikanje? (Is it like this?)*((L1 asks again))*

L2: I bond ikuphi? (Where is the bond?). I-bonda nayiphi? (Which one does it bond with?)

In Mr. Kagiso's CRIM class

L1: Uthini wena? (What are you saying?)

[5] Black beads represents carbon, white beads represents hydrogen, pink beads represents oxygen, blue beads represents nitrogen.

L2: Rona re etseng? (What should we do then?)Bae bitsa eng ntho e? (What do they call this thing?) *((Setswana))*

L3: Mina Ngizoyenza abo "c" (I'll do all the "c") *((isiZulu))*

L1: Di OH deyi kae (how many OH are there?) *((Sesotho))*

L2: Re busy kadi fructose ne? *((SeSotho))* (We are doing fructose now)*((L2 telling the cameraman what they are doing))* Fructose; Fructose *((Perhaps wanting to get the correct pronunciation from each other))*

L1: Nthotshe kedi atoms or elements (what are they, Atoms or elements?)*((Dialogues from group A).* Elements ne! Yeah. The "C' are they elements?

L2: Now re Kenya pink this side and re Kenya white kamole (we put pink this side and white on the other side) *((L2 answers L1)).* H ke eng (What is H?) Remind me.

Group B

L1: Is it supposed to be like this? (Confirming)

L2: Bakuphi abo cc? (Where is the cc?) we just take one Ngicela ungiboleke ipencil (please borrow me the pencil) iphelele? (Is it finished?) *((Referring to their structure)).*

In Mr. Kagiso's traditional teacher centered classroom, the learners answered in a one word answer. See below excerpts from his class.

Mr. Kagiso: we shall be looking at the xylem. The xylem consists of four cells which are: No (1), we have the xylem vessel, (No 2) we have the xylem tracheid. (No 3) we have the xylem sclerenchyma. And lastly we have the xylem parenchyma. Right

Learners: Yes

Mr Kagiso: So, our xylem sclerenchyma and our xylem parenchyma, it works in exactly the same way as the ordinary parenchyma and the sclerenchyma. What is the function of the xylem sclerenchyma? What is the function of the xylem sclerenchyma? What is the function of the sclerenchyma?

Learners: Yes

Mr. Kagiso: Provides mechanical support, if the sclerenchyma provides mechanical support then what is the function of the xylem sclerenchyma? It is also the same, since it is similar then it means it does the exact same thing and the exact same function

In Ms. Karabo's culturally-related instructional models (CRIM) class

L1: go shorta eng (what is missing) *((L2 trying to assess what they have done))*

L2: Ba itse re etsentho e so? (L2 Did they say we should do this?) *((Setswana))*

L1: Hai nqha bathe it doesn't matter (they said it doesn't matter) *(IsiXhosa)*

L3: Lento i- crom *((slang))* (this thing is not straight) *((group A members talking to each other))* Yes, Yathella *((Sesotho)) (meaning the beads are slippery)*.

Group 2

L1: Letha, iwhite ngenzayona and maningi laphayana!. (Bring the white beads, I am doing it... there are a lot of beads there!).*((Meaning be patient with me))* Tsheyi .z (h), s (we need H"). Sesicedile? no (Are we done? No) *((L1 asks l2))*

L2: Tracey tshwara (take beads); Kushoda I-pink. (We need more pink); Why uthatha amancane? (Why is she taking small beads?) Bheka laphayana (look there) *((on the board to confirm))*. There is an H. Yenza double bond (do a double bond).

In Ms. Karabo's traditional classroom, see below excerpts of interactions as learners' answered in a one word answer.

Ms. Karabo: Because it is been used as a what?

Learners: no response

Ms. Karabo: as a storage compound. So the reason why we need to convert glucose to starch is so that we can store our food. We can what?

Learners: No response

Ms Karabo: Store our food. Now if you remember, cellulose is also used for what?

Learners: No response

Ms. Karabo: For structure of what

Learners: for structure of cells. Cells of what? Plant cells. That's y we are saying plant cells are made of cellulose cell walls. Did we say that?

Learners: yes

Ms. Karabo: When we are talking of cellulose here. We talking of starch. The reason why convert cellulose into starch is so that we can be able

In Ms. Mbali's culturally related instructional models (CRIM) class

L1: Asenzeni I fructose (let's do the fructose) *((isiZulu))* Wena yenza ipink and white *((isiZulu))* (you will do all the pink and white beads).

L2: Izanama beads lapho amakhulu (come with more beads the big ones) excited because of the reward).

L3: Faka ipink la ususelezi (put pink and remove the other beads) Suza lezi (remove this)

L2: Faka iPink lana (put pink here) *((isiZulu))*

L1: Yenza idouble bond (do a double bond). *((L1 telling L2 to do a double bond))*

L3: Uthini wena? (What[6] are you saying?) *((Peer questioning))*

[6] The interpretations and corrections of the spellings of the local languages were done by a professional interpreter.

In Ms. Mbali's traditional classroom, see below excerpts of interactions as learners' answered in a one word answer.

Ms. Mbali: I am pronouncing it so that you are able to write it down. And steroids boost the immune system in our bodies. So they boost the immune system in our bodies. And the second part is that since the scientist has discovered that is has a lot of natural resources, and it is being introduced to traditional medicine it is now been used to increase the body's natural resistant to diseases. Neh

Learners: Yes

Ms. Mbali: And it has been proven that it slows down the progress of HIV? AIDS, TB, cancer and arthritis

The happenings in the traditional teachers-centered classroom is similar across the four teachers while contrast with the happenings in the CRIM classrooms. The happenings in the CRIM classrooms are similar also despite the two schools (two teachers per school) being at indigenous but different localities.

Learners, switching from a language to another seem to also enhance learners understanding of life science concepts. An indigenous learner whose first language is not English, learns English as the second language and the indigenous learner is been taught science using his second language (English language). An indigenous learners in a way digs dip to understand the science concepts being taught in English language. As indigenous learners learn science, the teacher speaks English; the learners hear in English, process it immediately and interpret it in their local language to the other learners. Learners' use of their local languages places more significance on the use of local languages in learning sciences. Chilisa (2012) reported that Xiaobo Yang (2005) collected her data during her research study in native Chinese language, but wrote the dissertation in English language. She observes that "when you translate every sentence, you feel so guilty because you lose so much information which can only be expressed and understood in one's own language and cultural tacit knowledge". Phenomenon of meaning making using translanguaging could result that a deeper meaning can be made in order to understand science concepts better. It can also be translated as when an indigenous learner interprets a concept from English to the native language, it gives much more information to the native learner. Hence, the learners know this and utilized this as it may help him/her with their everyday live-world. The learners' use of language to enhance their science learning is a form of linguistic science discourse. The moment learners are able to express science in their local language their understanding of science is as well as their science learning outcome. Been successful science learners aided by (CRIM) also improves their science identity.

Peer Identity Formation

Learners from the four teachers' classes (CRIM classes) were captured on video negotiating identities of success or positive performance (affinity and discursive identities; Gee, 2000) and by being learners in the classroom; they possess institutional identity (i-identity). Learners formed identities of successes individually and collectively in the CRIM classes. Gee's (2000) concept of identity is explained as being "a certain kind of person in a given context" (p. 99). Learners being identified as possessing identities of successes because they are part of the group that got their tasks done correctly. They formed same identities at the end of their successful tasks of creating glucose and fructose, lipids and protein structures as instructional models from beads and beadwork (cultural artifacts). The teachers observed the structures learners have created and assessed them. They were successful in their tasks as teachers continued to fomatively assess the lesson. The teachers' approval sends a signal to learners in the other groups to strive to become successful in the tasks they were given: hence, an identity of success. When the learners are unsuccessful in their given tasks, there seems to be low positive energy and the learners struggle to form a collective identity of success. By collective, I mean a group of individuals sharing "allegiance to, access to and participation in specific practice" (Gee, 2000, p. 105). By individual, I mean members of a group who acts independently.

Transcripts from in the four teachers CRIM classes, as excerpt below, indicate individual and collective success identities. For example, in Mr. Brighton's class, there were statements such as:

`"we are done sir, we are done sir",`

With the learners fist in the air to depict victory in the given tasks. A group collectively told the teacher that they are confident of what they have done. There were also statements like

"We are dogs! *((Dogs are symbols for brave and courageous situations)).*

Another group said

"Wow, it looked like the real deal"

In a loud energized collective voice.

Another group said

"Sir, we are done, this is nice, and it's like art".

Statements that showed collective identities have word like "we". They collectively showed the pride in their work achieved and hence their identity as African and collective. These words were said at different times and at different moments as the lesson progressed. While in Ms. Mbali's class, there were statements like:

"It is like cheese"

As they posed to show the whole class their class tasks. In Ms. Karabo's class, there were statements like

"This is free touch here" *((meaning it is easy with us here))* in a group, and another group says: "call this group KP"

As they stood up with their created models in their hands. "KP" stands for the first letter of each of the names in the groups (a collective name of a group). As well as another group saying

"We are done sir".

In Mr. Kagiso's class, statements like

"Yeah, we got it, this is our structure" *((as the learners held their models proudly high up))*

And another groups saying,

“This structure is from the hood, ‘the hood of Thembisa’”,

Thembisa being the community where the school and from where the learners came from. The learners were proud of their work. As a researcher, I did not see these happenings in the traditional teacher-centered classroom. The learners’ body language suggested that, they identified with the model created and that they can also do science. According to Somerville (2016), a sense of belonging is fundamental to the learners’ learning curve as well as sustaining learners’ identity in schools.

Identity formation in relation to pedagogy of place. More understanding of identity formation in relation to pedagogy of place elaborates that learners’ sense of place is culturally negotiated. If learners can relate their science understanding to their lived-experience, they seem to understand better (Ogunniyi & Mushayikwa, 2015). The learners related their learning to phenomena related to their environment (lived-experience) such as “the hood of Thembisa”, “we are the dogs”, “call these groups KP” in the teachers classroom where CRIM were created from beads and beadwork. All of these names are related to what they have and relate to their immediate environment. Learners alluding to their lived-world (‘dogs’, ‘Thembisa’, ‘KP’) in forming collective identities seem to identify with the pedagogy of place. The fact that learners did not only learn with CRIM using beads and beadwork (cultural artifacts) but with translanguaging to generate better understanding of science concepts, thereby becoming successful learners of science. Their identity formation is rooted in the pedagogy of place as evident in the study. The use of CRIM created from beads and beadwork (cultural artifacts) seem to illuminates further the importance of socio-culturally constructive process of learning from cognitive, affective and behavioral to cultural formation of successful identities of successes or identities of positive performance in a science classroom. This also seems to not happen in the teacher-centered classroom.

Learners as resources to each other. Learners, as seen in this study seem to visualize each other as resources (hotspots) for learning. As the learners participated in these CRIM tasks, there seem to be positive emotional energy (Collins, 2004) within and across the groups. As learners participated in the CRIM tasks, they seem to be energized positively. As learners succeeded in getting the tasks right, they collectively erupt into shared applause and there is increased emotional energy embodied by them. They tend to collectively share the applause and an increase emotional energy. The embodiment of the increased positive emotional energy also seems to increase learners' self-efficacy as success begat success; hence the learners want to construct more complex structured organic compounds. They collectively work to arrive at the correct answer. Otherwise, learners drew energy from within themselves and/or other groups' members and continued to work harder to arrive at the correct answer. The positive emotional energy of one learner in a group (hotspot) tends to kindle the other members of the group. This collective shared passion is evident in the collective identity formation of learners in the CRIM class and also seems to serve in the energization process during cognitive tasks. This phenomenon is at variance with the low energy observed in the traditional teachers-centered classroom where learners' self-expressions seemed constrained.

Thinking Together, Acting Together.

According to Hott, Walker, and Sahni (2012), peer tutoring is a role in which learners take up roles are continuously shifting the teaching responsibility in a fellow learner. Those that enable others are called tutors while those that are being enabled are called tutees. In this context, CRIM classroom enabled learners became a shifting role where anyone can be a tutor and the others be a tutee, hence, distributed leadership which could be momentary co-tutoring and co-tutee. Previous studies on peer tutoring showed that peer tutors assists learners in gaining more understanding of lesson goals, supplementary to lectures (Harper & Maheady, 2007), as teaching and learning progresses in the classroom. Peer tutoring also creates a sort of teaching and learning partners due to the interactions in the classroom. This strategy enables learners to take up initiative to learn each other rather than the teacher directing the whole classroom lesson all by his//herself. In essence, learners became co-teachers in the classroom by explaining concepts in local parlance or street language to other learners as they exchange ideas to get the task done. Using cultural artifacts (beads and beadwork) to create CRIM of life sciences concepts by shifting roles from tutor to tutee and from tutee to tutor, learners become hotspots for learning for each other in the science classroom thereby actively participating in their own learning. According to Hott, Walker and Sahni (2012), there are ways teachers can achieve the peer tutoring role in learners. As a facilitator of learning in the classroom, rather than constrain distributed leadership and learners expression as it is observed in the traditional teacher centered classroom.

In the CRIM classroom, peer tutors emerged naturally as teaching and learning was aided by culturally responsive pedagogical resources (CRPR)[7]. The role of a more knowledgeable order (MKO) (Vygotsky, 1999) is similar to the tutor tutee relationship, however, the roles does not have to be permanent as it can be a shift role. In all the four CRIM classes, the learners were seen rotating the peer tutoring role among each other as they unpacked the learning concept. There is the possibility that the learners were enabled to be able to peer tutor each other because of the enabling contexts created by CRIM and aided by CRPR. In unpacking these concepts the learners peer tutored each other by learners exchanging. Learners assisted each other, instructed each other, some learners volunteered to take up a role or the other, shared responsibilities and complimented each other when they got the tasks right. This constructs were captured in the classes where CRIM was used for teaching and learning of life science concepts in the classroom. There is the possibility that the use of beads and beadworks (cultural artifacts) created an enabling environment for active participation and the share of knowledge by the learners with or without the teacher tutoring in the science classroom. As I enumerated earlier, learners alternated their peer tutor roles in the classroom. Learners role begin to emerge as peer tutors, self-directing as they were thinking and acting together. The role begin to manifest, in the thinking together, suggesting direction to each other and acting on those direction even when they get stalk with one direction, they stop and start again. It was a constantly shifting role, giving each other the space to talk and think. In the CRIM classroom, exchanging the tutors' role among each other was observed as well as learners giving instructions and implementing these instructions for construction of the models.

Peer instruction. Peer tutoring as a role, required giving instructions as the lesson progressed. Learners instructed each other and the individuals being instructed seemed happy to carry the instructed tasks out. For example in Ms Karabo's class, the learners alternated the role of peer tutorship. Tracy (one of the three groups, group A learners in Ms. Karabo's class) was captured on video instructing and taking instruction from her group members (See excerpts below)

Group 1

[7] Culturally responsive pedagogical resources are cognitized objects used as culturally related instructional models (CRIM)

(L2): Tracey tshwara (take beads), *((a member of the group talking to Tracey))*

Group 1

(L2): Tracey: Kushoda I-pink? (We need more pink?),

Group 1

(L1) Bheka laphayana (look there) *((Tracey talking to the two other members of the group))*. There is an H, *((Tracy continues to explain further to the other two members of group A))* Yenza double bond (do a double bond) *((Tracey, after explaining to the other two members, told them to try it themselves))*.

Then, one of the other two members of Tracey's group, after the group had created the glucose structure, enjoined the other member to create her own fructose structure.

Group 1

(L3): Asenzeni I fructose (let's do the fructose) *((isiZulu))*, *((the third member of Tracey's group enjoined the whole members to create the next structure-glucose structure))* Wena yenza pink and white *((isiZulu))* (you will do all the pink and white beads) *((And they distributed what to do among the other two members))*.

While in another group, learners took up the role as a peer tutor, instructed his fellow group members to bring some beads (from the front space)) so that he can explain further to them. (See excerpts below)

Group 4

(L1 to L2): Izanama beads lapho amakhulu (come with more beads the big ones). Faka I –pink la ususelezim (put pink and remove the other beads), Suzalezi (remove this) *((this learner instructs the other learners in the same group, as they learn from each other))*. Pink la? (The pink?).

This conversation continued In Ms. Mbali's class, learners learnt from each other though learners instructing each other to carry out a task as others supervise. A learner instructed the other learner to write the structural formulae down. (See excerpts below)

Group 5.

L1. Bhala phansi, (write it down), *((L1 telling L2 to write it on the paper))*, Wena uzodrowa, (you are the one who is going to draw) *((L1 instructing another member of the same group (l2) to sketch the structure of glucose. This could be a sort of division of labor)).*

Group 1

L2: (He is the one to draw), Yenza i (e) oxygen i(e) (be straight ne carbon) *((make oxygen align with carbon)). ((L2 tells L3 to draw it neatly)).* And then, Oxygen, carbon ((learner pointing the model they are doing)), Ngicela ungihlanganisele ipink (can someone please connect pink for me please) *((Group 1, L3 asking for assistance from any other member of the same group)) ((Group 1, L2 had pink beads in his hands)), ((L3 learner had white beads in his hand also)) ((division of labor)).*

Group 1

L3 Ngithengicela, iHydrogen, wena umile (I said I am asking for hydrogen but you are delaying}).

In another group in Ms. Mbali's class, learners' that suggested the group creates the glucose models when told by the teacher (Ms. Mbali) to choose between the structures of glucose and fructose, and create. The learners choose the fructose structure for model creation on behalf of the group. (See excerpts below)

Group 6

L1: 'A re dire'' glucose (let us do glucose) *((isipedi))*, Glucose; 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11; 1, 2, 3, 4, 5, 6*((All group 6 learners counting the number of hydrogen molecules in the chemical structure of fructose compound))*. So, now you do this one. *((L1 telling L2 In the same group to attempt the glucose structure after he has successfully done the fructose structure. ((Teacher points at the glucose structure as the learners count))*

Carbon, hydrogen. And then hydrogen again. *((Learners confirming what they have done, by counting if the oxygen and carbon-dioxide molecules are complete)).*

The learners in all CRIM classes, peer tutored as they translanguaged. Translanguaging became a mediating process in the learners participating and learning process. As the learners taught themselves in the classroom, the positive emotional energy also remained strong for the learners' further learning in the classroom. This translates to describing that the learners' cultural capital enabled the learners in their role as peer tutors-the interplay of cultural capital and cognitive capital.

In Mr. Brighton's class, some learners, as a form of peer tutoring, complemented each other. (see below)

Group 3

L2: Ke nahana Hore iHlobaso.(I think it will be like this) *((L2 telling the other two members how he thinks the glucose structure will be after being at cross roads on how to go about creating the double bond in the glucose structure.))*

The learners' continues to create a hydrogen molecule and a hydroxyl (OH) molecule. Hence, the learner said

Group 2

L1: OH again! *((As she connects the H and OH to the carbon skeleton))*. This is H, OH, H, OH, OH, Bhekalaphayana yi OH, and OH. (Look there! It's OH, OH), *((L1 correcting L3))*, OH Again,

Group 2

L3: Etsa so! Bond O to H, (do this, bond O to H), *((L3 instructs L1 who is creating the bond so that they can complete their task)).*

Group 2

L4 Ninze sure ukuthi ibond yenu icala nge pink (Make sure your bonds start with pink) *((L4 referring to double* *bonds))*. Uyetsa so? (You do it like this*). ((Learners do the double bond with two short rolled glue))*.Do the next one and I will finish this one. (L4 talking to L2)

Learners from a group explained to another learner in their group of three and said

Group 3

L1 "uyetsa so (do you it like this).

She instructs the other fellow from the same group to create it as she had created it. The next instruction was to combine the glue (see below)

Group 3 (L1)

Hlakantsa prestick, Unyaka ho hoyetsang? (combine the prestick), (who do you want to do it for you) *((L2 talking to L4))*.

The learner tells the one that has created the glucose structure to put the glue in its original position as she expects her fellow learner to be more responsible towards her own learning process, hence, the question;

Group 2

L1 "Who do you want to do it for"? Kentse direct mos (I said direct) Ba itse double bond (They said double bond).

In the fourth teacher's (Mr. Kagiso) class, similar constructs were observed as the learners who were captured on video per-tutoring instructed the learners as the teacher might have perhaps done. Could this be a form of imitation especially as the learners seemingly acted like the teacher in the classroom? To assume the position of peer tutors, is imitation involved? (Bandura, 1977)

Peer complimenting. In the four teacher's classes, learners were also seen complimenting each other. (See excerpts below)

Mr Kagiso's class includes

Group A

L1 “That’s good!” *((L1 in Group A commending the work of another member (l2) in the same group.))*

Group A

L1 “It is like art”. “Yes, this is nice; this is nice” *((the learner appreciates what he has done))*.

Group B

L2 “It is attractive, now I know”. *((a compliment on the work the group created)) ((Learner 4 joins an oxygen bond to the model while another rolls the bond to be joined to the model)).*

Group C

L4 “I smart” (it’s beautiful).

Group D

L1 “It is interesting. Too much”.

Also in Ms. Karabo’s class

Group A

L1 ”Yeah! But you did well”.

Group B

L2 “Oh! You are right”!

Group c

L3 “Yeah, that’s good” *((learner compliments each other in Ms. Karabo’s class))*.

Learners perhaps understand the efficacy of complimenting themselves during cognitive practice. A sort of affirmation of self-identity which also aligns with self-efficacy. A form of self-awareness of self-accomplishment. It is a confirmation of capital acquisition. Compliments could be a form of reward to each other as when tasks are done correctly, there is a reward and when tasks are incorrectly completed, there is a negative reward. There may be a negative reward from peers for incorrect completed tasks and this may hopefully serve as an energizer to achieving a kind of correctly completed tasks. This seems to be a form of positive reinforcement (Skinner, 1976). Peer complements as seen in this study, can be a sort of feedback after assessment from the peer learners. An expression of admiration after accessing the task or after learners' peers had a chance to access the tasks. It can be a form of a marker for whom to peer within the next group task. It is a form of capital imbued by a learner on another learner who is a recipient of a complement and also a marker for group and individual identity of success. Self-compliment or compliment by others enables an individual to see one self in a different identity. When successful in a task, and complimented by others for being successful, one's identity or view of self is enabled. There is mental acknowledgement that one belongs to a group of successful learners who is also successful in the same task and as success begat success (Tobin, 2005), the individual wants to continue to be successful. As I have said before, self-compliment is a form of self-efficacy. It seems to increase the individual's (symbolic, social cognitive and cultural) capital.

As forms of peer-learning (tutor-tutee), learners volunteered carry out responsibilities within a group or across groups so that the tasks can be done. It is a form of division of labor with shifting roles.

In Mr. Kagiso's class, a learner in a group asked his fellow members

Group A

L1 "Akhona, etsa di space ketlokgona hoetsa di lines" *((Akhona (Name of a learner) make space so that I can do the lines))) ((L3 learner telling L2 to give space so that she can use ruler to draw the lines in the glucose molecules)).*

The learners also share and take responsibility among the groups members. Learners tends to be willing to take responsibility of their learning and in doing so, they want to see themselves interdependent of anyone during learning. They ask questions from each other and from the teacher to open up their understanding of the science concepts.

Peer questioning. Peer questioning in this study, seems to be part of a process of peer learning. Questioning can be a strategy towards facilitating learners' understanding of concepts. Questions, according to Chin and Osborne (2008) assist learners' self-regulatory and monitoring skills. According to the authors, questions helps learners to understand better the models and materials used for learning while they construct new knowledge. King (2002) posits that, questioning bolsters high level cognitive reasoning. King (2002) further posits that, questions helps learners to understand and remember new knowledge. Chin and Kayalvizhi (2005) both argue that questions are important in enhancing discourse activities, dialectical thinking, eliciting explanations as well as helping critical and creative thinking. Watts and Pedrosa de Jesus (2005) learners asking questions from each other is an important step in achieving the lesson goals of the teacher in the science classroom. It allows the learners to fully articulate the content understanding as well as make connections between the learners' prior knowledge and the new knowledge. Wallace, Hand and Prain (2004) posit that questioning helps to enhance productive thinking as well as higher order thinking skills. These various views on the relevance of questioning to learners strengthen the fact that questioning in learners should be supported. This is not the same in the teacher-centered traditional classroom where learners were not permitted to even talk let alone ask questions in the classroom. With interaction less advocated in the teacher-centered classroom, questioning by learners are most often constrained.

Looking further into the current study, the studies above were carried out in a guided questioning context. Learners were guided towards the questions they asked to elicit their higher order thinking skills. However, in this study, learners' questioning happened spontaneously. It was not pre-planned or guided. Learners were enabled by culturally relevant pedagogical resources (CRPR) while they negotiated their own meaning-making themselves. In the questions asked by the learners, it appeared that they (i) self- and peer-assessed each other. (See excerpts below)

From Mr. Brighton's CRIM classroom;

Group 1

Group A members	we are done with H *((learners group A conclude that they have finished their task))*
L1	Is there no bond here? *((another learner asks the question from the two other group members))*; it is not like this;
L2	It is not like this; it is like this ((the second learner in group A in a loud voice, in view of correcting the others)). There is no bond here;

it was supposed to be here ((the member of the group corrected the other learners.

From Ms. Karabo's CRIM class:

Group C

Group C members: we are done; we are done. ((Learners conclude they were done)) re feditse?

Group c

L1 (Is it finished?)((Learners asking questions while referring to the structure they said they have finished with)).

L2 go shorta eng (what is missing) ((L2 trying to assess what they have done))

L3 Double bond. O ((the third learner in the group discovers what was missing)).Oh I see! Ba itse re etsentho e so? *((tswana))* (L2) Did they say we should do this?

From Mr. Kagiso's CRIM class;

Group B

Group B members we are done *((learners in this group tell the teacher they are done with the task.))* E untidy ha e le so (it is untidy when it is like this?) *((A group member asks if what they created was neat))*. *((A learner accessing the models they created in comparison to what others in other group did))*

L2 Lento yimbi uyayibona nawe (This is ugly you can also see it) *((another learner discovered the untidiness))*. We get it; we get it.

L3 uyayibona into esiyenzayo (Can you see what we are doing).*((A learner telling learners in another group to check out what they are doing))* Bona bazamile (These ones tried) *((learners referring to another group's work))*

From Ms. Mbali's CRIM class:

Group E

L1 Is this too far? *((A learner in a group asking the whole group if the hydrogen atom is far from the double bond.)).* It's too far *((L1 telling the whole group)).*

L2 Ok *((L1 wanted to position the pink beads far from the black beads, then L2 corrects L1))* L2. Is it fine?

L1 Its fine.

Learners asking question from each other enhances critical thinking processes as well as enable learners' self-assessment. In self-evaluation, learners may observe their work, compare it to others and proceed to the next complex task after getting the first simple task correct.

Peer observation. Learning with CRIM using beads and beadwork (cultural artifacts) seems to have enabled a context that allowed learners observe the teacher as well as observe each other while learning. It seems to be an opportunity for learners to improve their learning processes and understanding of the content being taught. This nature of observation seems to be in a form of learners observing their peers (Bandura, 1977).It is a form of accessing fellow learners as in plugging into hotspots in the classroom. In the professional development and training workshop, the teachers observed and learned from the researcher while in the CRIM class with beads ad beadwork, learners observed and learned from their teacher and from each other. According to Hendry and Oliver (2012), seeing is believing, as colleagues (teachers), with the plan to improve their pedagogical practice, observe others in their teaching. Hendry and Oliver (2012), study was carried out with pre-service and in-service teachers with the aim of improving pre-service and in-service teachers teaching prowess. The current study shows that observation is not only applied by teachers but learners also. It seems to help learners' reflection on their work or on other people's work. Learners' opportunity to observe themselves seems to illuminate the learners' ability to assess and learn from each other. In observing each other, they can question themselves as seen in the previous paragraphs, assess their learning task whether right or wrong before the teacher does. Peer observation seems to be an affordance and an enabler.

The learners were enabled by the cultural context available to the learners to understand science concepts better. The use of CRPR enabled the learners, a life-time successful experience in the life sciences classroom. It appears integral to how the learners learn in the life science classroom because they self-assessed themselves, assessed other groups' task as well as assessed the teacher lesson also. Such class conversations where learners assessed each other of other groups were captured on video. (See below excerpts)

Mr. Brighton's class

Group D members	we are done *((group D learners telling the teacher while the surrounding groups listen to them))*.
L1	E untidy ha e le so (It is untidy when it is like this) ((a learner assessing the models they created in comparison to what others in other group did))
L2	Lento yimbi uyayibona nawe (This is ugly you can also see it).
Group D members	we get it, we get it. Uyanyi into oyenzayo (Can you see what we are doing) ((learners telling another group to check out what they are doing))
Group A learners	Bona bazamile (These ones tried) ((Group A learners referring to another group's work))

This context afforded the learners the opportunity to observe and subsequently check their learning progress and receive feedback to enhance the task at hand. As they learners observes and assessed each other's work, learners asked questions related to the content from themselves (self and members of the same group) (see excerpts below). The nature of questions the learners asked were those eliciting high order skills. Questions of what, why, how, were not only posed in English language but in the learners local language. (See excerpts below)

In Mr. Brighton's class

Group A

L1 "What if siyenza into e wrong, sithatha ioxygen? *((isiZulu))* (What if we are doing the wrong thing taking oxygen?)

L2 Siyenza so? (Should we do it like this?) *((L1 asking other members of the groups as he creates the model for the group and other group members watching))*

Group 2

L2 Ubhalelaphi? (Where you writing at?) Ke engen? (What is this one?)*((Setswana)). ((L2 asking from L3 what OH means in the glucose structure)*

Group 3

L1 Black is what? *((L1 asking from L3)) ((Learners gather in group to show the camera the glucose and water models they have done)) Kantisifunani? What do we want? ((L1 asking the L4 the number of carbons they need)),* Sifuna ezi black? We want seven black? *((L1 answers L4))*

Group 4

L! Manje I carbon, ingenaphi? Where does carbon fit? *((L3 asking L2));* six carbon; I (e) short I (e) one; No Keing, ke-pink (what does pink represent) *((L2 asking from L1)),*

In Mr. Kagiso's class

Group 1

L1 Eye oxygen soyishayanjani? (How will we do the oxygen one?) *((L3 asking the other member of the group))*

Group 2

L2 Keisa kae nna? Ha e tengmo (why would I need it. It is not here

Group 4

L4 Ekae Bostick? (Setsotho) (Where is the Bostic?) *((a member of the same group asks another member)).*

L3 "Odirile tshe kae? (How many did you do?) *((and this lead to the learners counting "1, 2, 3, 4, 5, 6"))* ; i six she replied. *((A learner telling another in group A member))*

Ms Mbali's class

Group 1

L2 Anqi understand man jemakuyi double bond? sizofaka eziyingakhi? (I don't understand, if its double bond, what must we do put two beads?)*((A learner asks the other member of the group)).*

L3 Ekae cellotape? faka iBostic ayikho icellotape (Where is the tape? "I don't understand how to create a double bond" *((Group A (L3) asking from another members))*

Group 3

L1 "Besele nenjani ke? How is this one? …… O-H *((L1 asks L2)*

Group 4

L2 Iso? Is it like this? *((She is pointing to the beads as she asks from the other member in the same group))*

L3 Isono na? (Is it like this?) I bond ikuphi (where is the bond)

L4 I-bondanayiphi (which one does it bond with)

Ms. Karabo's class

Group 1

L1 Uthini wena? (What are you saying?)

L2 Rona re etseng, Di H? (What should we do then Anismiliniapho ma (Tsibo there man)

Group 2

L1 Baebitsangntho e? (What do they call this thing?) *((Setswana))*

L2 Mina Ngizoyenza abo "c" I'll do the entire "o" *((isiZulu))*

L3 Di OH deyikae (*(Setsotho))* (how many OH are there)?

Group 3

L1 "Why o fetsa bostik?" (Why are you finishing the bostik; learners gesturing). *((pointing to explain things to themselves)).*

L2 Ngiyenzani? Ama-bonds? (What am I doing, the bonds?) *((As she takes the bostik))*

Group 4

L1 "Double bond roetshajwong"? (How are we going to represent double bond?) *((The learners got to the point where they were challenged into creating a double bond, hence the learners asked themselves)).*

Group 5

L1 "Re feditse so? (Are we done like this?) Iso, iso, keyetshaekiyibona diagrammmmmmmmmmmmmmu (It's like this! I am doing what I am seeing on the diagram).

Most questions asked seems to be higher order eliciting questions that the learners were afforded as they negotiated their learning and understanding of simple and complex organic molecules.

Another dimension to learners' observation was that it led to the learners' demonstration of the content. By demonstration I mean the learners corroborated their learning with science content knowledge illustrations and expositions. During the learners' demonstration of content, they found ways to conceptualize the teacher's intended, overt and explicit (Eisner, 1994) (lesson content as well as ways to communicate the content more effectively back to the teacher. Hence, the teachers could assess the learners and determine if they have really grasped the lesson being taught. It also helps the learner to determine the point in the lesson content and where the learners seem weak or strengthened. This seems to not happen in the traditional teacher-centered method where they learners simply focused on the teacher teaching from the front of the classroom and see the teacher as the only source of learning.   (See excerpts below)

From Mr. Kagiso's class:

Group A

L1 Nayi o pink. (Here is the pink one). *((L1 showing Sibongile (L2) the pink one to paste to complete the water structure))*. Ngizoshiya i space. (I will leave a space)

L2 Beka I white lana. (Put the white one here). *((Still in the process of creating the glucose structure))*. White kamo. (White here). *((L3 doing the glucose structure as she talks and her voice remains audible))*.

From Ms. Mbali's class:

Group C

L1 Bathe si bhale i H20 la (they said we should write H20).You said six pink. *((L1 talking to L2))*.

L2 Hai, wena with your handwriting. ((L2 did not like L1 handwriting)). Ungababonisis ama ideas wami. (Don't show my ideas). And then eleven white. *((Learners count the number of oxygen, hydrogen beads they would need))*. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 .10... 11 And what... Eleven white beads, *((L1 raises voice))*. *((Learners continue counting))*.

L1 Carbon right? ((Answered by L1)). So before carbon we have Hydrogen. Before hydrogen we've got oxygen. So before carbon we have Hydrogen. Before hydrogen we've got oxygen. Yes; Besifuna ama oxygen ai seven. (We wanted seven (7) oxygen).

From Ms. Karabo's class:

Group D Members ((learners discuss)).

L1 Six *((L1 mention six perhaps the number of oxygens))*. Eleven hydrogen *((Learners continue to deliberate on the number of beads for the atoms-Hydrogen))*.

L2 Other people has started doing the second thing but you are still in the first thing. *((L2 encourages his group to get the tasks correctly as well as quickly))*. Seven pink, hydrogen …1, 2, 3, 4, 5, 6, 7. Eleven. Eleven hydrogen. *((Learners count the number of hydrogen beads they would need)).*

From Mr. Brighton's classroom:

Group E

L1 Keyewu. (Here is it). *((L1 talking to L2))* H, H, OH, OH. Yeah! Double bond. Othama H this side. It is attached directly to the carbon. *((L1 complements the groups work)).*

L2 It's direct. *((Learners rolling the glue on the table to form a long looking bond in the cyclic structure)).* O2-It is CHOH. There's no O2. ((L2 is explaining to L1 in her group). It's CH2OH. Uyaylbona I O2 Lana melekube ne H. (can you see an o2 here? There should be H here).

L1 Arethome kadi H (let's start with H). CH2. The last one. Yeah! CH2 OH on a carbon, H2. Yes, two hydrogen on a carbon. Two hydrogen's on a carbon. Retsuantswe refile nthwele *((we must fill that in papers. Write your name on the models you have done and the name of the models you have done)).*

Words such as "here", "there', "this is it" indicate that learners demonstrated science content knowledge to the teacher and themselves. Also, activities that involved counting, creativity and demonstration seem to depict that the learners actively engaged in demonstrating the enacted lesson (Dewey, 1997) as against the one-word answer that learners gave in the traditional-teacher centered lessons. The nature of observation enabled the learners to observe beyond their own group; hence they also observed and assessed other groups work in the classroom.

Peer inter-group evaluation. Furthermore, learners were captured assessing other groups (inter-group assessment) in the classroom as evident in the expressions captured in Mr. Brighton's class where a learner from group (c) saw what the learners in group (e) did and said

Group C

L1 "It is not like this. It is not like this. It is like this. *((he speaks aloud in view of correcting the other learner in the other group)).* There is no bond here; it was supposed to be here".

Similarly, In Mr. Kagiso's class, the learners' evaluation in form of interactions with other groups were captured such as

Group A

L1 "Uqedilenge water" "Are you done with water (H20)? "We know what we are doing *((Group B (L1) members telling learners from another group))* "H, ketse two". (There are two 'H") *((L1 answering L3))*

Group B members

Siyazi ukuthi mele senzani, (we know what we are doing) *((Group B members telling the camera man who questions what they are doing))* *((Group B asking Group 1))* Uqedilenge water. Are you done with water (H20)?

All conversations were from one group to the other. These affordances became a sort of assessment that allowed learners make corrections in their work. Similarly, learners questioned the teacher to elicit knowledge that was not enabled in the traditional teacher-centered method of the same classroom in a CRIM classroom.

Learners questioning the teachers' content knowledge. The CRIM class created the context in which the learners were able to question the teachers' content knowledge in a c-teaching, co-learning context. This shift in cultural dimension from where learners' traditional ethos forbid learners to question their teachers' content knowledge as in the teacher-centered classroom to where they now question the teachers content knowledge was structured by the use of cultural related pedagogical resources (CRPR). African culture as regards respecting older individuals does not permit younger individuals to ask questions when not permitted to do. The use of beads and beadwork (cultural artifacts) to create instructional materials seems to have, in a way opened up the teacher for direct access to the learners. This shift in power structure can be a sort of ontological authenticity (Guba & Lincoln, 1989) (See excerpts below). According to Guba and Lincoln (1989), Ontological shift happens as a result of individual constructions on the other as they become more informed and enabled. It could also be tactical as it unpacks the extent of which an individual is empowered to take action. The learners become empowered and enabled in the CRIM classroom to ask questions from the teacher without the teacher feeling "insubordinated".

Group A members

L1 why is the double bond there? *((Learners asking the teacher when they seem to be confused by what the teacher wrote))*

Teacher Why is it there *((The teacher also asking the learners in return))*

Group A members: Oh you are asking me? *((The learners asking the teacher if he was asking them a question in return when they were actually asking him)).* Aaaah! we are asking you.

Teacher: It's OH not HO *((the teacher looks at the chalkboard again and corrects the structural formula.*

Another learner-teacher conversation is shown below

Group B:

L1 Do I have to connect all the beads to the molecules with lines? *((She had already pasted the beads representing oxygen and hydrogen in the glucose structure on the paper))*.

The learners question made the teacher notice that some learners may not understand how to connect the molecules together; hence, the teacher become aware she has to check how these learners connected their molecules together: hence she started to check how other groups attached theirs. In Ms. Ditshego's class learners arrived at a point where they needed the teacher to guide them in understanding the concept being taught.

In Ms. Ditshego's class

Group B

L1 *"Why does this happen like this" ((the learner asking the teacher why the structure was constructed the way it was)).*

Teacher (answers) "Because, hydrogen only attaches to one, so it can't attach to anything else. It can't attach to the c *at the same time, so the C can attach to the O then to the H, Right"! ((Teacher explains to Group A as they create the glucose structure)).*

Teacher *"So whenever you attach an O, and C and an H at the same time, the C comes first, then the O then the H, C, O, H"*

The teacher explained. By the learners asking the teacher the questions, the teacher got to know the individual challenge the learners have and how to confront the challenges. Similarly, the learners in Ms. Mbali's class with the use of beads and beadwork (cultural artifacts) to teach simple and complex organic compounds, asked questions at different times in the classroom and when during their assimilation process they needed to clarify some challenging issues. A member of a group in Ms. Mbali's class asked:

Group D

L1 *"Do I have to connect all the beads to the atom with lines ((She was busy constructing the glucose structure* on the paper))

These questions made the teacher become aware she has to check how these learners are learning the science concepts. She saw they had represented the bonds with lines. The questions the learners asked from the teacher enabled and heighted awareness of the teacher to what she should have done earlier for the learners to understand the concepts better. In understanding the concepts better, the learners either at first evaluate themselves before the teacher does the evaluation or a peer learner (member of the group or another group) does the evaluation before the teacher does the final evaluation. More expressions by Ms. Mbali's learners are:

Group C

L1 *"it's too far (L1)*

L2 Ok ((L1 wanted to position the pink beads far from the black beads, then L2 corrects L1))

L2 Is it fine?

L1 Its fine.

In other cases, the learners asked,

L3 `Are we correct?`

`L1 and L2:  "yes we are" the other learners reply.`

Interestingly, as soon as the learners task are approved by the teacher, at the end of the CRIM class, the groups exhibited collective effervescence such as collectively saying "Yeehh!", with their fists up as well as (learners clapping for themselves as they shouted for joy in the classroom). Another group in Ms. Mbali's class said with their fist up

`Group B learners:  double bond! It is attractive.`

`L1 in group B:     Now I know.`

`Group B learners:  Yea we can. Yeah we understand it. Yes sir, x4.`

One could see the joyful mood experienced by the group of learners as they achieved success in their tasks. The learners now feel enabled to access the teacher at any time because the structure in the teacher-centered classroom has been transformed by the CRIM to teach and learn in the classroom. The use of beads and beadwork (cultural artifacts) seem to have created in the learners the sense of ownership of their own learning.

Summary of the Chapter

In this chapter, I have discussed the teachers' roles as learners in the professional development and training workshop, how they teach in the traditional teacher-centered classroom and how the use of CRPR transformed their pedagogical practice in the CRIM classroom. I also discussed learners expressive individualism as a characteristic nature of indigenous learners and how, when enabled in the CRIM classroom, enabled a context that enhanced learners learning of simple and complex organic structures. In essence, enabling learners with the CRIM context enabled the learners to translanguage, to peer-tutor, to peer-questioned each other and the teacher, to-peer complimented each other, to observe and imitate themselves in the science classroom. All these constructs enabled the learners' transformation processes of the teachers intended goals and the desired outcomes of the learners. These phenomenon were not captured happening in the traditional teacher-centered classroom as learners were seemingly passive in their learning process in the classroom.   The use of cultural artifacts (a common factor in the various learning enterprises) seem to be central to indigenous learners science understanding process as it sustained learners interest and engagement in classroom pedagogical practice. CRIM also enhanced practicability and pragmatic ability in the learners (Dewey, 1934).

Chapter Seven

Overview, Conclusion and Recommendation

Introduction

The last chapter comprised a comparative analysis of both traditional teacher-centered classrooms and the learner-centered classrooms where beads and beadworks (cultural artifacts) were used as culturally-mediated instructional models in stimulating learners' understanding of simple and complex molecules was discussed. Also discussed were the affordances created for learners by the use of cultural artifacts as models for learning in the classroom. As I conclude this study, and reminiscence on how the whole study started, in digging deep, I have uncovered things that I would have not envisaged. Also the findings are not definitive but help to describe cultural circumstances that involved the use of beads and beadwork to create instructional models as aids.

As I dug deep, I found that teachers and learners became willing to suggest other models that beads and beadwork (cultural artifacts) could be used to create. In fact, the vice-principal of one of the schools where this research was conducted showed me test questions the Grade 10 learners were to write the following day. It was a provincial test; hence, the whole province was to write the test. The test questions were Agricultural science questions and almost eighty-percent of the questions were on simple and complex organic compounds. He said, "And these questions are difficult for the learners because they forget these organic structures". The question shows the concern the vice-principal has for the learners as well as the passion for their understanding of science concepts. The natural sciences teachers also enumerated aspects of the sciences where beads and beadworks (cultural artifacts) can be used to teach and learn in the science classroom. The aims should not be the use of beads and beadwork (cultural artifacts) alone but the use of culturally related materials for teaching and learning in the science classrooms. This is because the improvement of indigenous learners learning of science has been of concern for educators, policy makers and researchers. Other concerns by educators and policy makers are the indigenous learners' approaches to learning and their retention of scientific concepts taught.

When science is taught with illustrations and representations that the learners are not familiar with, especially indigenous learners, the learners tends just to memorize what was taught as well as the representations. The learners taught with illustrations and representations they find and see in their environment tends to have an advantage of being familiar with the content being taught; hence we have two learners; one apparently advantaged and the other apparently disadvantaged despite being taught with the seemingly the same western science. But one had the tendency to understand better than the other. Further outcomes learning outcomes of the two learners seem not to be the same. Placing indigenous learners in an advantageous position seems ideal for the continued growth of the indigenous learners. This process is what I unconsciously adopted with my high school life sciences learners as indicated in Chapter One.

Summary of Chapters

The learning experiences of my life sciences learners appeared pragmatic, engaging with an active and practical process of learning as similar to the practical process I engaged with during my early childhood learning moments with my dad and siblings. In both experiences, it was hands-on, minds-on learning moments for me as there were visible changes from before the pragmatic experience and after the practical process of learning. The processes are not just practical but wholesomely learnt with culturally relevant instructional models. Both learning situations were also a sort of integrating the western science classroom with indigenous materials thereby creating an enabling environment for the indigenous learners. Chapter One also include my research questions and how they were unpacked to elicit the outcomes of the research study. In introduction to both theoretical and methodological frameworks was enumerated as well as processes related to data sources, gathering, processing and interpretation.

Chapter Two comprises the literature relevant to the use of culturally related instructional models for the teaching and learning in the classroom both past and present. Unpacking the literature underpinning learners' indigenous knowledge to issues of culture and how culture has enabled learners in the science classroom as reported by authors and researchers. From Ladson-Billings (2009) and Gay (2010) culturally relevant pedagogy to Aikenhead (2011) integration of western and indigenous system; hence Bhabha (2000)'s third space. Literature also elucidates the need to value and link the learners' prior knowledge to the current lesson the teacher teaches in the classroom. Hence, the need for an approach to learning that values the learners' indigenous knowledge as well as helping the learners to link the prior knowledge to the science being taught. Learners' prior knowledge is elicited from the culture in which the learners live which enables an increased importance on the culture of both the teacher and the learners. Part of the learners' culture that appeared to be able to be used as instructional models for teaching and learning in the science classroom is beads and beadwork (cultural artifacts). In understanding more of this led me to reach for Bridget's knowledge of beads and beadwork (cultural artifacts) in Chapter Three. Bridget's knowledge of beads and beadwork (cultural artifacts) was incorporated in Chapter four as she uncovered the basic knowledge of arrangement, pattering, categorizing, color, groupings, basic knowledge of mathematics such as addition and subtraction. The influence of engagement as narrated by Bridget and how it resonates with the nature of interactions with my life science learners and the interactions in my learning moments in during my early childhood with my dad and siblings is written in Chapter Three. Enabled by the knowledge of beads and beadwork (cultural artifacts), I proceeded to the processes needed to unpack the possibilities of using beads and beadwork (cultural artifacts) to create culturally related instructional models in the teaching and learning of life sciences in Chapter Four.

The processes of understanding my data collected from my participants is built up in chapter four with the use of Polyvices to capture the interactions among the learners in the four teachers' life sciences classroom. Also the descriptions of the happenings to uncover the salient influence of expanded constructs by the learners on each other towards achieving the object (goal) of the study as see in Engeström activity theory. Hence the descriptive analysis of the happenings in the four teachers' classroom both the traditional teacher-centered classroom and the classroom with the use of culturally related instructional models created from beads and beadwork (cultural artifacts). The descriptive analysis in Chapter Four is followed by the comparative analysis of the happenings in Chapter Five.

In Chapter Five, the constructs and themes from both four teachers classrooms (the teacher-centered traditional classroom and the classroom with the use of beads and beadwork (cultural artifacts) to create culturally related instructional models for teaching and learning was compared and contrasted. Learners' roles in both four classes and how their roles influenced learners' understanding of science concepts were also compared and contrasted. Following my comparisons and contractions, the theoretical underpinnings were discussed in Chapter Six. Multiple theories were bricolaged to weave a beautiful tapestry as regards the fabrics of the study. Vygotsky's (1978) mediated theory which translated to Engeström activity theory was weaved with Bourdieu's (1975) capital as well as Bandura's (2007) imitation processes and influences on each agent in the classroom learning and Lave and Wenger's (1991) communities of practice concepts. Months after I had gone to the schools for video stimulated recall of the captured events in the life sciences classrooms, one of the four teachers that was involved in the teaching and learning of organic structures with beads and beadwork (cultural artifacts) to create instructional models told a colleague that "the learners never forgot those structures".

The teachers' comments alluded to the strengths of using cultural artifacts for instructional models to teach science in the life sciences classroom. The interests of learners in the cultural artifacts seem to spur the interest in the use of cultural artifacts for learning by the learners and teachers especially in the life sciences classroom. The continued interests therefore seem to spur interaction between learners and the culturally related instructional models during school lessons in the life science classrooms. A survey on whether the learners would like the teachers to always adopt the use of cultural artifacts as instructional models in a sort of activity-centered lessons or learners continued learning in the traditional teacher-centered classroom. Interestingly, one hundred percent of the learners adopted the use of culturally related materials because (i) they are not afraid to touch the culturally-related instructional models (ii) it helps them to show clearly their mistakes, share ideas between themselves, makes them work ten times faster to achieve a task (iii) it is fun, excitement, a way of expressing each other creatively, and enjoying communication together. (iv) to understand more and also exercise our brain (v) it helps not to forget, more hands-on, minds-on, and helps us to come up with different ideas (vi) it allows us to ask questions from our teacher when we want and it gives us more options to learn (vii) because we don't fall asleep (viii) we do what we know and also it makes learning easier. These responses are from the learners who seem to now have experiences on the outcomes of both teaching method (traditional teacher-centered and classroom with the use of culturally related instructional models) on themselves.

Summary of Findings

1. Teachers did not write lesson notes for the lessons they took, they depended on text books and their content knowledge. When they were persuaded to write, they still did not. One of the reasons maybe because some relatively new teachers were not aware of how to write lesson notes while others said I can find it on the department of Educaion online

website. They teachers were however enabled to write the lesson notes after the professional development and training seminar.

2. Teachers were also not aware of the curriculum stance to “construct models of simple and more complex molecules using beads and plasticine by the teachers despite it written and made compulsory in the curriculum. (CAPS, 2011. p. 23)
3. The curriculum did not provide beads and plasticine to the schools to construct these models of simple and more complex organic molecules using beads and plasticine . Teachers could also not asertain who is to provide the beads for the teachers to teach but suggested the that it was the government responsibility to provide the materials. Perhaps, if the government had provided the beads and plasticine, the teachers would have looked for what the government wanted it to be used for.
4. Teachers were interested in the professional development and training organised to acquaint teachers with the use of beads and beadwork (cultural artifacts) to create istructional models of simple and complex organic molecules.
5. The professional development and training workshop was an enabler towards the teachers heightened experience as it provided insights to other innovative ways to enhance their pedagogical practice.
6. As regards curriculum material development, the final beads and beadwork (cultural artifacts) used in classroom pedagogy developed overtime. The materials we started with (blade, straws and beads) were not what we ended up with (beads of bigger sizes, bostic glue). The instructional model further developed as we continued to use them
7. Using cultural artifacts seem to have an inherent value that was transferred to the instructional models used by the learners; hence, the interest the learners have for the cultural artifacts became a sustainable factor during the lesson. Cultural artifacts used as instructional models collapsed the power dynamics in the learning classroom; hence, th agents had access to each other.
8. Positive collective identity formation became markers for learners positive performance in the lesson. Positive identity formation also became an identifier as the teachers could point to the group who did not understand and facilitate their learning.
9. Learners’ language became a resource/repertoire/cognitive tool as they alluded to it to enhance their understanding of the life science concepts been taught. It also became a

channel through which they peer tutored, peer observed and peer asessed their given tasks.

10. There was common relationship between the community (group of shared passion) and the artifacts used (beads and beadwork) in the Engestrooms model.
11. Roles needed to be enabled by capitals (cognitive, cultural and social). Therefore removing this capital seems to deprive the learners of other learning options/resources in the life sciences classroom. The also seem to become inactive as it occurred in the traditional teachers-centered classroom.
12. Before the collective identity formation, there seems to be the Zone of proximal development followed by self efficacy by learners. These two constructs forms the proceses that leads to positive collctive identity formation.
13. The common factor between (i) my childhood learning experiences with my dad, my life sciences school learners (ii) Bridget's learning experience with her maternal granny (III) and the learning experiences of the co-participants (teachers and learners) in this study is the conscious or unconscious cognitization of non-cognitive objects enabled as Culturally responsive pedagogical resources (CRPR) for teaching and learning.
14. Culturally-related instructional models (CRIM) formed are:
    (i) Learners' Water and Carbon Dioxide and Linear Glucose Structure
    (ii) Learner's Water and Carbon dioxide and Cyclical Glucose Structure
    (iii) Learner's Cyclical Glucose Structure
    (iv) Cyclical Structure of Glucose Compound
    (v) Water and Linear Structure of Glucose
    (vi) Glycerol and Fatty Acid

Implications

Wong and Wong (2009) posit that lesson plan reflects the goals and intentions of the teacher. More interesting is the ability of the teacher to teach learners without a guide to avoid wandering in the teachers' pedagogical practice, inability to achieve the lessons goals and poor connections between the learners' prior knowledge and the present lesson goals. It is also interesting for the teacher to teach and avoid the lessons unavailability of instructional materials for teaching and learning in the life sciences classroom. If the teachers can teach without lesson plans and achieve what they have, then if the teacher is motivated to write lesson plans, how better would the teacher's pedagogical practice in achieving the life science classroom? To the learners, the ineptitude of the teacher seems to portray a case of a teacher that seems not enabled to be able to teach them and understand the teachers' concepts. The learners seem not to earn the respect of the teachers; hence they (learners) are called stubborn. The teachers' professional development and training workshop enabled the teacher to write a lesson plan for the use of culturally related instructional models created from beads and beadwork (cultural artifacts). The lesson plans written by the teachers or one of the teachers created for lessons where simple and complex organic molecules are to be taught with instructional models made from beads ad beadworks can be a curricular blue print for other teachers.

The teachers not been aware of the curricular stance to use beads and beadwork to construct models for instructional practices can be because they (teachers) do not allude to the curriculum and assessment policy statement to write or plan for the lessons. It could also be because it was not provided in the schools. So perhaps if it was provided, the teachers would scaffold for what the government had provided it for. The implication for the teachers is that they would be less enabled to teach the learners cognitively and socially. For the curriculum, the goals it is said to achieve is (for learners value of their indigenous system) would not be done. The learners themselves, the goals of understanding the simple and complex structures would appear to be less achieved. For a way forward, the government as suggested by some teachers should provide beads and Bostic or Prestik (environmentally-friendly glue) for the teachers in schools in order for the learners to be taught the simple and complex organic molecules with beads and beadworks (cultural artifacts). Teachers also should be provided with professional development and trainings to facilitate the integration of indigenous knowledge systems with western science in any area of integration. For instance, the use of beads and beadwork (cultural artifacts) to create instructional models for the teaching and learning of simple and complex molecules, if not for the professional development and training would have seemed not to be able to integrate better the indigenous knowledge systems with the western science. It may seem at first as a culture shock. The professional development and training seems to be able to enable the teachers to smoothen the integration process.

Teachers’ heightened experiences from the professional development and training also seems to place teachers in the role as a researcher because the teachers tends to now find ways to improve the curriculum material as well as discover ways to enhance learners’ learning with the curriculum materials. The teachers should also capitulate on the interest inherent in the cultural artifacts by the learners to create an enabling context friendly for the learners learning of science by using them in the classroom and by creating other instructional models made from cultural artifacts. To the learners, having new and different sorts of instructional models made from cultural artifacts, seems to enable a fun filled activity process, where their cultural heritage is valued and where they are not bored. Interested learners are also likely to radiate the excitement in using cultural artifacts to create instructional models to learn in the classroom, to other peers in the life science classroom; hence in a way circulate the positive emotional energy needed for learning. Teachers can also be considered to be involved in the periodical revision of the curricular statements because they are the agents of implementation. They can give suggestions on the knowledge to be integrated, how it can be integrated and the nature of learners we are concerned with the integration process. The government can also monitor the integration or implementation process (adopting which instructional model to be created from which cultural artifacts) as this stage seems crucial because as the indigenous knowledge is integrated, new ways of fine tuning the developing material emerges. And not developing these models (models made from cultural artifacts) will apparently place the educational system in the same place we have been (stagnancy) while educational advancements occurs in other continents.

As the teacher teaches in the classroom, the teacher also wants to assess and reassess the learners to apparently know their points of weakness and strength. The learners also want the teacher to attend to their weak points in the lesson while learning. Failure for the teacher to achieve this appears to leave a cognitive gap to be filled in the learners learning process. Collective or individual formation of identities tends to be a marker of learners positive performances as it seems to be a highlighter to the group that gets the lesson right or wrong. As a result of the positive identities formed, the teacher becomes satisfied with the task of the positive identities formed and the teacher knows the areas to channel his explanation energy. Rather than the teacher asking the learners if they understand the content and learners either keeps quiet or answer in chorus, a “Yes or No”, the teacher already knows the next point of action. Hence, individual learners can be sorted out of the challenges they may face while learning in the life science classroom. The provision of an enabling environment that presents more options (than depending solely on the teacher) for learners to allude to during learning sessions can certainly be a way of enhancing learners understanding of life sciences in the classroom. One of the resources the learners can allude to while learning is their language. Rather than verbally telling the learners to speak their languages, they were allowed to learn with the use of culturally related instructional models. This context (indigenous) in the western classroom appears to be triggered by the cultural artifacts (beads and beadwork) adopted for learning simple and complex organic structures. Withdrawing these options may further more narrow the learners' options to accessing knowledge.

Learners' language tends to bring a sort of similarity to those who speak the same language; hence, their social capital is enhanced and strengthened. So also is the cultural artifacts used to create instructional models for teaching and learning. Those who identify (indigenous learners) with the cultural artifacts seem to have a common and shared passion. Hence, the relationship between the community (group of shared passion) and the artifacts in the activity theory. The relationship in a way enables access to each other therefore the learners have a source from which knowledge needed for a role can be acquired. Learners were seen peer tutoring, peer observing, peer questioning, peer assessing each other, which seem to be roles enabled by the capitals (cultural social and cognitive). Not enabling a context to accommodate and grow these constructs may leave the learners with fewer channels to access knowledge except that of the teacher as seen in the traditional teacher centered-classroom. Perhaps, the greater the learners access to knowledge in the life sciences classroom, the better and perhaps the lesser access to knowledge in the classroom, the worse learning becomes for the learners. The learners learning and behavior during the teachers' pedagogical practice, is supervised by the teacher. There seems to be a build up to the processes leading to collective and individual positive identity formation. Understanding these processes can be of help to the teachers' pedagogical practice in the classroom. For example, it seems apparent in this study that before collective identity is formed, there seems to be learners' zone of proximal development, then the state of self-efficacy which later develops to learners collective positive identity.

One of the underlining factors in the learners' learning processes in the four classes where culturally related instructional models created from beads and beadworks (cultural artifacts) to teach simple and complex organic molecules is the learners interest in the learning goal and activity. More often, it appears that the challenges teachers face with learners in the life sciences classroom is caused by learners disinterest in science. Learners do not find anything interesting in the class activity anymore. The use of cultural artifacts found in the culture of the learners to create instructional models seems to endear the learning process more to the learners. This statement is as seen in the learners in the four teachers classes (classes where instructional models were created from beads and beadwork to teach simple and complex organic compounds. It is also similar to my child hood learning experience with my dad and siblings as well as my high school life sciences learners and Bridget's learning experiences with her maternal granny. Undervaluing the learners' interest in the life sciences classes may not be productive for both teachers and learners.

Lessons Learned

Before this study, I carried out my pedagogical practice unknowingly to just find the best way for my learners to understand my lessons. At first, during my pedagogical practice with my high school learners, after teaching in the classroom, if I ask learners what we have just taught, some would be able to tell me something while some other will not be able to tell me anything. The next lesson, most of the learners would not be able to say anything related to the lesons learnt. Then, I start to feel frustrated. I became hard on the learners by scolding them. My principle then was to tell them to "read, eat and sleep life sciences". If I meet any of my learners anywhere in the school, I asks them questions related to the topic we learnt previously. Learners started to avoid and perhaps even hate me. My goal was not to bother the learners, it was to make sure they learn and understand life sciences. When I discovered they were avoiding me, I had to change my pedagogical practice to telling them to bring materials from their homes to xplain some concepts in the classroom. I became a bricoleur of materials. Unknowing to me, it seem to work, as the learners suggested presenting ther work for the whole school to see what they had done. They became interested in the lessons, and all of my life sciences learners enrolled for the external examinations on confidence that they would pass excellently and which they did. This research brought an heightened awareness on the efficacy of cultural artfacts in learning science concepts.

Secondly, embarking on this research at first seemed like a dark journey. I was skeptical about how it will carried out. Particularly when I only saw beads used in an abacus to learn basic maths. It was a sort of going gradually into the research process with the guide of a more knowledgeable other (my supervisor). He also mediated my access to the field; hence, I learnt almost that every successful learning process must be mediated by a more knowledgeable other. Access to the field also demanded cautiousness as one must be seen to be a respected and respectful individual. Whether the research was indigeous based ot purely western science related, the people (co-participants) view of the researcher also matteres most. In essence, no matter the research the context in which the research is to be carried out matters. This study was carried out in a peri-urban area where most learners are indigenous to the area. Again, Learners seem to really identity with the beads while they were brought to the classroom for pedagogical purposes. Some were even like lets construct some stuff with these beads now. The learners were estatic about the use of cultural artifacts some of which I was not aware off. Initially I felt there may not be teachers or learners interested in these artifacts to teach until I got there to discover, they were so much willing because it looked like their knowledge was now valued as a panacea to their learners challenges.

Thirdly, I taught I had learnt through reading of research books the nitty gritty of carring out the research study. Until I got to the field to negotiate my way through, I discovered real learning was in the doing. While studing I felt I will do this and that until I wanted to do what I needed to do at the moment, I could not really do it; hence, I learnt on the field what I read in the text books. The number of participants (teachers and learners) I had envisaged changed as I entered the field. Many teachers became interested but I could only accommodate the life sciences teachers while I told the other sciences (natural and physical) teachers the life sciences teachers would put them through the process of creating instructional models from cultural artifacts such as beads and beadwork. Applause to the works of Ladson-billings, Gay, Aikenhead, Ogunniyi, Otulaja, Chilisa who all have posited for a culturally related learning. But this study heightens my awareness in the area of what indigenous instructional models to be created and adopted, the influence of these culturally related instructional models on learners learning as well as how it can be integrated into the western science classroom.

Limitations

Of course, for this kind of study, there will be limitations. First of all, the performance of learners with the use of beads and beadworks specifically was an intention. To access their end of term or periodical tests were to be graded but, the questions on simple and complex organic molecules were not the only questions set and so it became difficult to ascertain or lay claim emperically to the relationship with the learners' performance; hence I relied on the teachers' report on learners' performance after the examinations. I also relied on the learners report on how it has influenced their learning and retention and also "on the spot" assessment of that the learners created in the classroom. Again, some older female teachers (those with few years left in governement service) were not so estatic about atending the workshop on the use of beads and beadwork (cultural artifacts) to create instructional models for the teaching and learning. Despite other science teachers both make and female, natural, life and physical sciences, these older female one did not attend the professional development and training. I can not say this was the reason for their non attendance. Hence, some teachers could be at first skeptical about the process of creation and integration, hence, the professional development and training to ease the inegration process. it is when the teachers are fully abreast of the "how" and "why" of the whole peocess, they can enjoy learning to the fullest.

For those learners whose faith may not seem to allow, the use of beads for anything like I was told when I was growing up. I was told wearing or using these ancient materials are sinful. Until I began to see he usefullness of these artifacts, I still held the thoughts of these sinful materials. For those who are like I was before, a workshop for interation (teachers and learners) would be a space for cognitive interaction; just to ease the mediation of these processes. In urban settings, the use of beads and beadworks can also be applied into the teachers pedagogical practice as another opportunity for learners to allude to while learning as a repertoire or knowledge resource. It can also be useful to other people of color as even europeans/westerners even have other types of beads made from glass, plastic and other ornaments and they trade with it also. Beads and beadwork has become a global ornament. Another limitation I encountered was that in interpreting the various South African languages, I had to depend on professional interpreters to interprete to English language.

Way Forward

The possibilities of using beads and beadwork (cultural artifacts) as instructional models for enhancing the classroom pedagogical practice has unpacked the findings above. This stage necessitate further exploration of other African artifacts that can be used to teach and learn in the science classroom. Some examples could be the cognitization of the process of basket making, the different African women plaiting style and the knowledge that emerges from it. The use of beads and beadworks by the learners in their lived-world seems to be gender based as beaworks appears more worn by females than males. But the survey conducted with open-ended questionaires on "if the learners loved beads", one hundred percent of the learners responded "yes". When they were asked why they loved beads, their responses ranged from "because it is attractive, cultural, traditional, used to make jewelries to designing ornaments". Of course, traditionally, both male and female wear them during traditional ceremonies, learners in the science classroom where not disinterested in the use of beads and beadwork to learn their science concepts. In case of Multiculturally diverse science classroom, beads especially in Africa is generally worn during traditional occasions.

Contributions of the Study

In pursuance of the possibilities of using beads and beadwork (cultural artifacts) as instructional models in the teaching and learning of simple and complex organic molecules, ans the zeal to unpack the apparent influence of the use of these culturally related artifacts on learners learning, the following contributions were made.

- Methodologically, the use of polyvices to capture the micro-level interactions among the learners in the life sciences classroom was highlighted.
- Apart from methodological triangulation, investigator triangulation, triangulation of data sources and theoretical triangulation as Chilisa (2012) posits, and triangulation of theories, multiple investigators, multiple theories and multiple sources of data as Denzin (1970, 1978), Kimchi, Polivka and Stevenson (1991); Patton (1999) also posited, this study applied Polyvices triangulation. This is the triangulation of multiple instruments to eliminate errors and authenticate the process of data collection.

- In the Engestrom activity theory, acccording to the study, there is a transformation process between the object and outcomes in the classroom. Engestrom defined object in the activity theory as the goals of the lesson as determined by the teacher. The outcomes also imply the learners end result (performance). For learners to process and transform goals to successful outcomes, the learners peer tutored, translanguaged, questioned themselves and the teacher, peer observation and imitation and at the end produced peer identity formation.
- In integrating cultural artifacts (not being used before in the classroom) into the teaching and learning of sciences in the classroom, the cultural artifacts instructional model (CAIM) models can be adopted. (see below).

The CAIM model appears important to inorder to actualize the efforts for the integration of indigenous knowledge with western knowledge in the science classroom to enhance indigenous learners. Particularly when indigenous knowledge that can be integrated with western science is in form of cultural related instrcutional models (CRIM) created from cultural artifacts. This elicited knowledge from the professional has to be endeared to the teachers consciousness by having a professional development and training workshop which seem to heighten the teachers consciousness.

The CAIM model encompasses the cultural artficacts and they overlap where the knowledge from cultural artifacts is needed to construct other models thereby becoming culturally responsive pedagogical resources. (CRPR).

- Aesthetic objects (beads and beadwork) transformed the classroom pedagogical practice in the classroom. They (cultural artifacts) became tools for the learners cognitively. Hence the process of cognitization which is explained as a process of making an aesthetic object (non-cognitive) to become a cognitive enabling object as it happened in the study.
- Cognitization theory is the theory of turning non-cognitive objects (aesthetic) into learning and teaching objects.
- Energization is the process of and procedure for kindling learning by an MKO through vicarious learning

- Learners' social, cultural and symbolic capital appear to be embodied in their cognitive capital. Social+cultural+symbolic= cognitive capitlal. Cognitive capital involves capital that enables and stimulate higher order thinking skills. It became an embodiment of the three (social, cultural and symbolic) because of the process of higher order thinking.
- Apart from age difference and class as posited by Vygotsky (1978) to enable the emergence of an (MKO) in an individual, (MKO) is equally enablled by the individual capitals.
- Self effiacy appears to be a precursor to the formation of learners identity of positive performance in the life sciences classroom.
- Beads and beadwork (cultural artifacts became culturally responsive pedagogical resources (CRPR) when used as a culturally related instrutional models through the cognitization process.
- Learners (groups/individual) became hotspots from which other learners (seemingly weaker and the teacher) can energize (gain cognitive content) to enhance and sustain their learning processes.

The heightened teachers' consciousness then helps the teachers personal cognitive and cultural knowledge development as they prepare for the introduction to the learners. The teachers professional development and training seems important because the teachers seems only western trained on the knowledge of science. The indigenous knowledge of the teachers seems to them not so much valuable to their existence. The teachers professional and training seems a bridge to cover the seeming gap in being also indigenously trained and equipp to extend the knowledge to the learnes. The teachers here also serve as a mediating agent for the integration of indigenous knowledge with western knowledge. After the teachers' cultural and cogitive development, the teachers become equip to mediated learning to the learners in the science classroom. The teachers mediating prowess appears important in enhancing the integration of the cultural artifacts as instrcutional models in the science classroom.

In the use of CAIM model (framework) to develop other models by the teacher, using different cultural artifacts, the teacher should first:

(i) seek more of the knowledge from the knowledge holders. The knowledge holders apprears to understand better than other persons especially when the value for indigenous knowledge seems at the lowest ebb compare for the value placed on westernized science knowledge.

(ii) thereafter, the teacher practices the knowledge received from the knowledge holder on the artifacts to be used to enhance pedagogical practice in the science classroom.

(iii) In a sort of MKO, the teacher should validate the processes involved with other teachers of the same subject so that any sort of ambiguity can be erased before transfering the knowledge to the classroom.

(iv) On getting into the classroom, the teacher, after member-checking the processes of integrating the knowledge received from the knowledge holder, teaches the learners the knowledge received.

Suggestions for Further Studies

From my experience in this study and my heightened awareness of my past experience with cultural artifacts, the use of culturally related instructional artifacts has really enhanced learners learning by (i) enabling a friendly hands-on minds-on with the learners (ii) naturally colapsing the power dynamics in the science classroom, (iii) enabled a group interactive activity based learning context (iv) enabled increased engagement and sustained interest of science with the learners (v) enabled an heightened awareness in the teachers and leaners in the science classroom thereby enabling an increased value of indigenous materials in the learners. But to what degree of performance has the artifacts enhanced the learners understanding emperically, appears to be a future research as all four teachers practically suggested the use of culturally related instructional models for teaching and learning in a group activity-based science classroom.

Other areas of futher studies is to explore other cultural artifacts and knowledge that can be integrated in the teaching and learning of science to indigenous learners. The western science representations are most times not related to the learners lived-world. Hence, the learners just memorize the content and not really understand the science in it and as it is related to their environment. As I conclude, I draw from a yoruba (a major tribe in the western part of Nigeria) proverb that says “Oun ani laa n gbe laruge”. It metaphorically means we have to value our knowledge. In alluding to our knowledge as the making of the African being, our value system increases and our young ones value themselves more; hence, our educational system becomes valued and enhanced.

References

Abd-El-Khalick, F., & Lederman, N. G. (2000). Improving science teachers' conceptions of nature of science: A critical review of the literature. *International Journal of Science Education*, *22*(7), 665-701.

Adams, J. (2014). Place and identity: Growing up bricoleur. In K. Tobin & A. Shady (Eds), *Transforming urban education: Urban teachers and students working collaboratively*. (pp 341-354). The Netherlands: Sense Publisher.

Adeyemi, M. B., & Adeyinka, A. A. (2003). The principles and content of African traditional education. *Educational Philosophy and Theory 35*(4), 425-440.

Agbo, S. A. (2001). Enhancing success in American Indian students: Participatory research at Akwesasne as part of the development of a culturally relevant curriculum. *Journal of American Indian Education*, *(40)*1, 31-56.

Aikenhead, G. (1996). Science education: Border crossing into the subculture of science. *Studies in Science Education, 27* (1), 1-52.

Aikenhead, G. (1997). Toward a First Nations cross-cultural science and technology curriculum. *Science Education*, 81, 217-238.

Aikenhead, G.S. (2000). Renegotiating the culture of school science. In R. Millar, J. Leach, & J Osborne (Eds.), *Improving science education: The contribution of research* (pp.245-264). Buckingham: Open University Press.

Aikenhead, G. (2000). Rekindling Traditions: Cross-cultural science & technology units. Retrieved March 17, 2006, from http://www.usask.ca/education/ccstu/.

Aikenhead, G. (2001a). Integrating western and aboriginal science: Cross-cultural science teaching. Research in Science Education, 31(3), 337-355.

Aikenhead, G. S. (2005). Science-based occupations and the science curriculum: Concepts of evidence. *Science Education*, 89, 242-275.

Aikenhead, G. S. (2006). *Science education for everyday life: Evidence-based practice*. New York. NY: Teachers College Press.

Aikenhead, G. S. (2007). Humanistic perspectives in the science curriculum. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of research on science education* (pp. 881–910). Mahwah: Lawrence Erlbaum.

Aikenhead, G. S., & Ogawa, M. (2007). Indigenous knowledge and science revisited. *Cultural Studies of Science Education*, *2*(3), 539-620.

Aikenhead, G. S (2011). Towards a cultural view on quality science teaching. In D. Corrigan, J Dillon, R Gunstone (Eds).*The professional knowledge base of science teaching* (pp. 107-127). Springer, Dordrecht.

Aikenhead, G. S. (2017). School mathematics for reconciliation: From a 19th to a 21st century curriculum. *Self-published monograph. Downloaded on January*, 29, 2017.

Althusser, L. (1971). A letter on art in reply to André *Daspre*. *Lenin and Philosophy and Other Essays*, 201-08.

Allen, J. P., Porter, M. R., McFarland, F. C., Marsh, P., & McElhaney, K. B. (2005). The two faces of adolescents' success with peers: Adolescent popularity, social adaptation, and deviant behavior. *Child Development*, 76(3), 747-760.

Allen, B. A., & Boykin, A. W. (1991). The Influence of Contextual Factors on Afro-American and Euro-American Children's Performance: Effects of Movement Opportunity and Music. *International Journal of Psychology*, *26*(3), 373-387.

Angaama, D. A, Fatoba, A.F, Riffel A. D, & Ogunniyi, M. B (2016). *Harnessing Indigenous knowledge for science teaching: The voices of learners*. Proceedings of the 2nd International Conference of the African Association for the Study of Indigenous Knowledge Systems (pp 23-32). Mozambique. Universidade Pedagogica, Maputo, Mozambique.

Asante, M. K. (2010). Afrocentricity. In M. K. Asante & A. Mazama (Eds.). *The International Encyclopedia of Intercultural Communication*. Pp.760–769. John Wiley.

Asante, M. K. (2016). "Afrocentricity and its critics…" (Available at http://science.jrank.org/pages/8216/AfrocentricityAfrocentricity-Its-Critics.html, as accessed on 2 April 2016; WE Reed, EJ Lawson & T Gibbs, "Afrocentrism in the 21st century", *The Western Journal of Black Studies*, (21)3, 1997, pp. 73-79.

Au, K., & Jordan, C. (1981). Teaching reading to Hawaiian children: Finding a culturally appropriate solution. *Culture and the bilingual classroom: Studies in classroom ethnography*, 139-152.

Ayers, W. (2001). To teach: *The journey of a teacher*. New York: Teachers College Press.

Bailey, C. T., & Boykin, A. W. (2001). The role of task variability and home contextual factors in the academic performance and task motivation of African American elementary school children. *Journal of Negro Education*, 70(1-2) 84-95.

Baker, D., & Taylor, P. C. (1995). The effect of culture on the learning of science in non-western countries: the results of an integrated research review. *International Journal of Science Education*, 17(6), 695-704.

Baker, C. (2011). *Foundations of bilingual education and bilingualism* (5th Ed.). Clevedon, UK: Multilingual Matters Ltd.

Bandura, A. (1977). *Social learning theory*. Englewood cliffs, N.J; Prentice-Hall.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: W.H. Freeman.

Bandura, A. (2007). Much ado over a faulty conception of perceived self–efficacy grounded in faulty experimentation. *Journal of Social and Clinical Psychology*, *26*(6), 641-658.

Bailey, F., & Pransky, K. (2005). Are" Other People's Children" constructivist learners too? *Theory into Practice*, *44*(1), 19-26.

Baquete, A. M., Grayson, D., & Mutimucuio, I. V. (2016). An exploration of indigenous knowledge related to physics concepts held by senior citizens in Chokwe, Mozambique. *International Journal of Science Education*, 38(1), 1-16.

Barnhardt, R., & Kawagley, A. O. (1998). Culture, Chaos and Complexity: Catalysts for Change in Indigenous Education. *Cultural Survival Quarterly 27*(4), 59-64.

Barnhardt, R., & Kawagley, A. O. (2005). Indigenous knowledge systems and Alaska Native ways of knowing. *Anthropology & Education Quarterly*, *36*(1), 8-23.

Barnhardt, R. (2013). Indigenous education renewal in Rural Alaska. In J. Reyhner, J. Martin, L. Lockard & W. S. Gilbert. (Eds.). *Honoring our children: Culturally appropriate approaches to indigenous education* (pp. 11-20). Flagstaff: Northern Arizona University.

Battiste, M. (2002). *Indigenous knowledge and pedagogy in First Nations education: A literature review with recommendations* Prepared for the National Working Group on Education. Ottawa, Canada: ON. (pp. 1-69).

Bloom, A. (2008). *The closing of the American mind: How higher education has failed democracy and impoverished the souls of today's students*. New York: NY. Simon and Schuster.

Berkes, F., Colding, J., & Folke, C. (2000). Rediscovery of traditional ecological knowledge as adaptive management. *Ecological Applications*, *10*(5), 1251-1262.

Bernstein, B. (1971). *Class, Code s and Control 1: Theoretical Studies towards a Sociology of Language.* London: Routledge.

Baxter, P., & Jack, S. (2008). Qualitative case study methodology: Study design and implementation for novice researchers. *The Qualitative Report*, *13*(4), 544-559.

Berry, K. S. (2004a). Structures of bricolage and complexity. In J. L. Kincheloe & Berry, K. S. (Eds.), *Rigour and complexity in educational research: Conceptualizing the bricolage* (pp. 103-127). Maidenhead: Open University Press.

Berry, K. S. (2004b) Feedback looping for increasing complexity. In J. L. Kincheloe & Berry, K. S. (Eds.), *Rigour and complexity in educational research: Conceptualizing the bricolage* (pp. 128-146). Maidenhead: Open University Press.

Berry, K. S. (2006). Research as bricolage: Embracing relationality, multiplicity and complexity. In K. Tobin & J. L. Kincheloe (Eds.), *Doing educational research: A handbook* (pp. 87-116). Rotterdam: The Netherlands: Sense Publishers.

Berry, K. S. (2011). Embracing radical research. In Joe L. Kincheloe (Ed.), *Key works in critical pedagogy* (pp. 279-284). Rotterdam: The Netherlands Sense Publishers.

Biggs, J. (1999). What the student does: Teaching for enhanced learning. *Higher Education Research & Development*, 18(1), 57-75.

Bergold, J., & Thomas, S. (2012). Participatory research methods: A methodological approach in motion. *Historical Social Research/Historische Sozialforschung*, 37(4), 191-222.

Boykin, A. W. (1978). Psychological/behavioral verve in academic/task performance: Pre-theoretical considerations. *The Journal of Negro Education*, *47*(4), 343-354.

Boykin, A. W., Albury, A., Tyler, K. M., Hurley, E. A., Bailey, C. T., & Miller, O. A. (2005). Culture-based perceptions of academic achievement among low-income elementary students. *Cultural Diversity and Ethnic Minority Psychology*, 11(4), 339.

Boykin, A. (1986). The triple quandary and the schooling of Afro-American children. In U. Neisser (Ed.), *The school achievement of minority children: New perspectives* (pp. 57–92). Hillsdale, NJ: Erlbaum.

Boykin, A. (1994). Harvesting talent and culture: African American children and educational reform. In R. J. Rossi (Ed.), *Schools and students at risk: Context and framework for positive change* (pp. 116–138). New York: Teachers College Press.

Bhabha, H.K. (1994). *The location of culture*. London: Routledge.

Bhabha, H. K. (1996). Culture's in-between. *Questions of cultural identity*, *1*, 53-60.

Bhabha, H. K. (1998). The white stuff (Whiteness studies). *Art forum*, *36*(9), 21.

Bhabha, H. K. (2000). How newness enters the world: Postmodern space, postcolonial times, and the trials of cultural translation. *Writing Black Britain, an Interdisciplinary Anthology, Manchester, Manchester UP*, 300-306.

Bloomberg, D. (2004). *Code switching*. Retrieved May 21, 2011 from http://www.usingenglish.com/weblog/archives/000157.html.

Borich, G. D. (2007. *Effective teaching Methods, Unit and Lesson Planning*, six edition, Pearson, Merrill Prentice Hall, Ohio.

Booth, A., Sutton, A., & Papaioannou, D. (2016). *Systematic approaches to a successful literature review*. London; Sage.

Bourdieu, P. (1967). Systems of education and systems of thought. *International Social Science Journal* 19: 338-58.

Bourdieu, P. (1975). The specificity of the scientific field and the social conditions of the progress of reason. *Information (International Social Science Council)*, *14*(6), 19-47.

Bourdieu, P. (1977). *Outline of a Theory of Practice* (Vol. 16). Trans. Richard Nice: Cambridge University Press.

Bourdieu, P. (1978). Sport and social class. *International Social Science Council*, *17*(6), 819-840.

Bourdieu, P. (1984). *A social critique of the judgement of taste. Traducido del francés por R.* Nice. Londres, Routledge.

Bourdieu, P. (1985). The social space and the genesis of groups. *Information (International Social Science Council)*, *24*(2), 195-220.

Bourdieu, P. (1986). The Forms of Capital. In J. G. Richardson. (Ed) *Handbook of Theory and Research for the Sociology of Education*. Westport, CT: Greenwood Press: 241-58.

Bourdieu, P. (1988). Program for a sociology of sport. *Sociology of Sport Journal*, *5*(2), 153-161.

Bourdieu, P., & Eagleton, T. (1992). Doxa and common life. *New Left Review*, *191*(1), 111-21.

Bourdieu, P. (1994). Structure, habitus, power: Basis for a theory of symbolic power. In N. Dirks, 8c G. Eley (Eds.), *Culture, power/history: A reader in contemporary social theory* (pp. 155—99). Princeton, NJ: Princeton.

Bowles, S., & Gintis, H. (1976). *Schooling in capitalist America* (Vol. 57). New York: Basic Books.

Bowles, S. & Gintis, H. (2001). “Schooling in Capitalist America Revisited. *Sociology of Education*, 75(1), 1–18.

Brayboy, B. M. J., & Maughan, E. (2009). Indigenous knowledges and the story of the bean. *Harvard Educational Review*, 79(1), 1-21.

Brown, B. B., & Fleming, J. (1974). *New mind, new body*. New. York: Academic Press

Brown, B. A., & Spang, E. (2008). Double talk: Synthesizing every day and science language in the classroom. *Science Education*, 92(4), 708–732.

Bruner, J. (1996). *The Culture of Education*, Harvard University Press, Cambridge, MA.

Bullock, Barbara E. & Almeida Jacqueline Toribio. (2009). Themes in the study of Code-switching. In Barbara E. Bullock & Almeida Jacqueline Toribio (Eds.), *The Cambridge handbook of linguistic code-switching*, 1-17. Cambridge: Cambridge University Press.

Cajete, G. (2000). *Native science: Natural laws of interdependence*. Santa Fe, NM: Clear light.

Cajete, G (1994). *Look to the mountain. An ecology of Indigenous education*. Skyland NC: Kivaki Press.

Cardinal, H. (1999). *The unjust society: The tragedy of Canada's Indians*. Vancouver: Douglas & McIntyre.

Canagarajah, S. (2011). Code meshing in academic writing: Identifying teachable strategies of translanguaging. *The Modern Language Journal*, 95(3), 401-417.

Canagarajah, S. (2011). Translanguaging in the classroom: Emerging issues for research and pedagogy. *Applied Linguistics Review* (2), 1-28.

Canagarajah, A. S. (2012b). *Toward a rhetoric of translingual writing. The Working Papers Series on Negotiating Differences in Language and Literacy*. Louisville, KY: University of Louisville, Louisville, Kentucky.

Cassie, V. (2010). Retrieved August 24, 2010, from http://classroomtales.com/2010/01/05/ict-inite/#comment-17.

Catalani, C., & Minkler, M. (2010). Photo voice: A review of the literature in health and public health. *Health Education & Behavior, 37*(3), 424-451.

Cazden, C., & Leggett, E. (1981). Culturally responsive education: Recommendations for achieving Lau remedies II. In H. T. Trueba, G. P. Guthrie, & K. Au (Eds.), *Culture and the bilingual classroom: Studies in classroom ethnography* (pp. 69–86). Rowley, MA: Newbury House.

Chambers, R. (1989). Editorial introduction: vulnerability, coping and policy. *IDS bulletin*, *20*(2), 1-7.

Charlesworth, Z. M. (2008). Learning styles across cultures: suggestions for educators. *Education+ Training*, 50(2), 115-127.

Chandler, R., Anstey, E., & Ross, H. (2015). Listening to voices and visualizing data in qualitative research: Hyper modal dissemination possibilities. *SAGE Open*, 5 (2), 2158244015592166.

Chisenga, J. (2000). Global information and libraries in sub-Saharan Africa. *Library Management*, 21(4), 178-187.

Chisholm, L., & Leyendecker, R. (2008). Curriculum reform in post-1990s sub-Saharan Africa. *International Journal of Educational Development*, 28(2), 195-205.

Chilisa, B., & Preece, J. (2005). *Research methods for adult educators in Africa*. Pearson: South Africa.

Chilisa, B., & Ntseane, G. (2010). Resisting dominant discourses: Implications of indigenous, African feminist theory and methods for gender and education research. *Gender and Education*, *22*(6), 617-632.

Chilisa, B. (2011). *Indigenous research methodologies*. Thousand Oaks, Calif. Sage Publications.

Chilisa, B., Major, T. E., & Khudu-Petersen, K. (2017). Community engagement with a postcolonial, African-based relational paradigm. *Qualitative Research*, 17(3), 326-339.

Chin, C., & Kayalvizhi, G. (2005). What do pupils think of open science investigations? A study of Singaporean primary 6 pupils. *Educational Research,* 47(1), 107-126.

Chin, C., & Osborne, J. (2008). Students' questions: a potential resource for teaching and learning science. *Studies in Science Education*, 44(1), 1-39.

Christie, P., 2008, *Opening the doors of learning,* Heinemann, Johannesburg.

Cobern, W. W, Aikenhead, G. S., Fraser, B. J., & Tobin, K. (1998). *International handbook of science education.* Klower Academic Publishes.

Collins, R. 2004. *Interaction Ritual Chains*. Princeton, NJ: Princeton University Press

Collins, R. L. (2011). Content analysis of gender roles in media: Where are we now and where should we go? *Sex Roles*, 64(3-4), 290-298.

Collins, R. (2014). *Interaction ritual chains*. Princeton, NJ. Princeton University Press:

Comte, A. (1988). *Introduction to positive philosophy***.** Indianapolis, IN: Hackett Publishing.

Cole, B. L., & Parker Brown, M. (1996). Action on worksite health and safety problems: A follow-up survey of workers participating in a hazardous waste worker training program. *American Journal of Industrial Medicine*, 30(6), 730-743.

Corbin, J., & Strauss, A. (2007). *Basics of qualitative research: Techniques and procedures for developing grounded theory (3rd Ed.).* Thousand Oaks, CA: Sage.

Clandinin, D. J. (1986). *Classroom practice: Teacher images in action*. London. Falmer Press.

Coburn, W. W., & Loving, C. C. (2001). Defining 'science' in a multicultural world: Implications for science education. *Science Education*, 85(1), 50–67.

Castellano, M. B., Davis, L., & Lahache, L. (2000). *Aboriginal education: Fulfilling the promise*. UBC Press.

Creswell, J. W. (1994). *Research design: Qualitative & quantitative approaches*. Thousand Oaks. CA: Sage Publications.

Creswell, J. (2009). *Research Design: Quantitative, Qualitative and Mixed method approach*. Thousand Oaks. CA .SAGE Publications,

Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. Thousand Oaks. CA. Sage publications.

Cuban, L. (1993). *How teachers taught*: *constancy and change in American classrooms*, 1890-1990. 2nd (Ed.). New York: Teachers College Press.

Cullum-Swan, & Manning, P. (1994). Narrative, content, and semiotic analysis. In Lincoln (Ed), *Handbook of qualitative research*, (pp. 463-477. Thousand Oaks, CA: Sage.

Cuccio-Schirripa, S., & Steiner, H. E. (2000). Enhancement and analysis of science question level for middle school students. *Journal of Research in Science Teaching*: *The Official Journal of the National Association for Research in Science Teaching, 37*(2), 210-224.

Curriculum Assessment Policy Statements (CAPS. 2011). Retrieved from www. education. gov.za/Curriculum/CurriculumAssessmentPolicyStatements (CAPS).aspx).

Department of Basic Education. (2011a). Curriculum and Assessment Policy Statement (CAPS) Life Sciences: Grades 10, 11 and 12. Pretoria: Department of Basic Education.

Descartes, Rene. 1637. *Discourse on the Method of Rightly Conducting the Reason, and Seeking Truth in the Sciences.* pp. 19–20.—. 1641 (1911). Meditations on First Philosophy. Cambridge: Cambridge University Press. pp. 14–17.

Denzin, N. K. (1970). *The research act in sociology*. A theoretical introduction to Sociology method. London: Butterworth.

Denzin, N. K. (1978). *The research act: A theoretical introduction to sociological methods*. (3rd) Englewood Cliffs, N.J Prentice Hall.

Denzin, N. K. (1989). *Qualitative research methods, Vol. 17. Interpretive biography.* Thousand Oaks, CA: Sage Publications, Inc.

Denzin, N. K., & Lincoln, Y. S. (1994). Introduction: Entering the field of qualitative research. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (pp. 354 1-17). Thousand Oaks, CA: Sage Publications.

Denzin, N. K., & Lincoln, Y. S. (1999). *The SAGE handbook of qualitative research* (3rd ed.). Thousand Oaks, CA: Sage Publications.

Denzin, N. K., & Lincoln, Y. S. (2001). The American tradition in qualitative research. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research*. London: Sage Publishers.

Denzin, Norman K. & Lincoln, Yvonna S. (2005). Introduction: The discipline and practice of qualitative research. In Norman K. Denzin & Yvonna S. Lincoln (Eds.), *The Sage handbook of qualitative research* (3rd ed., pp.1-32). Thousand Oaks, CA: Sage.

Denzin, N. K., & Lincoln, Y. S. (Eds.). (2011). *The Sage handbook of qualitative research*. Thousand Oaks, CA Sage.

Denzin, N. K., & Giardina, M. D. (2016). *Introduction. In Qualitative Inquiry: Past, Present, and Future*. New York. Routledge.

Dewey, J. (1934). Art as Experience. Jo Ann Boydston, (ed*). The Later Works (1925-1953)*, *10*.

Dewey, J. (1938). *Experience and education*. New York: Macmillan Co.

Dewey, J. (1997). *How we think.* New York, NY: Courier Corporation.

Durkheim, É. (2002). *La educación moral*. Ediciones Morata.

Eisner, E.W. (1994). *The educational imagination: On design and evaluation of school programs*. (3rd.ed) New York: Macmillan.

Emeagwali, G., & Dei, G. J. S. (2014). *African indigenous knowledge and the disciplines.* New York; NY. Springer.

Engeström, Y. (1987). *Learning by expanding: An activity-theoretical approach to developmental research.* Helsinki: Orienta-Konsultit.

Engestrom. Y. (1993)."Developmental studies of work as a test bench of activity theory: The case of primary care medical practice. In S. Chaiklin and J. Lave (Eds). *Understanding practice: perspectives on activity theory and context.* Cambridge: Cambridge University Press, pp, 64-103.

Engestrom, Y. (1998). Reorganizing the motivational sphere of classroom culture: An activity theoretical analysis of planning in a teacher team. In F. Seeger, J. Voight, & U. Waschescio (Eds.). *The culture of the mathematics classroom* (pp. 76–103). New York: Cambridge University Press.

Engestrom, Y. (1999). Activity theory and individual and Social transformation. In Engestr6m Y, Miettinen R, Punamaki R L. *Perspectives on Activity Theory.* Cambridge: Cambridge University Press.

Engeström, Y. (2000). Activity theory and the social construction of knowledge: A story of four umpires. *Organization*, *7*(2), 301-310.

Engeström, Y. (2001). Making expansive decisions: An activity-theoretical study of practitioners building collaborative medical care for children. In C. M. Allwood & M. Selart (Eds.), *Decision making: Social and creative dimensions* (pp. 281–301). Dordrecht, the Netherlands: Kluwer Academic.

Farnsworth, V., Kleanthous, I., & Wenger-Trayner, E. (2016). Communities of practice as a social theory of learning: A conversation with Etienne Wenger. *British Journal of Educational Studies*, *64*(2), 139-160.

Feierman, S. (1999). Colonizers, scholars, and the creation of invisible histories. In V.E Bonnes & L. Hunt, (Eds). *Beyond the cultural turn: new directions in the study of society and culture*, University of California Press , Berkeley, Calif., London; 182-216.

Fernandez, P.G. (1994) Indigenous seed practices for sustainable development. *Indigenous Knowledge and Development Monitor*, The Hague, Netherlands. 2 (2) 9-12. Online: http://www. Nuffi ccs.nl/ciran/ikdm/

Fela-Anikulapo kuti, (1974). https// www.youtube.com/watch?v=zishssk90gc.

Flick, U. (2014). *An introduction to qualitative research*. London. Sage.

Freire, P. (1970). *Pedagogy of the Oppressed. Translated by Myra Bergman Ramos. New York: Continuum* International publishing.

Freire, P. (2000). *Pedagogy of indignation: pedagogical letters and other writings.* São Paulo: UNESP Publishing House,

Freire, P. (2002). *Education for critical consciousness.* New York: Continuum

Freire, P. (2004). *Pedagogy of Indignation*. Paradigm Publishers, Boulder, CO.

Frith, C. D. (2012). The role of metacognition in human social interactions. *Phil. Trans. R. Soc. B*, *367*(1599), 2213-2223.

Gagner, R.M. (1984). Learning outcomes and their effects: Useful categories of human performance. American Psychologist. In Gagner, R.M. (1989), *Studies of Learning*. Tallahassee, Florida: Learning Systems Institute. p. 511-526.

García, O., & Wei, L. (2014). *Translanguaging: Language, bilingualism and education*. Basingstoke: Palgrave Macmillan

Gardner, P. L. (1972). Structure of knowledge theory and science education. *Educational Philosophy and Theory*, *4*(2), 25-46.

Gay, G., & Howard, T. C. (2000). Multicultural teacher education for the 21st century. *The Teacher Educator*, *36*(1), 1-16.

Gay, G. (2002). Preparing for culturally responsive teaching. *Journal of teacher education*, *53*(2), 106-116.

Gay, G. (2010). *Culturally responsive teaching: Theory, research, and practice* (2nd ed.). New York, NY: Teachers College Press.

Gee, J. P. (2000). Identity as an analytic lens for research in education. *Review of Research in Education* 25, (1). 99-125.

Geertz, C. (1973). *The interpretation of cultures* (Vol. 5019). New York. Basic books.

Geijsel, F., & Meijers, F. (2005). Identity learning: The core process of educational change. *Educational Studies*, *31*(4), 419-430.

Giddens, A. (1981). Agency, institution, and time-space analysis. *Advances in social theory and methodology. Toward an integration of micro-and macro-sociologies*, 161-174.

Giddens. (1984).*The constitution of society: Outline of the theory of structuration*. Califonia, CA. Univ of California Press.

Gilbert, J. K., Osborne, R. J., & Fensham, P. J. (1982). Children's science and its consequences for teaching. *Science education*, *66*(4), 623-633.

Giroux, H. A. (2007). *Border crossings: Cultural workers and the politics of education*. New York. Routledge, Taylor and Francis Group.

Ghebru, S & Ogunniyi, M. B (2016). A systematic review of selected research studies focusing on participants reflections on the Science Indigenous Knowledge Systems project. Proceedings of the 2nd International Conference of the African Association for the Study of Indigenous Knowledge Systems (pp. 23-32). Mozambique. Universidade Pedagogica, Maputo, Mozambique.

Goduka, N. (2005). Eziko: Sipheka sisophula: Nguni foundations for educating/researching for substainable development. *South African Journal of Higher Education*, *19*(3), 467-481.

Goduka, N. I., & Kunnie, J. E. (Eds.). (2006). *Indigenous Peoples' Wisdom and Power: Affirming Our Knowledge through Narratives*. Farnham Ash gate.

Griffin, T. (2017). Reflections on Using Video as a Data Collection Tool in Narrative Inquiry. Proceedings of the 2017 International Conference of the Qualitative Research Methods, from the 20th of June till the 22nd of June 2017, Quebec City. Quebec, Canada.

Grbich, C. (2012). *Qualitative data analysis: An introduction*. New York. Sage.

Grolink. 2005. *Organic Agriculture Development Training Material*. Torfolk, Sweden.

Gruenewald, D. A. (2003). Foundations of place: A multidisciplinary framework for place-conscious education. *American Educational Research Journal*, *40*(3), 619-654.

Gyekye, K. (1997). *Tradition and modernity: Philosophical reflections on the African experience*. United Kingdom: Oxford University Press.

Guba, E. G., & Lincoln, Y. S. (1989). *Fourth generation evaluation*. New York: Sage.

Haberman, M. (1995). Selecting 'star' teachers for children and youth in urban poverty. *Phi Delta Kappan*, *76*(10), 777.

Handa, S. A., & Tippins, D. J. (2012).Tensions in the third space: Locating relevancy in pre-service science teacher preparation. *International Journal of Science and Mathematics Education, 11* (1), 237-265.

Harding, S. G. (1998). *Is science multicultural? Post colonialisms, feminisms, and epistemologies*. Bloomington: Indiana University Press.

Harvey, E. J., & Kenyon, M. C. (2013). Classroom seating considerations for 21st century students and faculty. *Journal of Learning Spaces*, *2*(1), 1-16

Haralambos, M., Holborn, M., & Herald, R. (2008). *Sociology and Perspectives*. London. Hammer Smith: Harper Collins Limited, 7th edition.

Harley, K., & Wedekind, V. (2004). Political change, curriculum change and social formation, 1990 to 2002. In L. Chisholm (ed.). *Changing class: Education and social change in post-apartheid South Africa*, HSRC Press, Cape Town. pp. 195-220.

Harper, G. F., & Maheady, L. (2007). Peer-mediated teaching and students with learning disabilities. *Intervention in School and Clinic*, 43(2), 101-107.

Hayes, A.E. (2010). *A rationale for comprehensive family literacy services: theoretical and philosophical foundations and a summary of findings from follow-up studies*. Wilmington, NC: University of North Carolina, Watson School of Education.

Hayes, J. (2014). *The theory and practice of change management*. Palgrave: Macmillan.

Hancock, D. R., & Algozzine, B. (2016). *Doing case study research: A practical guide for beginning researchers*. 1234 Amsterdam Avenue, New York, NY: Teachers College Press.

Hendry, G. D., & Oliver, G. R. (2012). Seeing is believing: The benefits of peer observation. *Journal of University Teaching & Learning Practice*, 9(1), 7.

Hernandez Sheets, R., & Gay, G. (1996). Student perceptions of disciplinary conflict in ethnically diverse classrooms. *Nassp Bulletin*, *80*(580), 84-94.

Hood, S., Frierson, H., & Hopson, R. (Eds.). (2005). *The role of culture and cultural context in evaluation: A mandate for inclusion, the discovery of truth and understanding*. Greenwich CT: Info Age Publishing Co.

Hooley, N. (2000). Reconciling indigenous and western knowing. A paper presented at the annual conference of the Australian Association for research in education. Sydney. Dec 4 -7.

Hott, B., Walker, J., & Sahni, J. (2012). Peer tutoring. George Mason University. JasneenSahni, Marymount University. CLD (Council for Learning Diabilities).

Horton, M. & Freire, P. (1990). *We make the road by walking: Conversations on education and social change*. Philadelphia, PA: Temple University Press.

Hofstede, G. (1984). *Culture's consequences: International differences in work-related values* (Vol. 5). London: sage.

Hughes, J. A., & Sharrock, W. W. (2016). *The philosophy of social research*. London: Routledge.

Heidegger, M. (1995). *The fundamental concepts of metaphysics: World, finitude, solitude*. BloomingtonIndiana University Press.

Idang, G. E. (2015). African culture and values. *Phronimon*, 16(2), 97-111.

Irvine, J. J. (1990). *Black students and school failure. Policies, practices, and prescriptions*. Greenwood Press, Inc. Westport, CT 06881.

Jamshidi, Azam & MahdiehNavehebrahim. (2013). Learners use of code switching in the English as a foreign language classroom. *Australian Journal of Basic and Applied Sciences.* 7(1): 186-190.

Jegede, O. J. (1995). Collateral learning and the eco-cultural paradigm in science and mathematics education in Africa. *Studies in Science Education*, *25(1)*, 97–137.

Jegede, O. J., & Aikenhead, G. S. (1999). Transcending cultural borders: Implications for science teaching. *Research in Science & Technological Education*, *17*(1), 45-66.

Jordan, C. (1985). Translating culture: From ethnographic information to educational program. *Anthropology & Education Quarterly*, 16, 105–123. Doi: 10.1525/ aeq.1985.16.2.04x0631g.

Johnson, B., & Christensen, L. (2008). *Educational research: Quantitative, qualitative, and mixed approaches*. London: Sage.

Johnson, C. C., & Fargo, J. D. (2010). Urban school reform enabled by transformative professional development: Impact on teacher change and student learning of science. *Urban Education*, *45*(1), 4-29.

Julie, A. & Peter, A. (2014). Research on teacher professional development programs in science. *In Handbook of research on science education*. (2) 889-906.

Kaahwa, J. (2011). The role of culture in rural Ugandan mathematics teaching and learning. *Diaspora, Indigenous, and Minority Education*, *5*(1), 48-62.

Kalolo, J. F. (2015). Towards Contextual and Cultural Relevant Science Education in Non-Western Countries: The African Experience. *Journal of Studies in Education*, 5(3), 38-56.

Kalumuna, G.F. 2000. Towards improving efficiency in records management in local authorities: the case of Dar Es Salaam Municipalities. M.A. Thesis. Dar E Salaam: University of Dar Es Salaam.

Kagoda, A. M. (2009). Integrating appropriate indigenous knowledge in the geography lessons in secondary schools of Uganda. *Current Research Journal of Social Sciences*, *1*(3), 117-122.

Karlsson, A., Larsson, P. N., & Jakobsson, A. (2018). Multilingual students' use of translanguaging in science classrooms. *International Journal of Science Education*, 1-21.

Kawagley, A. O., & Barnhardt, R. (1999). Education indigenous to place: Western science meets native reality. In G. A. Smith & D. Williams (Eds.), *Ecological education in action: On weaving education, culture, and the environment* (pp. 117-142). Albany, NY: State University of New York Press.

Kawagley, A. O., Norris-Tull, D., & Norris-Tull, R. A. (1998). The indigenous worldview of Yupiaq culture: Its scientific nature and relevance to the practice and teaching of science. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, *35*(2), 133-144.

Kaya, H. O., & Kale, S. E. (2016). African Indigenous Institutions and Contemporary Global Security. *Journal of Social Sciences*, 46(2), 114-122.

Keane M. & Moyo, D. (2010). Science Educators" ideas of the science" in IKS and their willingness to include IKS in the School Science Curriculum. Proceedings of the 18th Annual Conference of the Southern African Association for Research in Mathematics, Science and Technology Education Research, Durban, 18-21 January 2010.

Kennedy, M. M., (1999). Form and substance in mathematics and science professional development. *NISE Brief*, 3(2), 1-8.

Kennedy, M. M., (1998). Education reform and subject matter Knowledge. *Journal of research in science Teaching, 35* (3), 249-263.

Kincheloe, J. L. (1999). The struggle to define and reinvent whiteness: A pedagogical analysis. *College Literature*, *26*(3), 162-194.

Kincheloe, J. L. (2001). Describing the bricolage: Conceptualizing a new rigor in qualitative research. *Qualitative Inquiry*, 7(6), 679-692.

Kincheloe, J. L. (2002). *The sign of the burger: McDonald's and the culture of power*. Philadelphia, PA: Temple University Press.

Kincheloe, J. L. (2004a). Introduction: The power of the bricolage: Expanding research methods. In J. L. Kincheloe & K. S. Berry (Eds.), *Rigour and complexity in educational research: Conceptualizing the bricolage* (pp. 1-22). Maidenhead: Open University Press.

Kincheloe, J. L. (2004b). Redefining rigour and complexity in research. In J. L. Kincheloe & K. S. Berry (Eds.), *Rigour and complexity in educational research: Conceptualizing the bricolage* (pp. 23-49). Maidenhead: Open University Press.

Kincheloe, J. L. (2004c). Questions of disciplinarity/interdisciplinarity in a changing world. In J.L. Kincheloe & K. S. Berry (Eds.), *Rigour and complexity in educational research: Conceptualizing the bricolage* (pp. 50-81). Maidenhead: Open University Press.

Kincheloe, J. L. (2004d). Redefining and interpreting the object of study. In J. L. Kincheloe & K. S. Berry (Eds.), *Rigour and complexity in educational research: Conceptualizing the bricolage* (pp. 82-102). Maidenhead: Open University Press.

Kincheloe, J. L. (2005a). On to the next level: Continuing the conceptualization of the bricolage. *Qualitative Inquiry*, 11(3), 323-350.

Kincheloe, J. L. (2005b). Critical constructivism primer. New York, NY: P. Lang. In Kincheloe, J. L. (2008). *Knowledge and critical pedagogy: An introduction*. Dordrecht: Springer.

Kincheloe, J., & Berry, K. (2004). *Rigour and complexity in educational research: Conceptualising the bricolage (Conducting educational research)*. Berkshire: Open University Press.

Kincheloe, J., & Tobin, K. (2006). Doing educational research in a complex world. In K. Tobin and J. Kincheloe (Eds), *Doing educational research: A handbook*, 3-13. Rotterdam, Netherlands:

Kincheloe, J. L. & Berry, K. S. (Eds.). (2004). *Rigour and complexity in educational research: Conceptualizing the bricolage*. Maidenhead: Open University Press.

Kincheloe, J. L. (2008). *Knowledge and critical pedagogy: An introduction.* Dordrecht: Springer.

Kincheloe, J. L., McLaren, P., & Steinberg, S. (2011). Critical pedagogy and qualitative research: Moving to the bricolage. In N. K. Denzin & Y. S. Lincoln (Eds.), *The SAGE handbook of qualitative research* (4th ed., pp. 163-178). Thousand Oaks, CA: Sage Publications.

Kincheloe, J. L., Hayes, K., Steinberg, S., & Tobin, K. (2011). *Key works in critical pedagogy*. Rotterdam: Sense Publishers.

Kimchi, J., Polivka, B., & Stevenson, J. S. (1991). Triangulation: operational definitions. *Nursing Research*, 40(6), 364-366.

King, A. (1990). Reciprocal Peer-Questioning: A strategy for teaching students how to learn from Lectures. *The Clearing House*, 64(2), 131-135.

King, A. (2002). Structuring peer interaction to promote high-level cognitive processing. *Theory into Practice*, 41(1), 33-39.

Kirk, J. (2010). Gender, forced migration and education: identities and experiences of refugee women teachers. *Gender and Education*, 22(2), 161-176.

Kluckhohn, C. (1951). Values and value-orientations in the theory of action: An exploration in definition and classification. In: Parsons, T. and Shils, E., Eds., *Toward a General Theory of Action*, Harvard University Press, Cambridge, 388-433. http://dx.doi.org/10.4159/harvard. 9780674863507. C8.

Kodjo, E. (1987). *Africa tomorrow*. New York: Continuum.

Kroeber, A. L., & Kluckhohn, C. (1952). *Culture: A Critical Review of Concepts and Definitions*. Papers: Peabody Museum of Archeology and Ethnology, 47 (1), Cambridge: University Press.

Kuhn, T. S. (2012). The structure of scientific revolutions. University of Chicago press.

Kull, K. (2014). Catalysis and scaffolding in semiosis. In *The Catalyzing Mind* (pp. 111-121). Springer, New York, NY.

Ladson-Billings, G. (1992). Reading between the lines and beyond the pages: A culturally relevant approach to literacy teaching. *Theory into practice*, *31*(4), 312-320.

Ladson-Billings, G. (1995). Toward a theory of culturally relevant pedagogy. *American educational research journal*, *32*(3), 465-491.

Ladson-Billings, G. (1998). Just what is critical race theory and what's it doing in a nice field like education? *International journal of qualitative studies in education*, *11*(1), 7-24.

Ladson-Billings, G. (2009). *The dreamkeepers: Successful teachers of African American children*. San Francisco, CA: John Wiley & Sons.

Ladson-Billings, G. (2010). Race to the Top, again: Comments on the genealogy of Critical Race Theory. *Conn. L. Rev.*, *43*, 1439.

Lave, J (1988). *Cognition in practice: mind, mathematics, and culture in everyday life*. New York, NY, US. Cambridge University Press http://dx.doi.org/10.1017/

Lave, J. & Wenger, E. (1991). *Situated Learning: Legitimate Peripheral Participation*. Cambridge, UK: Cambridge University Press.

Lave, J. & Wenger, E. (1999). Learning and pedagogy in communities of practice. In J. Leach and B. Moon (Eds) *Learners and pedagogy*, Buckingham: Open University Press pp 21-33.

Lederman, N. G. (1992). Students' and teachers' conceptions of the nature of science: A review of the research. *Journal of research in science teaching*, *29*(4), 331-359.

Lee, C. D. (1992). Literacy, cultural diversity, and instruction. *Education and Urban Society*, *24*(2), 279-291.

Lee, O. (2003). Equity for culturally and linguistically diverse students in science education: Recommendations for a research agenda. *Teachers College Record*, *105*(3), 465-489.

Lee, O. (2005). Science education with English language learners: Synthesis and research agenda. *Review of Educational Research*, 75(4), 491–530.

Le Grange, L. (2004). Western science and indigenous knowledge: competing perspectives or complementary frameworks? Perspectives on higher education. *South African Journal of Higher Education*, 18(3), 82-91.

Lemke, J.L. (2001). Articulating Communities: sociocultural perspectives on science education, *Journal of Research in Science Teaching*, 38(3), pp. 296-316.

Leontiev, A. N. (1974). *Activity, awareness, personality*. *Moscow. Politizdat*.

Leontiev, O. K. (1985). *The World's Coastline.* New York, Van NoStrand Reinhold, 481-486.

Leontiev, A. N. & Luria, A. R. (1999). The psychological ideas of LS Vygotskii 1. In Lev. Vygotsky (ed.). Critical Assessments, 1, 56.

Lesh, R. & Lamon, S. J. (1992). *Assessment of authentic performance in school mathematics.* Washington, DC: AAAS Press.

Lewthwaite, B., McMillan, B., Renaud, R., Hainnu, R., & MacDonald, C. (2010). Combining the Views of" Both Worlds": Science Education in Nunavut" Piqusiit Tamainik Katisugit". *Canadian Journal of Educational Administration and Policy*. 98, 1-71.

Lévi-Strauss, C. (1966). *The savage mind*. Chicago, IL: University of Chicago Press.

Lévi-Strauss, C. (1966). The scope of anthropology. *Current anthropology*, *7*(2), 112-123.

Lévi-Strauss, C. (1996). *The Savage Mind.* Oxford. Oxford University Press.

Lieberman, A. (1995). Practices that support teacher development: Transforming conceptions of professional learning. *Phi Delta Kappan, 76,* 591-596.

Lincoln, Y. S., & Guba, E. G. (1985). *Establishing trustworthiness. Naturalistic inquiry*, Newbury Park, CA: Sage Publications.

Lincoln, A. (1989). *Speeches and Writings 1832-1858: Speeches, Letters, and Miscellaneous Writings: the Lincoln-Douglas Debates* (Vol. 45). New York: Library of America.

Lincoln, Y. (1995). Emerging criteria for quality in qualitative and interpretive research. *Qualitative Inquiry*, 1, 275-289.

Lincoln, Y. S., & Denzin, N. K. (2000). The seventh moment: Out of the past. *Handbook of qualitative research*, 2, 1047-1065.

Lincoln, Y. (2001). An emerging new bricoleur: Promises and possibilities: A reaction to Joe Kincheloe's "Describing the Bricoleur". *Qualitative Inquiry,* 7(6), 693-705.

Loucks-Horsley, S., & Hewson, P. W. (2010). *Designing Professional Development for teachers of science and mathematics.* (3rd edition). Thousand Oaks, CA: Corwin Press.

Lowyck, J., Elen, J., & Clarebout, G. (2004). Instructional conceptions: Analysis from an instructional design perspective. *International Journal of Educational Research, 41*(6), 429-444.

Luykx, A., Lee, O., Mahotiere, M., Lester, B., Hart, J., & Deaktor, R. (2007). Cultural and home language influences on children's responses to science assessments. *Teachers College Record*, 109(4), 897–926.

Maathai, W. 2009. *The challenge for Africa: A new vision*. London: William Heinemann.

Macaro, E. (2005). *Teaching and learning a second language: A guide to recent research and its applications*. London; Bloomsbury Publishing.

Macaro, E., & Tian, L. (2012). Comparing the Effects of Teacher Code-Switching with English-Only Explanations on the Vocabulary acquisition of Chinese University Students: A Lexical Focus-on-Form Study. *Language Teaching Research*, 16, 367-391.

Manik, S. (2014). South African migrant teachers' decision-making: levels of influence and 'Relative deprivation'. *Journal of Southern African Studies,* 40(1), 151-165

Mapara, J. (2009). Indigenous knowledge systems in Zimbabwe: Juxtaposing postcolonial theory. *Journal of Pan African Studies, 3*(1). 139-155

Makinde, O. O., & Shorunke, O. A. (2013). Exploiting the Values of Indigenous Knowledge in Attaining Sustainable Development in Nigeria: the place of the Library. Library Philosophy & Practice**.** ISSN 1522-0222

Masote, S. E. (2017). *Teachers' understanding and implementation of Values Education in the Foundation Phase* (Doctoral dissertation, University of Pretoria).

Mavuru, L., & Ramnarain, U. (2018). Relationship between Teaching Context and Teachers' Orientations to Science Teaching. *EURASIA Journal of Mathematics, Science and Technology Education*, *14*, 8. 1564. DOI:10.29333/ejmste/91910

Maxwell, K. L., & Chahine, I. C. (2013). Cultural immersion and mathematics teacher education: Explorations in Morocco and South Africa. *Journal of Humanistic Mathematics*, *3*(2), 62-75.

Mawere, M. (2012). *The struggle of African indigenous knowledge systems in an age of globalization: A case for children's traditional games in south-eastern Zimbabwe*. Bamenda: Langaa RPCIG Publishers.

Mawere, M. (2014). *Culture, indigenous knowledge and development in Africa: Reviving interconnections for sustainable development*. Langaa Rpcig.

Mazrui, A. A. (1978). *Political values and the educated class in Africa*. Berkeley and Los Angeles. University of California Press.

McLeod, J. (2011). *Qualitative research in counselling and psychotherapy*. London: Sage Publications.

McNiff, J. (2010). *Action research for professional development: Concise advice for new action researchers.* Dorset: September books.

McMillan, J. H., & Schumacher, S. (2010). *Research in education: Evidence-based inquiry*. Essex: Pearson.

Mckinley, E. (2007). Post colonialism, indigenous students and science education. In S. K. Abell & N. G. Lederman (Eds.). *Handbook of research on science education* (pp. 199-226). Mahwah, NJ: Lawrence Erlbaum.

Meichtry, Y.J. (1992). Influencing students understanding of Nature of Science: Data from a case of curriculum development, *Journal of Research in Science Teaching*, 29, 389-407.

Memmi, A. (2013). *The colonizer and the colonized*. London: Routledge.

Merriam, S. B. (2002). *Qualitative research in practice: Examples for discussion and analysis*. San Francisco, CA: Jossey-Bass Inc Pub.

Merriam, S. B. (2009). *Qualitative research: A guide to design and implementation*. San Francisco, CA: Jossey-Bass.

Merriam, S. B. (2015). Qualitative Research: Designing, Implementing, and Publishing a Study. In *Handbook of research on scholarly publishing and research methods* (pp. 125-140)' San Francisco, CA: Jossey-Bass Inc.

Michie, S. (2002). Causes and management of stress at work. *Occupational and environmental medicine*, *59*(1), 67-72.

Mpofu, V., Otulaja, F. S., & Mushayikwa, E. (2014). Towards culturally relevant classroom science: a theoretical framework focusing on traditional plant healing. *Cultural Studies of Science Education*, *9*(1), 221-242.

Mpofu, V., Mushayikwa, E., and Otulaja, F.S. (2015). Indigenous knowledge of plant healing: What classroom science materials can be drawn fron it? Paper presented at the 23rd Annual Meeting of the Southern African Association for Research in Mathematics, Science and Technology Education (SAARMSTE), Universidade Pedagogicica, Maputo, Mozambique.

Mkabela, Q. (2005). Using the Afrocentric method in researching indigenous African culture. *The Qualitative Report*, *10*(1), 178-189.

Mohatt, G., & Erickson, F. (1981). Cultural differences in teaching styles in an Odawa school: A sociolinguistic approach. In H. T. Trueba, G. P. Guthrie, & K. Au (Eds.), *Culture and the bilingual classroom: Studies in classroom ethnography* (pp. 105– 119). Rowley, MA: Newbury.

Moll, L. C., Amanti, C., Neff, D., & González, N. (1992). Funds of knowledge for teaching: Using a qualitative approach to connect homes and classrooms. *Theory into Practice, 31*(2), 132-141.

Mosha, H. J. (2000). Conceptualizing quality of education. *The Quality of Education in Tanzania: Issues and experiences*,

Mosha, H. J. (2000). Conceptualizing quality education. In J.C.J. Galabawa, F.M.K. Senkoro and A.F. Lwaitama (eds.). *The quality of Education in Tanzania: Issues and experiences*. 1-18. Faculty of Education, University of Dar es Salaam.

Morrow, W. (2007). *Learning to teach in South Africa*. South Africa. HSRC. Press.

Mortimer, E., & Scott, P. (2003). *Meaning Making In Secondary Science Classroomsaa*. UK McGraw-Hill Education.

Musalika, B. M. (1994). Ethical issues in photojournalism in Africa. In F.B. Kasoma (ed), *Journalism Ethics in Africa*, 136-158. Nairobi: ACCE.

Nakashima, D., & Roué, M. (2002). Indigenous knowledge, peoples and sustainable practice. *Encyclopedia of global environmental change*, *5*, 314-324.

Nakashima, D., Prott, L., & Bridgewater, P. (2000). Tapping into the world's wisdom. *UNESCO sources*, *125*(5), 12.

Nieto, S., Bode, P., Kang, E., & Raible, J. (2008). Identity, community, and diversity: Retheorizing multicultural curriculum for the postmodern era. *The Sage handbook of curriculum and instruction*, 176-197. Los Angeles: Sage Publishers.

Nhalevilo, E. A., & Ogunniyi, M.B. (2014). Reflections on the SIKSP: Voices of the participants. *South African Journal of Higher Education*, *28* (1), 221 -235.

Nieuwenhuis, J. (2007). Qualitative research designs and data gathering techniques. In Maree. K., (ed.). *First steps in research,* Pretoria: Van Schaik. p. 69-97.

Nyerere, J. K. (1968). *Freedom and socialism: Uhuru na ujamaa; a selection from writings and speeches, 1965-1967*. London: Oxford University Press.

Nygård Larsson, P. (2011). Biologiämnets texter: Text, språk och lärande i en språkligt heterogen gymnasieklass [*The texts in the subject of biology: Text, language and learning in a linguistic heterogeneous high school class*]. Malmö: Faculty of Education and Society, Malmö University.

Numan, D., & Carter, D. (2001). *Teaching English to speakers of other languages*. Cambridge: Cambridge university press.

Odora-Hoppers, C. (2000). *Indigenous knowledge systems and the transformation of academic institutions in South Africa*. Pretoria: HSRC Unpublished paper.

Odora-Hoppers, C. A. (2002). *Indigenous knowledge and the integration of knowledge systems: Towards a philosophy of articulation*. Claremont: New Africa Books.

Odora Hoppers, C. A. (2005). *Culture, indigenous knowledge and development. The role of universities.* Johannesburg: Centre for Education Policy Development publishers.

Ogawa, M. (1986) 'Toward a rationale of science education in non-western society', *European Journal of Science Education,* (8)1, 113-119.

Ogawa, M. (1995). Science education in a multiscience perspective. *Science Education, 79*(5), 583-593.

Ogunniyi, M. B. (2000). Teachers' and pupils' scientific and indigenous knowledge of natural phenomena. *Journal of the Southern African Association for Research in Mathematics, Science and Technology Education*, *4*(1), 70-77.

Ogunniyi, M. B. (2004). The challenge of preparing and equipping science teachers in higher education to integrate knowledge system for learners. Cape Town. *South African Journal of Higher Education 18(*3): 289- 304.

Ogunniyi, M. B. (2007). Teachers' stances and practical arguments regarding a science-indigenous knowledge curriculum: Part 1. *International Journal of Science Education*, *29*(8), 963-986.

Ogunniyi, M. B. (2007). Teachers' stances and practical arguments regarding a science-indigenous knowledge curriculum: Part 1. *International Journal of Science Education*, *29*(8), 963-986.

Ogunniyi, M. B. (2007). Teachers' Stances and Practical Arguments regarding a Science-Indigenous Knowledge Curriculum: Part 2. *International Journal of Science Education. 29(1)*, 1189-1207.

Ogunniyi, M. B., & Hewson, M. G. (2008). Effect of an argumentation-based course on teachers' disposition towards a science-indigenous knowledge curriculum. *International Journal of Environmental and Science Education*, *3*(4), 159-177.

Ogunniyi, Amosun and Otulaja (2013). Science teachers searching the academic literature as a resource for implementing culturally- relevant curriculum/instructional methods in science classrooms. Fourth international Conference of the Science and Indigenous Knowledge Systems Project/ South Mozambican Collaborative Research programme.

Oguniyi, M.B. (2013). Teachers' and teacher trainers' reflexibility and perceptual shifts in an argumentation driven indigenized science curriculum project. Proceedings of the 21st annual Conference of the Southern African Association for Research in Mathematics and Science Education (pp.446-457). South Africa, University of the Western Cape.

Ogunniyi, M. B., & Mushayikwa, E. (2015). Teacher Education in South Africa: Issues and Challenges. *Teacher Education Systems in Africa in the Digital Era*, 71.

Ogunniyi, M. B., & Rollnick, M. (2015). Pre-service science teacher education in Africa: Prospects and challenges. *Journal of Science Teacher Education*, *26*(1), 65-79.

Okafor, E. E. (2011). Youth unemployment and implications for stability of democracy in Nigeria. *Journal of sustainable Development in Africa*, *13*(1), 358-373.

Onwu, G. (2009). Introducing IKS with the science curriculum: what develops? An exercise with in-service student teachers. In M.B Ogunniyi (Ed), *second national workshop on science indigenous knowledge systems*, pp.21-27): University of Western Cape.

Onwu, G., and Mosimege, M. (2004). “Indigenous Knowledge Systems and Science and Technology Education: A Dialogue.” *African Journal of Research in SMT Education, 8*(1): 1-12.

Onwu, G. O. M., & Kyle, W. C. Jr. (2011). Increasing the socio-cultural relevance of education for sustainable development. *African Journal of Research in Mathematics, Science and Technology Education, 15* (3), special issue

Orlove B, Roncoli C, Kabugo M, Majugu A (2009). Indigenous climate knowledge in Southern Uganda: the multiple components of a dynamic regional system. *Climate Change. 100* (2): 243–265.doi:10.1007/ s10584-009-9586-2.

Osborne, J. W. (2002). *The Effects of Minimum Values on Data Transformations* New Orleans, LA. Educational Research.

Ottevanger, W., van den Akker, J., & de Feiter, L. (2007). Developing science, mathematics, and ICT education in sub-Saharan Africa: Patterns and promising practices. The World Bank.

Otulaja, F. S. (2010). *Using cogenerative dialogue to afford the teaching and learning of biology in an urban high school*. Published doctoral dissertation. City University of New York.

Oyserman, D., & Sorensen, N. (2009). Understanding cultural syndrome effects on what and how we think: A situated cognition model. In C.-Y. Chiu, R. Wyer, & Y.-Y. Hong (Eds.), *Problems and solutions in crosscultural theory, research and application* (pp. 25–52). New York: Psychology Press

Otulaja, F., & Ogunniyi, M. (2017). *The World of Science Education: Handbook of research in science education in sub-Saharan Africa.* Rotterdam: Sense Publishers. ISBN: 978-94-6351-087-5.

Oyelekan, O. S., & Omiwale, J. B. (2017). Trends in Nigeria’s science education within the global context. *The World of Science Education* (pp. 43-64). Sense Publishers, Rotterdam.

Parsons, E. C., Travis, C., & Simpson, J. S. (2005). The black cultural ethos, students’ instructional context preferences, and student achievement: An examination of culturally congruent science instruction in the eighth grade classes of one African American and one Euro-American teacher. *The Negro Educational Review*, 56, 183–203.

Parsons, E. C. (2008). Learning contexts, black cultural ethos, and the science achievement of African American students in an urban middle school. *Journal of Research in Science Teaching,* 45(6), 665-683.

Patton, M. Q. (1999). Enhancing the quality and credibility of qualitative analysis. *Health Services Research,* 34(5) P, 1189.

Peshkin, A. (1992). The relationship between culture and curriculum: A many fitting thing. In P.W. Jackson (Ed.), *Handbook on research on curriculum* (pp. 248-267). New York: Macmillan.

Pewewardy, C. (2002). Learning styles of American Indian/Alaska Native students: A review of the literature and implications for practice. *Journal of American Indian Education*, 22-56.

Phelan, P., Davidson, A. L., & Cao, H. T. (1991). Students' multiple worlds: Negotiating the boundaries of family, peer, and school cultures. *Anthropology & Education Quarterly*, *22*(3), 224-250.

Piaget J (1952). *The origins of intelligence in children.* New York: International Universities press.

Piaget, J. (1970). Piaget's Theory (G. Gellerier & J. Langer, Trans.). In: P.H. Mussen (Ed.), *Carmichael's Manual of Child Psychology* (3rd Edition, Vol. 1). New York: Wiley.

Piaget, J. (1971). The theory of stages in cognitive development. In D. R. Green, M. P. Ford, & G. B. Flamer, *Measurement and Piaget.* New York, NY, US: McGraw-Hill.

Piaget, J. (2013). *The moral judgment of the child*. London: Routledge.

Piaget, J. (2015). *The Grasp of Consciousness (Psychology Revivals): Action and Concept in the Young Child.* New York, NY: Psychology Press.

Qvortrup, A., Wiberg, M., Christensen, G., & Hansbøl, M. (Eds.). (2016). On the definition of learning. In A Qvortrup & M. Wiberg (Eds.), *Dealing with Conceptualizations of Learning: Learning between Means and Aims in Theory and Practice*. Rotterdam: Sense Publishers.

Reason, P., & Bradbury, H. (2008). *The Sage handbook of action research: Participative inquiry and practice.* London: Sage publishers.

Rennie, L. J. (2006). The community's contribution to science learning: Making it count. Plenary address to the ACER Research Conference 2006, "Boosting science learning-What will it take," Canberra. http://www.acer.edu.au/documents/RC2006_Rennie.pdf.

Richardson, L., Denzin, N. K., & Lincoln, Y. S. (2000). Handbook of qualitative research. *Writing: A method of inquiry*, 923-948.

Roehrig, G. H., & Luft, J. A. (2006). Does one size fit all? The induction experience of beginning science teachers from different teacher-preparation programs. *Journal of Research in Science Teaching*, *43*(9), 963-985.

Rogers, M. (2012). Contextualizing theories and practices of bricolage research. *The Qualitative Report*, 17(48), 1-17.

Rogoff, B. (1995) Observing Sociocultural Activity on Three Planes: participatory appropriation, guided participation, and apprenticeship. In J. Wertsch, P. del Río & A. Alvarez (Eds.). *Sociocultural Studies of Mind*, pp. 139-163. Cambridge: Cambridge University Press.

Rogoff, B. (1998). Cognition as a Collaborative Process. In W. Damon (Chief Ed.), D. Kuhn & R.S. Siegler (Volume Eds) *Cognition, Perceptions and Language*, *5th edn. Handbook of Child Psychology*, pp. 679-744. New York: Wiley

Rollin, C. (2012). Philosophy of science; Contextual empiricism. http://www.uta.fi/yky/fil/kaytannot/materiaalit/index/FILP3Luento6.pdf

Rollnick, M. (2017). The growth of science education organisations in the old and new South Africa. In The World of Science Education (pp. 27-41). Rotterdam. Sense Publishers,.

Rousseau, N. (2015). *The role of reflection in integrating theory and practice in foundation phase teacher education* (Doctoral dissertation, Stellenbosch: Stellenbosch University).

Rossman, G. B., & Rallis, S. F. (2003). *Learning in the field: An introduction to qualitative research*. London: Sage publications.

Rumelhart, D. E., Smolensky, P., McClelland, J. L., & Hinton, G. (1986). Sequential thought processes in PDP models. In D.E. Rumelhart, J.L. McClelland (Eds). *The PDP Research Group (Eds.), Parallel distributed processing: Explorations in the microstructure of cognition,* Vols. 1–3, MIT Press, Cambridge, MA.

Sarpong, P. (1991).*Ghana in retrospect: Some aspects of the Ghanaian culture*. African Books Collective Ltd., Ghana.

Schwartz, R., & Lederman, N. (2008). What scientists say: Scientists' views of nature of science and relation to science context. *International Journal of Science Education*, *30*(6), 727-771.

Schutz, A., & Luckmann, T. (1973). *The structures of the life world* (vol. I). Evanston, IL: Northwestern University Press.

Seale, C. (1999). Quality in qualitative research. *Qualitative Inquiry,* 5(4), 465-478.

Sebeok, T. A. (1988). 'Animal' in biological and semiotic perspective. In T. Ingold (Ed.), *What is an Animal?* London: Unwin Hyma. (pp. 63– 76).

Seel, N.M. (1991). *Weltwissen und mentale Modelle*. [World knowledge and mental models] Go¨ttingen: Hogrefe, Verlag f. Psychologie.

Seel, N. M. (2003). Model centered learning and instruction. *Technology, Instruction, Cognition and Learning*, 1(1), 59-85.

Semali, L. M., & Kincheloe, J. L. (1999). What is indigenous knowledge and should we study it? In L. M. Semali & J. L. Kincheloe (Eds.). *What is indigenous knowledge?: Voices from the Academy* (pp. 3-58). Oxford: Taylor & Francis.

Sesanti, S. (2010). The concept of 'respect' in African culture in the context of journalism practice: An Afrocentric intervention. Communication: *South African Journal for Communication Theory and Research*, 36(3), 343-358.Somerville, P. (2016).

Sewell Jr, W. H. (1992). A theory of structure: Duality, agency, and transformation. *American Journal of Sociology*, *98*(1), 1-29.

Sewell, W. H. (1999). The concept(s) of culture. In V. E. Bonell & L. Hunt (Eds.). *Beyond the cultural turn: New directions in the study of society and culture* (pp. 35-61). Berkeley: University of California Press.

Sarpong, P. (2002). *Peoples differ: An approach to in-culturation in evangelism*, sub-Saharan Publishers. Accra.

Sharma, R. (2012). Teachers on the move: international migration of school teachers from India. *Journal of Studies in International Education, 17*(3), 262e283.

Shenton, A. K. (2004). Strategies for ensuring trustworthiness in qualitative research projects. *Education for information, 22*(2), 63-75.

Shizha, E. (2010). The interface of neoliberal globalization, science education and indigenous African knowledges in Africa. *Journal of Alternative Perspectives in the Social Sciences, 2(*1), 27-58.

Shizha, E. (2013). Reclaiming our indigenous voices: The problem with postcolonial Sub-Saharan African school curriculum. *Journal of Indigenous Social Development*. 2(1) pp1-18.

Shizha, E. (2015). Reclaiming indigenous cultures in Sub-Saharan African education. In J. W. Jacob, Y. S. Cheng, & K. M. Porter (Eds.), *Indigenous education: Language, culture and identity* (pp. 301–317). Dordrecht: Springer, Netherlands.

Shor, I., & Freire, P. (1987). *A pedagogy for liberation: Dialogues on transforming education*. Westport, CT. Greenwood Publishing Group.

Sideris, T. 2005. 'You have to change and you don't know how!': Contesting what it means to be a man in a rural area of South Africa. In Reid, G. & Walker, L. (eds.). *Men Behaving Differently: South African men since 1994.* Cape Town: Double Storey Books: 111 - 137.

Skinner, B. F. (1976). *Particulars of my life*. McGraw-Hill. Pennsylvania. U S A

Socrates, P. (1978). *Aristotle in Social Context*. Oxford: Basil Blackwell.

Soyinka. W. (1988). Power and Creative Strategies. *Index on Censorship*. 17(7), 7 - 9.

Soyinka, W. (1993). The Transitional Politics on Human Rights, *Index on Censorship*, 22(2), 2 - 3.

Spindler, G., & Spindler, L. (1994). What is cultural therapy? In G. Spindler & L. Spindler (Eds). *Pathways to cultural awareness: Cultural therapy with teachers and students*, 1-33. Thousand Oaks, CA: Corwin.

Snively, G., & Corsiglia, J. (2001). Discovering indigenous science: Implications for science education. *Science Education*, *85*(1), 6-34.

Steinberg, S. (2011). Introduction to “Describing the bricolage”. In J. L. Kincheloe, k. Hayes, S. Steinberg, and K. Tobin (Eds.), *Key works in critical pedagogy*. Rotterdam, The Netherlands: Sense Publishers (pp. 177).

Stevenson, A. R. (2013). How fifth grade Latino/a bilingual students use their linguistic resources in the classroom and laboratory during science instruction. *Cultural Studies of Science Education, 8* (4), 973–989.

Stigler, J. W., & J. Hiebert. 1999. *The teaching gap: Best ideas from the world’s teachers for improving education in the classroom*. New York: Free Press.

Tan, E., Barton, A. C., Turner, E., & Gutiérrez, M. V. (2012). *Empowering science and mathematics education in urban schools*. Chicago, IL: University of Chicago Press.

Thomas, W. P., & Collier, V. (1997). *School effectiveness for language minority students.* Washington, DC: Washington NCBE.

Tobin, K. (2005). Using technology in the classroom. In L, Kincheloe (Ed.). *Classroom teaching: An introduction*. New York, NY: Peter Lang.

Tobin, K. G. (2006). *Doing educational research (Vol. 1).* Rotterdam: Sense Publishers.

Turner, J. H., & Stets, J. E. (2005). *The sociology of emotions*. Cambridge: Cambridge University Press.

Turkan, S., & Liu, O. L. (2012). Differential performance by English language learners on an inquiry-based science assessment. *International Journal of Science Education, 34*(15), 2343–2369.

Tylor, E. B. (1958). *Primitive culture*. New York: JP Putnam's Sons.

Rogers, M. (2012). Contextualizing theories and practices of bricolage research. *The Qualitative Report,* 17(48), 1-17.

Rollnick, M. (2017). The growth of science education organizations in the old and new South Africa. In Femi S. Otulaja and Meshach B. Ogunniyi (Eds.). *The World of Science Education Handbook of Research in Science Education in Sub-Saharan Africa* (pp. 27-41). Rotterdam. Sense Publishers.

Warren, E., & Cooper, T. (2008). Generalizing the pattern rule for visual growth patterns: Actions that support 8 year olds' thinking. *Educational Studies in Mathematics*, *67*(2), 171-185.

Vhurumuku E 2004. An Investigation of Zimbabwe A level Chemistry Teachers' Epistemological Beliefs, Laboratory Instructional Practices and Students' Images of the Nature of Science. PhD (Education). Thesis. Belleville, South Africa: University of Western Cape.

Villegas, A. M., & Lucas, T. (2002). Preparing culturally responsive teachers: Rethinking the curriculum. *Journal of Teacher Education*, *53*(1), 20-32.

Vogt, L. A., Jordan, C., & Tharp, R. G. (1987). Explaining school failure, producing school success: Two cases. *Anthropology & Education Quarterly*, *18*(4), 276-286.

Vygotsky, L. (1978). *Mind in Society: The Development of Higher Psychological Processes*. Cambridge, MA: Harvard University Press.

Vygotsky, L. S. (1987a). . The Collected Works of L.S. Vygotsky: Volume 1: Problems of General Psychology, Including the Volume Thinking and Speech

Vygotsky, L. S. (1987b). Problems of general psychology. The collected works of L. S. Vygotsky, Vol. 1. In *R. W.* Rieber & A. S. Carton, (Eds.), *Problems of general psychology*. New York, NY, US: Plenum Press.

Vygotsky, L. S. V., Rieber, R. W., Carton, A. S., & Wollock, J. (1998). *The collected works of LS Vygotsky: Child psychology*. New York, NY, US: Plenum Press.

Vygotsky, L. S. (1997). The Historical Meaning of the Crisis in Psychology: A Methodological Investigation. In R. W. Rieber & J. Wollock (Eds.). The Collected Works of L. S. Vygotsky. Vol. 3. *Problems of the Theory and History of Psychology* New York: Plenum. (pp. 233-344).

Vygotsky, L. S. (1998). Infancy. In Rieber R. W. (Ed.). *The Collected Works of L.S. Vygotsky Vol. 5*. Plenum Press, New York (207-241).

Vygotsky, L. S. (1999). Tool and sign in the development of the child. *The collected works of LS Vygotsky, 6*, 3-68.

Vygotsky, L. S. (2003). *Psicologia pedagógica.* Porto Alegre, RS: Artmed. (Original work published 1926.

Wacquant, L. (2011). Habitus as topic and tool: Reflections on becoming a prizefighter. *Qualitative Research in Psychology*, *8*(1), 81-92.

Walberg, G. (1976). Kamares: *A Study of the Character of Palatial Middle Minoan Pottery,* (ActaUniversitatisUpsaliensis. Boreas 8), Uppsala.

Wallace, C.S., Hand, B., & Prain, V. (2004). *Writing and learning in the science classroom*. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Watts, M., & Pedrosa de Jesus, H. (2005). The cause and effect of asking questions: Reflective case studies from undergraduate students. *Canadian Journal of Science, Mathematics, and Technology Education*, 5(4), 437–452.

Warren, D. M., & Rajasekaran, B. (1993). Putting local knowledge to good use. *International Agricultural Development*, *13*(4), 8-10.

Wenger, E. (1998) Communities of practice: learning, meaning, and identity.Cambridge: Cambridge University Press.

Wilson, E. (2009). School-based research: *British Journal of Educational Technology*, 40(1): 971.

Wilson, S. (2001). What is Indigenous research methodology? *Canadian Journal of Native Education*, *25*(1), 175–179.

Weidmann Koop, M.-C. (Ed.). (2003). *Le Quebec au´ jourd'hui: Identite, soci ´ et´ e et culture´* [*Quebec today: ´ Identity, society, and culture]*. Sainte-Foy, Quebec, ´ Canada: Presses de l'Universite Laval.

Weinstein, C. S., Tomlinson-Clarke, S., & Curran, M. (2004). Toward a conception of culturally responsive classroom management. *Journal of teacher education, 55*(1), 25-38.

Wertsch, J.V. (1991). *Voices of the Mind: a sociocultural approach to mediated action*. Cambridge, MA: Harvard University Press

Wibberley, C. (2012). Getting to grips with bricolage: A personal account. *The qualitative report*, *17*(25), 1.

Wolpert, L. (1 993). *The unnatural nature of science*. London: Faber and Faber.

Wolcott, H. F. (1991). Propriospect and the acquisition of culture. *Anthropology & Education Quarterly, 22*(3), 251-273.

Wong, H. K., Wong, R. T. (2009). The First Days of School: How to Be an Effective Teacher, *Harry K. Wong Publications*, (12), 81-87.

.

Yamagata-Lynch, L. C. (2010). Understanding cultural historical activity theory. In In **L.C.** Yamagata-Lynch (Ed.). *Activity systems analysis methods* (pp. 13-26). Boston, MA. Springer,

Yang, X. (2005). Institutional challenges and leadership competencies in Chinese ministry of education-directed universities in implementing the 1999 Chinese action scheme for invigorating education towards the 21st century. Unpublished doctoral dissertation, Texas A&M University, college station.

Yin, R. K. (2009). *Case study research: Design and methods (applied social research methods).* London and Singapore: Sage publications.

Young, P. A. (2014). The presence of culture in learning. In J.M Spector**,** M.D., Merrill**,** J. Elen, M. J., Bishop**.** (Eds.*).* *Handbook of research on educational communications and technology (Fourth edition)* (pp. 349-361). New York, NY. Springer Academics.

Zinyeka, G. (2011). Integration of Indigenous Knowledge into School Science Curriculum: Educational Effectiveness: Indaba Conference Concept Paper. Pretoria University, Faculty of Education.

Zulu, I. M. (2018). Exploring the African Centered Paradigm: Discourse and Innovation in African World Community Studies. *Journal of Pan African Studies*, *11*(4). 34-52.

Appendix: A

School A's Teacher's Questionnaires (Ms. Mbali)

1. Do you use beads in the classroom? *No*

2. Do other teachers use beads to teach? *No*

3. How do you think beads can be used to teach in the life science classroom?

With the exercise given I think that they can work well when learners are learning the organic compounds.

4. How do you think beads can be used to teach in the life science classroom?

It will help them to remember how many oxygens carbon etc. are in a compound.

5. How do you think learners will respond to the use of beads in the teaching of life sciences?

I think in a positive manner

6. How can you modify your lesson to include beads to teach?

I think I can use it for a cell organelle diagram if possible with the variation of colours so that they will remember which bead for example is the vacuole and the function of it and it will be easier for them.

Appendix: B

School A's Teacher's Questionnaires (Ms. Karabo)

1. Do you use beads in the classroom? Yes- No- .if yes, what do you use beads for If no, kindly explain.

Beads are easy to get and constructing models with beads is easy

2. Do other teachers use beads to teach? No

3. How do you think beads can be used to teach in the life science classroom?

Beads are easy to get and constructing models with beads is easy

4. How do you think beads can be used to teach in the life science classroom?

Learners will not forget easily

5. How do you think learners will respond to the use of beads in the teaching of life sciences?

It is interesting because they are colourful.

6. How can you modify your lesson to include beads to teach?

Instructions will be easily followed because they will be using different coloured beads

Other comments: How to create an aldo ring and a keto ring.

Appendix: C

School B's Teacher's Questionnaires (Mr. Brighton)

1. Do you use beads in the classroom? Yes- No. If yes, what do you use beads for If no, kindly explain.

The school has not provided the teachers with the necessary and relevant materials

2. How do you think beads can be used to teach in the life science classroom?

The learning of organic compound such as DNA and RNA is not only made easier but even more exciting

3. How do you think beads can be used to teach in the life science classroom?

Models will better be understood by the learners unlike the traditional lecturing method.

4. How do you think learners will respond to the use of beads in the teaching of life sciences?

They will definitely enjoy it and predictability may never want to miss a science lesson.

5. How can you modify your lesson to include beads to teach?

Use of interrogative teaching techniques whereby learners infer from models that they would have constructed

Other comments: It is a teaching method that will surely aid learning and understanding of concepts.

Appendix: D

School B Teacher's Questionnaires (Mr. Kagiso)

1. Do you use beads in the classroom? Yes-No. If yes, what do you use beads for? If no, kindly explain.

Reason being it is because they have no beads in the school, meaning they are not supply in or I haven't seen them meaning there is lack of resource of the beads

2. How do you think beads can be used to teach in the life science classroom?

It can be used to teach some many life sciences concepts such as genetic inheritance, to represent certain allele for example for trait a certain colour different large and for recessive small bond.

3. How do you think the use of beads and beadwork will improve your teaching.

Since improving teaching goes with improving learning then it will improve my teaching in a way that learners will understand since they like hands-on activities.

4. How do you think learners will respond to the use of beads in the teaching of life sciences?

It will be new to them since they are not used to it but then since many learners like hands-on activities, they will enjoy and remember the lesson better with understanding.

5. How can you modify your lesson to include beads to teach?

By teaching organic compounds in a way that they understand the compounds which contain C, H and oxygen and have glued on the bonds on whether the bonds are single or double between atoms.

Appendix: E

Summary of Mr. Brighton's Learners' Responses to Questionnaire

1. **Have you seen beads before? Yes—No ---**

a. Yes! Beads are used to design cloths and necklace
b. Yes! Making jewelry
c. Yes! For making decoration on traditional attire(s) and on necklaces and bracelets
d. Yes! Beads are used to decorate, making jewelry to be lookable
e. Yes! Decoration in traditional clothes for jewelry
f. Yes! To make decoration
g. Yes! Are used for designing clothes
h. Yes! Used to decorate cultural dresses
i. Yes! Beads are used for decoration. They are used to do traditional necklaces
j. Yes! Beads are used for decoration
k. Yes! They are used to make traditional clothing
l. Yes! It is used for learning
m. Yes! For neckaces, jewelry and many other things
n. Yes! They are used to do necklaces and decorate what you planted on your hair
o. Yes! To make design or decorate cloths
p. Yes! Beads are used to do something or anything creatively/design
q. Yes! Making a bracelet and necklace

2. **Do you like beads? Yes --- No---**

Yes! Because they are colourful and I can make colourful things with them
Yes! Because they can be used for doing anything creativity
Yes! Because they keep me busy in something
Yes! Because they are colourful
Yes! They are fun things to use for everything
Yes! Because they are making me learn easy
Yes! Because they can be used to do anything
Yes! I like beads because I use them to decorate my watch
Yes! Because they help so much just like decorating it doesn't only decorate clothes
Yes! Cause they are suitable to my culture
Yes! Because you learn many things in it e. g to decorate
Yes! They bring colour to a person
Yes! They are helpful in terms of understanding something
Yes! Since I am super creative beads make my imagination go wild
Yes! Because they are colourful and beautiful
Yes! Because they are beautiful and could be used for art

Yes! I do like beads because they are beautiful and they are used to decorate traditional cultural cloths

3. What do you think beads are used for?

a. Beads are used to decorate cloths and design a beautiful clothing
b. For making designs such as necklace and traditional attire
c. To make jewelry and colourful handwork
d. For decoration on almost anything e. g clothing and handbag
e. To decorate and something to be more lookable
f. For jewelry mostly
g. To make decoration and jewelry and many things
h. Are used for designing
i. Beads are used to build some necklaces
j. Beads are used for decorating out traditional cloths
k. To decorate to make traditional necklaces
l. To represent or highlight something
m. To create things
n. Are used for doing colourful stuff
o. It can be used for making cloths or design
p. Beads are used for doing anything or any design e'g decoration for bags
q. Making and creating things

4. Can beads be used for learning? Yes---- No----

Yes! Making and constructing structures
Yes! By doing elements
Yes! It can be used for making cloths or design
Yes! Because you can learn to do things
Yes! To see colours of substances
Yes! To represent or highlight something
Yes! Beads can help use learn how to be neat
Yes! I can make molecules
Yes! Beads like in life science can be used for drawing
Yes! By building saccharides with beads
Yes! MoNoSaccharide, disaccharide and polysaccharide structure
Yes! Mathematics
Yes! I can learn how to make a structure formula of glucose, water
Yes! In kindergarten or primary school, beads can be used in mathematics, art and culture
Yes! They can be used to count with them
Yes! They could be used for making structure with and for counting numbers elements

Yes! You can make life sciences experiment and other subject experiment

5. **How do you think beads can be used for learning?**
   a. For experiments at school
   b. For designing structures and labeling some compounds
   c. To count with them and to be used when doing creative arts
   d. In mathematics, they can be used in terms of counting, addition, number pattern and the likes
   e. Because now I know how to draw a structure formula of glucose and water
   f. Subtraction and addition
   g. To see the difference between oxygen, nitrogen, and hydrogen flow they look in colour
   h. Cause it makes it easier for children to understand
   i. Beads can be used for arts, building beautiful projects
   j. Beads can be used for glucose molecules
   k. It can help to design anything
   l. In showing certain materials of products
   m. By showing learners of some elements
   n. Learn to create different things in different ways
   o. Design
   p. Yes! By creating things E. g elements
   q. Make giants molecular structures

6. **Should teachers use beads to teach in the classroom?**

a. Because they want us to understand about what they are teaching us
b. No! because it will disturb
c. Yes!
d. Yes!
e. Yes! Because they make it easier for learners to understand the concepts
f. Yes! It will be easier for learners to understand
g. Yes!
h. Yes! Teachers can use beads for showing learners their arts
i. Yes! it is easier for them to see it
j. Yes! So that learners will be able to understand in class
k. Yes!
l. Yes! From my experience, Beads makes learning fun and understandable
m. Yes! From my experienced, beads makes learning fun and lets me use mu creativity and imagination
n. Yes! Because they can be useful in classes and make work easier

o. Yes! So that we will understand some activities which we are doing and so that we could be creative to make art in life sciences and physical sciences
p. Yes! So that they can present science experiments

Appendix: F

Summary of Mr. Kagiso's Learners' Responses to Questionnaire

1. **Have you seen beads before? Yes …. No….. (choose one by marking X on the line)**
   If yes, what are the beads used for
   If no, what do you think beads can be used to do?

   L1. Yes! For making different things like designing
   L2. Yes! Because beads are used for decoration when knitting or doing something
   L3. Yes! They are used for making bracelets, decorate clothes, and to represent the bonding of elements
   L4. Yes! To create molecules or traditional jewelries
   L5. Yes! You can make baskets, shoes, and you can decorate your knitted cloths
   L5. Yes! Some are used for making jewelry
   L6. Yes! For decorating and they can be included in learning
   L7. Yes! To decorate shoes and cloths
   L8. Yes! Beads are mostly used for decorating and create a lot of things for arts
   L9. Yes! Beads are used for our cloths in our cultural things and creations
   L10.Yes! Bead are used for making bracelets
   L11.yes! Beads are used for making traditional bracelets
   L12. Yes! Creating you can necklace or bracelets
   L13. Yes! To make bracelets and to decorate shoes and clothes
   L14. Yes! They are used to make bracelets and necklaces
   L15. Yes! Beads are used for making bracelets and traditional clothes
   L16. Yes! They are used for making necklaces, bracelets and other things
   L17. Yes! For making brace lets or even shoes

2. **Do you like beads? Yes…. No ……. (Choose one by marking X on the line).**
   If yes, why do you like beads? If no why do you not like beads

   L1. Yes! Because beads are colorful and they decorate our creations
   L2. Yes! Because they make a beautiful work
   L3. Yes! Because they are fashionable and colorful too
   L4. Yes! Because they are beautiful and can create many things using them
   L5.Yes! Because they are beautiful and can create many things using them
   L5. Yes! Because when I see beads they remind me of my culture and doing traditional necklaces
   L6. Yes! Because beads can be used to make different and beautiful materials
   L7. Yes! Because then color are bright and they are attractive
   L8. Yes! Because it makes your art work beautiful and create many things using them

L9. Yes! Because they are beautiful and you can create whatever you wanna create
L10. Yes! Beads are fashionable and colorful
L11. Yes! Because they are colorful and lovely
L12.Yes! Because they decorate our cloths for culturing and that are colorful
L13. Yes! Beads are art and they show confidence in advertising out cultures like beads necklace
L14.Yes! Because most of them are colorful and they make things to look more beautiful
L15. Yes! Because beads can be used to create a lot of things (like cloths to make them colorful
L15. Yes! They are part of our cultural attire. Out attires are also made from beads
L16. Yes! Because they can make your art work look more nicer and beautiful
L17. Yes! Because they make a design look more colorful.

3. What do you think beads are used for?

L1.To design different things like making jewelry and traditional cloths

L2. You can use beads for learning in Maths and you can also use beads to make or decorate clothes and necklaces

L3. Decoration and other traditional things, more especially traditional clothes
L4. To decorate different types of clothes, shoes and e. t .c,
L5. They are used for various of things, decorate clothes and show use of learning
L6. To decorate clothes and for jewelry
L7. Beads are used to make bracelets or decorating cloths
L8. Beads are used to create fashionable traditional attires and jewelry
L9. It can be used to do anything you want to do also you can decorate
L10. To design cloths, bracelets and clothes using them to decorate
L11. They are used to make atoms
L12. Beads are used for making different objects like bracelets and traditional cloths
L13. They are used to decorate cloths,(cultural clothes) and shoes and they are used to make bracelets.
L14. They are used to create different types of jewelry and decorate clothes too
L15. For decoration in something
L16. I think beads are used for different objects by creating different objects like molecules, jewelries and a lot more. E. g decorations
L 17. They are used for necklaces and bracelets to wear to make us beautiful

4. Can beads be used for learning? Yes… No…..(Choose one by marking X on the line) If yes what can you learn using beads

L1. Yes! For combining atoms together, atoms that are bonding and sharing of electrons
L2. Yes! We can use beads by creating different kinds of molecules
L3. Yes! Life sciences
L4. Yes! I can learn life sciences and mathematics
L5. Yes! We can learn physical science and life science subjects
L6. Yes! Can learn more different things by making atoms (C02)
L7. Yes! Because it is easier to understand what is happening
L8. Yes! We can use them to learn life sciences and physical sciences
L9. Yes! Molecules
L10. Yes! Mathematics and life sciences
L11. Yes! We can learn Maths, Physical sciences and life sciences
L12. Yes! Beads can be used for learning because it can do the Lewis dot diagram for physics
L13. Yes! You can learn different of molecules by showing them different colour beads
L14. Yes! By indicating different types of bond
L15. Yes! We can learn to do molecules using beads
L16. Yes! They help us understood the molecules through how to their colours
L17. Yes! You can learn how to count in Maths and to form different kinds of micro/ organic organisms and making jewelry
L18. Yes! To design clothes and making jewelry. You can combine molecules by using beads and how to make structures with them

5. How do you think beads can be used in learning

L1. Maintain design things
L2. You can use beads as a calculator and to build organic organisms
L3. They help us understand the molecules through their colours
L4. They can be used by different colours to identify different molecules or atoms
L5. To show the bond in molecules
L6. To indicate the bond and do they bond
L7. They help to show different bonds in molecules and you can use different colored beads to show such
L8. I think beads can be used in learning to classify the bonds
L9. They can be used to show elements and for counting
L10. Beads can be counted for Maths or used to show elements in life sciences and bonds between atoms
L11. Because when you learn using them, you will never forget what you have done
L12. You can combine molecules by using beads and how to make structures with them
L13. By forming the atoms
L14. They can be used by making examples of what we are learning about

L15. We can learn how to create molecules and structures so we can be able to remember the structure when we write
L16. By representing different types of elements using different colour of beads
L17. By connecting them together while learning with oxygen and hydrogen and carbon
L 18. I think beads can be used in learning by creating colorful molecules
L18. By using them in atoms and elements

6. Should teachers use beads to teach in the classroom Yes… No…

L1. Yes! In order for learners to know the purpose of the beads
L2. Yes! Because it makes everything easy and possible to complete, and it would be hard for us to forgets
L3. Yes! Because the bonds can help us to understand more, more especially when we talk about the bonds in molecules
L4. Yes! Because it is easy for student to not forget thing, Cause most of us we like or good in visual learning and there will be no harms in using beads
L5. Yes! Some learners believe in what they see therefore it will be useful to show them by using different colored beads and represent the compounds using them
L6. Yes! Teachers must use beads to teach in the classroom so that we can be able to learn more and know the bond
L7. Yes! Because some or most learners understand better if they are doing practical
L8. Yes! Not all subjects will need beads for teaching
L9. Yes! Because it makes us to learn more about using beads and how to create structures using beads
L10. Because easier for us to understand it
L11. Because we will not forget what we did and it will be easy for us to remember the module we have learned
L12. Yes
L13. Yes! They use beads because some learners understand better when doing practical work (meaning using their hands)
L14. Yes! Learners can understand better if they use beads because it is more fun.
L15. Yes! Teachers will easily explain to learners how molecules are formed and how they present in their own colours
L16. Yes! Because we will never forget what we learned about the previous day and they will always be in our minds.

Appendix: G

Summary of Ms. Karabo's Learner's Responses to Questionnaire

1. **Have you seen beads before? Yes …. No….. (Choose one by marking X on the line)**
   L1. Yes! Decoration of the hair and cultural cloth
   L2. Yes! They are used to create things and decoration of cultural tradition
   L3. Yes! To conduct an experiment based on bonds of different molecules
   L4. Yes! Tradition and decoration of art
   L5. Yes! For jewelry in tradition
   L6.Yes! Used in making decorations on cloths mostly cultural cloths also hand bends
   L7.Yes! They are used for making compounds and for decorating
   L8. Yes! For decorations
   L9! Yes! The beads can be used for decorations
   L10.yes! Beads are used to design prototype models and even to decorate
   L11. Yes! They are usually used by traditional people to make bangles to wear on their hands
   L12. Yes! They are used to make necklaces, bracelets and design clothes (decoration)
   L13. Yes! Are used to combine two elements to form a bond
   L14.Yes! Necklaces bracelets and to design clothes and shoes
   L15. Yes! They are pretty and they make clothes look attractive and beautiful
   L16.yes! To make jewelry like bracelets, necklaces, to also design clothes and decoration
   L17. Yes! To decorate clothes and to make bracelets
   L18. Yes! To decorate clothes and used as jewelries
   L19. Yes! Because you can use them to make bracelets
   L20. Yes! To design clothes or decorating clothes and doing bracelets
   L21.Yes! To decorate clothes in my culture
   L22. Yes! To make bracelets or necklaces
   L23.Yes! Usually they are used to make bracelets

2. **Do you like beads? Yes…. No …….(Choose one by marking X on the line).**
   L1.Yes! They can form any decoration and they can also be used to form better understanding of bonds
   L2. Yes! Because they can be to form any decoration
   L3.Yes! Because its easy to understand the colours show which bead is it
   L4. Yes! They help me understand any chemical formula
   L5. Because you can make a lot of designs and create lot of things
   L6. I think they can make a good decoration in cultural clothes and also creating art
   L7. They make us to understand about molecules

L8. Yes! Because they a=can be used for many things
L9.Yes!
L10. Yes! Because I can use them to design models and even to decorate
L11. Yes! I like beads because they are very useful in learning
L12. Yes! They are beautiful and they make clothes beautiful
L13.Yes! Beads teach us to form a bond of two different elements
L14. Yes! They are beautiful and they things look nice
L15. Yes! They are pretty and they make clothes look attractive and beautiful
L16.Yes! Because I can wear them of my hands
L17.yes!
L18.Yes! For jewelry
L19. Yes! Because they decorate clothes nice and they make clothes colourful
L20. Yes! Like doing bracelets
L21.Yes! They are colourful
L22.Yes! I like their colours

3. What do you think beads are used for?

L1. Decoration, creativity, but mostly for making things beautiful
L2. Beads are used for the decoration of clothing and many things
L3. To make an experiment that is based on bonding molecule to form a structure of that molecule
L4. They can be used for clothing and designing of any structural formula such as ($C6H12O6$)
L5.For traditional designs and jewelry
L6.I think for creating that inner cultural beautiful clothes
L7.for decorating
L8. Decorations of designers
L9. Decoration of cloths
L10. Beads are used for decorations and even to design models e.g a structure of organic compounds
L11. They are used in some traditional clothes especially in the Zulu culture
L12.They are used to design traditional bracelets, necklaces and Maths
L13---
L14. Design clothes, shoes and necklaces, bracelets
L15. –
L16. To make bracelets
L17.to make bracelets and to decorate
L18. –
L19. To make bracelets
L20. To design clothes and doing structures

L21. To make handmade jewelry
L22.for making organic compounds (make a model)

4. Can beads be used for learning? Yes… No…..(Choose one by marking X on the line)

L1. Yes! Who chemical structures work and for better understanding and to be seen
L2. Creating different compound with different beads
L3. Yes! They make me understand the differences between the structure of a bond is formed
L4. Yes! Creating and structural formula for physics and life science
L5. Yes! By creating structure and models like atoms
L6. Yes! Making compounds such as water
L7. Yes! To make molecules with them
L8. Yes! Counting
L9. Yes! We can learn how to count for science adding and subtracting
L10. Yes! Learning how to decorate and learning how to design things
L11. Yes! To make bonds between organic compounds
L12. Yes! You can present diagrams so that you can understand them better
L13.making a bond molecule
L14. Yes! They can be used to make models of elements and compounds in sciences
L15. Yes! They can be used to make models of elements and compounds in science
L16. Yes! To construct molecules and teach learners more about the molecules
L17. Yes! To create model of molecules
L18. Yes! For bonding molecules
L19. Yes! To construct molecules or elements or to crate models
L20. Yes! Using them to do models and construct molecules
L21.Yes! To make structures representing organic compounds
L22. How different elements bonds and how bonds can an element have

5. How do you think beads can be used in learning?

L1. By forming idols by using beads in order to explain
L2, they can be used to create compounds
L3. To show different colours of beads which is in order to conduct an experiment.
L4.to help any learner understanding and also for practical solution
L5.By creating structures and molecules
L6. Learning is supposed to be fun and interesting therefore unlike knowing the structures or compound you can create your own by beads
L7.Because it’s easy to understand about beads
L8. Counting or in school projects

L9. By making examples and models
L10.By making examples and models like the one above
L11. Beads can be used to form bonds of organic compounds
L12. Design models of structures that are found on our school
L13. Making use of molecules and its forming of bond and combining molecules of different kind of beads colors together
L14. To design traditional clothes, necklaces, shoes and bracelets
L15. To make models of structures of compounds (atoms) in our school, by doing that, it gives us a clear picture of what the teacher is talking about.
L16. They can be used to construct models of element and molecules
L17. To create models of elements using different colours to distinguish between the elements
L18. By showing the type of bond double bond or single bond
L19. To construct molecules
L20. To show structures of compounds
L21. They can be used to illustrate models of things which can help learners understand
L22. Different elements will be given colours and learners can use beads tom make a model of an organic compounds

6. **Should teachers use beads to teach in the classroom yes… No…**

L1. Yes! Because learners will get to imagine the shape of the molecules and get to form them using beads
L2. Yes! Because forming different thing using the bead can encourage a learners mind
L3. Yes! Because the show as which is which and make an experiment by applying what the teachers taught as other to gain knowledge of their use
L4. Yes! For learners to understand in class and to check their understanding
L5. Yes! Because it's creative and fun to learn in that method and help learners to learn better
L6. Yes! A type of lesson would make learners have full dedication in terms of wanting to explore more therefore teachers is they teach using beads they would be helping also themselves
L7. Yes!
L8. Yes! Because beads can make examples and life easier for learners
L9, Yes! Can help to make examples and life easier for learners
L10. Yes! Because beads can make examples and life easier for learners
L11. Yes! Teachers can use beads for life sciences when we are dealing with organic compounds

L12. Yes! Present structures /diagrams in a simple way that can help the learners understand them better
L13. Yes! To make learners get used of bonding molecules so that they can easily be able to make molecules or bonds on their own
L14. Yes! Present structuring in a simple way that learner can understand the use of beads
L15. Yes! So that we can have an imagination of what the teacher would be teaching about
L16. Yes! So that they can teach learners to visualize aht they learn in class during lessons
L17. Yes!
L18.Yes! We can use them to explain more about bonding and structures such as methane (CH4)
L19. Yes! Because it makes it easier for learners to understand
L20. Yes!
L21. Yes! Some structures are difficult to understand, e.g. structures of alcohols and fatty acid. These beads making teaching and learning easier
L22. Yes! Learners would learn how to make models of organic compounds in their different forms and how to make double bonds using glue and different beads.

Appendix: H

Summary of Ms. Mbali's Learner's Responses to Questionnaire

1. **Have you seen beads before? Yes …. No….. (Choose one by marking X on the line)**
   L1.beads are used to decorate or make necklaces and cultural cloths
   L2.Beads are used to create nice and beautiful thing for example traditional clothes
   L3. Making jewelry and decorate and culture cloth
   L4. Most of the time they are used to make traditional necklaces and bracelet
   L5. To make jewelry mostly used in traditional attires and also to make sculptures
   L6. Beads are used to decorate sometime you learn with or create something like necklaces
   L7. Beads are used for decorating clothes, bracelets and necklaces
   L8. Used for decoration in making necklaces, making African clay pots and decorate them
   L8. Beads are used for making bracelets and necklaces. Some are used to decorate hair
   L9. They are used by our cultures when they make cloths or bracelets
   L10. They are used to decorate the cloths even to use them for learning so that we can understand better
   L11. In most cases, it is used for knitting Zulu clothes or hats
   L12. Beads are used for decoration mostly traditional attires and other things
   L13.Are things which they use to make jewelry and other beautiful art work
   L14. Beads are used to make things like, necklace, earrings and such things
   L15. Making necklaces and bracelets to wear with traditional clothes
   L16. Beads are used to create something that can be useful or connected together like a bracelets.
   L17. They are used to decorate things such as necklace and traditional
   L18. They are used to decorate fabrics or traditional clothes
   L19. Beads are used for making jewelry for example bracelets and necklace
   L20. They are used for making necklaces, bracelets; they are also used when making jersey
   L21. Beads are mostly used for making necklaces and bracelets
   L22. Beads are beautiful circle or shaped and some are colourful and or used to make necklaces and bracelets
   L23. Beads are used for making necklaces and bracelets, some used to decorate children hair
   L24. Hairstyles, decoration, jewelry
   L25. It is used to make jewelry
   L26. Mostly in our country, people use beads to design traditional clothes
   L27. Beads are used for counting and many more. It can be used to make something like necklace

L28. To make necklace and many more
L29. They are used to make jewelry that mostly women wear on their neck
L30. Beads are used to sew traditional clothes for them to be colourful and beautiful
L31. Beads are used by our grannies to design traditional skirts and other traditional things and they are still used
L32. They are used to make necklace, traditional clothes
L34. Beads are used to make bracelets and necklace even school projects
L35. Beads are used to decorate traditional attires and some are used to make different and of necklaces
L36. They are used to make a bracelets and necklace
L37. To create necklace and design clothes or shoes
L38. Beads are used to decorate clothes especially tradition and make necklaces
L38. Beads are used to make some of our traditional clothes they use them to make necklaces
L39. They are used to make bracelets
L40. Beads are used for different ways people use beads for jewelry
L41. Beads are used for representing elements of the periodic table
L42. Beads are used to make bracelets and decorate shoes, cloths
L43. Beads are used to make traditional necklaces
L44. They are beads for traditional thing.
L41. To do traditional decoration clothes
L42, Beads are used as decorative tools for objects/ anything you can create using your hands
L43. Beads are used for traditional jewelry and some designs in clothes
L44. They are used to make necklaces
L45. Theyare used to make jewelry and colorful clothes
L46. Beads are used for making or designing attractive clothes
L47. They are used to make traditional necklaces and other things

2. Do you like beads? Yes…. No ……. (Choose one by marking X on the line).

If yes, why do you like beads? If no why do you not like beads
L1. Because they make your cultural clothes to be colourful and lovable
L2. Because they make traditional clothes to become more colourful and beautiful like a peacock
L3. Because it makes cloths look good
L4.
L5. Because I can make some necklace using beads either traditional one or modern. It attracts viewers' attention
L6. Because they teach me how to be creative and make unique staff like decorating your clothes with them

L7. Because they make our traditional clothes to look more beautiful and colourful
L8. I can use them to decorate my star to look beautiful
L9. I like beads because they make our traditional clothes look more stunning
L10.Each of them is unique and each colour has a meaning, they are used to form cloths, bracelets and necklaces.
L11. Because they do many different things in our culture and in our subject we learn about them
L12. I like beads because you can make anything artistic with them
L13. Many learners prefer using glitters for decorating and not beads so by using beads it's going to make me unique
L14. I like them because I can make things that are beautiful out of them and also something that is creative
L15. I like them because I can connect them and make anything that I need
L16. Because majority of people who are creative often use beads to create things.
L17.Beads are beautiful and natural, they make you shine brighter and I like creating my own project
L18. Because they make what you are wearing to look nice
L19. Because they are so little and yet they can make something look beautiful
L20. Think they are useful and they make calculations easy and make bonding to be seen easily
L21. No! They are somehow not related to me career and interest.
L22. I like them because you can use them to count in mathematics and they are very colourful
L23. Because beads can make you to look outstanding and beautiful
L24. Because beads decorate my clothes especially cultural ones to be colourful and bright
L25. Because my father was given beads by my mother for engagement and I am planning to do so
L26. Because it makes a good source of making good traditional clothes and jewelry
L27.Because they can make most of the clothes look gorgeous and I like beads because I can design with them
L29.No! Because beads are for women so I don't like many colours
L30. They are lovely when worn with traditional attire
L31. Because beads make our traditional clothes colorful and I think they represent the rainbow nation
L32. See, beads remind us where we come from and before having clothes, beads were used for making us traditional cloths.
L33. Because they make your work look beautiful and creative
L34. Beads represent a lot of things and they show creativity of people

L35.beads colours are colours that are on the South African flag that represent South Africa and represent unity

L36. It’s because I can make any bracelet and very nice and I love different colours

L37. Because they are different colours and their necklaces are beautiful and brighter

L38. I like beads because I think when I am wearing a necklace made out of beads dignity within me restores, and I know where I am coming from

L39. I like beads because without them they won’t be interested in your traditional dress

L40. They can make someone’s art work look beautiful, since they have different colours

L41. Because they bring different things in our life every and we learn more things about them

L42. Because they are good examples when dealing with elements or decorating cloths with them

L43. No! Because of the carrier that I chose and not interested in beads

L44. Because they make you look spotless and spontaneous whenever you are wearing clothes or something

L45. Because I believe that beads make thing look colorful

L46. Because of many people are liking beads and especially in traditional thing

L47. I like beads because they make an object attractive and unique

L48. Because they played an important role in the history of our ancestors

L49. They are beautiful and colourful

L50. I like beads because they are beautiful and you can make a bracelets with them

L51. Because it has beautiful colour and texture so they make designs attractive

L52. No! Because beads are mostly weaved by girls and if you are a boy and you wear beads, people will think you are gay or something.

3. **What do you think beads are used for?**

L1. Beads are used for decoration and things

L2. Beads are used for creating cultural clothes, small car for children, school bags, hats, earrings

L3. They are used for decorating and making cloths to look good so that people can like or buy

L4. I think beads are used to make things look more colourful such as clothes and earring

L5.creating craft work like bowls, clothes for decoration also jewelry for tradition and even modern cloths

L6. Identify elements in subjects of physical and life science and also atoms

L7. For making glucose and fructose or other things.

L8. I think they are used for decoration

L9. They are used for decoration in other to attract and make your objects much more beautiful and colourful

L10. I think beads are used for decoration

L11. Cloths and bracelets
L12.beads are used for making cloths, to look beautiful even to decorate our hands by beads and its looks good because they are teaching us a lot about the beads
L13. For making clothes and necklaces and some other things I don't know about
L14. Beads are used to decorate
L15. Beads are used for making jewelry and also some colourful artwork and used for learning, making a lesson more interesting
L16.They are used to make things like jewelry
L17. For making things that needs a person's creativity e. g bracelets. And also cloths that are visible
L18. For making bracelets, necklace
L19. They are used to decorate, make things to look good and even in our tradituinal cloths
L20. I think they are used for learning, decorating, sowing cloths or any other fabric
L21.Are mostly used in traditional costumes such as necklace and bracelets
L22. They are used for making necklaces, bracelets and some clothes. They are used for teaching
L23. In our culture, they are used to make bracelets and necklaces. In science, they are used to show examples, in Maths; you can use them to count and teaching about probability
L24. I think that beads are used to make necklaces and bracelets and are worn by people for them to look beautiful
L25. They are used for decoration and decorating things
L26. Knitting, bracelets and chains
L27. For making jewelry and traditional clothes and are also used for decorating
L28. Mostly, beads are used to decorate cloths, and they can be used to decorate at the weddings and other peoples can put beads on their heads so that they look shinny, they can also be used for learning
L29. Creativity
L30. To design traditional clothes, shoes and hats
L31. For making things e, g cloths look lovely, with the matching colour when worn
L32. They are for traditional clothes and to represent our South African rainbow nation and to just make clothes colourful and beautiful
L33. Beads are used for playing, designing and decorating to make other artificial things
L34. Beads are used to do bracelets and you can decorate a house or your artwork
L35. Beads are used to represent a certain attire and its behaviour using coloured beads
L36. I can use beads for decorating things that can decorate a certain place and I can use beads to decorate casual clothes
L37. Beads are used to make anything look very nice and I love different colors
L38. To make necklace and to decorate traditional clothes and shoes and hats

L39. I think they are used for learning and exploring and also for
L40. Beads are used to represent some practical in life science and they are sued to decorate our traditional clothes.
L41. They are used to make bracelets and also earrings
L42. Beads are used in different ways, some people use beads to decorate in their houses or clothes and some use them to make jewelry
L43. I think beads are used for making examples for children when dealing with elements
L44. To make bracelets to decorate shoes especially tradition people. Also to calculate and sew
L45. Beads are often used by traditional people to create traditional beads by combining a lot of different beautiful colors
L46. They are used for traditional things and in some city they are used to calculate
L47. Calculating and sewing color chain with beads
L48. I think beads are used to brighten up or uniqueness and to attract and decorate
L49. Decoration, jewelry and clothing, decoration with designs
L50. I think they are used for making earrings
L51. They are used to make jewelry and traditional healers uses them to make necklaces
L52. Beads are used for making clothes to have colour and more variable and can be creative and make jewelry.
L53. Beads are used to make traditional necklaces and they are also used on clothes to make them unique.

4. **Can beads be used for learning? Yes… No…..(Choose one by marking X on the line)**
If yes what can you learn using beads.
L1. Yes! Because in life sciences we used coloured beads to differentiate.
L2. Yes! Because they may represent elements from the periodic table
L3. By making project in school
L4. To identify the element by using different colours of beads
L5. Identifying elements in subject of physical and life sciences and also atoms
L6. You can calculate with or make some science stuff like making hydrogen or carbon and all of that
L7. You can learn to see different elements and compounds and different colours
L8. They can teach people how to knit and make their own objects.
L9. According to life science, we use beads to differentiate the elements
L10. No! They are small easy to get lost
L11. We learn how to do the ion bonding in life sciences
L12. You can learn Maths and life science and also physics
L13. Mathematics, life sciences and physical sciences
L14.mathematics, they can help me count, physical science, they can help me make compounds e.g. NaCl

L15. I learn how to make things that can be also used by others
L16.Life sciences, physical sciences, and also orientation actually all subjects.
L17. You can learn how to connect or bond compound or elements even atoms
L18. Yes! To do different things such as the balancing things for physical
L19. Yes! Bonding elements with them or counting with them
L20. Yes! To see chemical bonding very well and use in Maths to calculate
L21. Yes! How elements and compounds are placed in physics and life sciences
L22. Yes! You can learn to count and use them to understand probability
L23. Yes! You can use beads maybe doing practical with them
L24. Yes! Interims of life science we used different coloured beads to identify compounds or elements
L26. No! Because it will take time and every subject would be difficult even L.o
Yes! Yes! For those who do creative, they can use beads to create new and nice designs
L27.Yes! I can learn to do the experiments and the projects
L28. Yes! You can learn mathematics, physical sciences, life sciences
L29.Yes! To make examples for different things
L30. Yes! I can learn making compounds out of my given elements physically
L31. Yes! Life sciences to represent elements
L32. Yes! We just used beads in class to symbolize different elements in different colours
L33. Yes! Projects for decorating things for arts subjects and also for life science to
L34. Yes! Beads can determine how hard or simple a certain thing is and beads can give ideas
L35. Yes! I can learn how to make a certain formula using beads, like making a formula of glucose
L36.Yes! If we use beads in Maths we can have more 80% pass mark in Maths
L37.Yes! So that they can be used to represent something
L38.Yes! I can learn about elements E.g. how many oxygen in fructose
L39. Yes! You can but if you are doing practical for example, we have used beads to represent a glucose diagram
L40.I can learn how to draw some scientific diagrams using different beads
L41. I can learn many different things using its such as Jewelry and many more
L42. Yes! When dealing with elements they are good examples
L43. Yes! To make the bracelets
L44. Yes! You can learn numbers by counting beads
L45. Yes! You can learn how to calculate using beads
L46. Yes! Calculating using beads
L47. Yes! I can learn how to balance equations in physics, be more creative
L48. Yes! Beads can be used to demonstrate the molecular structure of elements and compounds
L49. Yes! Life sciences

L50. You can learn to count using beads in Maths and they can represent the atoms
L51. Yes! Beads attract attention of a student and it makes you to understand better
L52. Yes! You can classify the use of beads in elements and compounds.

5. **How do you think beads can be used in learning?**
L1. Yes! By giving the children from lower graded to use them for counting.
L2. Yes! By making a key table for which a bead represent an element for example pink bead represent oxygen
L3. Yes! By using chemical molecule structure in life sciences and other subjects
L4. Yes! To identify the element of periodic table and it is easy to understand
L5. Yes! By differencing elements and compounds in class of science so that learners can understand easily and become understandable
L6. Yes! Can be used to be an examples of making glucose or calculate
L7. Yes! They can be used in term of knowing how to make colours be colourful and to know different colours
L8. They can use it to make and because it's part of it
L9. Beads can be used in learning mathematics to count numbers with a compass
l10. By calculating them
L11. By teaching us with beads to understand better things especially in ion bonding we wont be confused when we learn with beads
L12. In Maths they can be used in a form of adding the terms or same colours and in life sciences and physics used for the elements
L13. To represent a certain group according to their colours.
L14. We can use the mostly in physical sciences in making many compounds because they can act as elements
L15. To create the elements that would be provided
L16. By counting and making something out of them, and for representing types of compounds or elements
L17. I think that beads can be used as an instrument on how to bond compounds and creating jewelry in some other subjects as if it's a project and needs to be creative
L18. To mix them and make them to mean something
L19. Yes, they can be like any other thing you use for learning
L20. They can be used to make chemical bonds and solving mathematical problems
L21. By placing beads in the form of compounds and elements. You can also use them for counting
L22. You can make examples and differentiate things, to understand things easy
L23. Because there are different in color and you can use maybe doing practical to differentiate
L24. For grade one (1) for a compass so that they can learn how to count numbers
L25. For making chemical structure in life science, physics and use mathematics

L26. They can be used for making chemical molecules structure
L27. They can be used to do home works, projects and experiments if the teacher has given it to you.
L28. By giving the different colours a different heading
L29. To make examples of different things
L30. They can help us identify elements making a compound when attached
L31. They can be used as elements in physical sciences and life sciences
L32. For children in primary their teachers can use beads to symbolize different colours for the learners
L33. They can be used by highlighting and demonstrating for the kids as a teacher
L34. Teachers can use beads to highlight learners' minds and illustrate or demonstrate with beads during a lesson
L35. Beads can be used in learning because most of the children are struggling to understand things that the teacher is saying so when they make examples they will be able to understand
L36. To calculate in Maths and to help those who can't calculate.
L37. To do something interesting like designing a chart with beads
L38. They can be used by representing something such as Nitrogen and other things such as Nitrogen and other things depending on the subject
L39. They can be used in many ways like to do a life science practical we have used beads to show that this is a oxygen (pink B) Hydrogen (White B) carbon (Black B)
L40. Beads can be used in Maths is a person doesn't have a calculator and can also be used in life sciences when we draw diagrams
L41. As we all know that beads can be used in learning we use beads to make H2o which is water
L42. By comparing element with beads because beads are colorful and have different colours
L43. Can be used by making bracelets and to decorate your shoes
L44.beads can be used in learning by helping the learners who can't use calculations or who can't count numbers. Though they can use beads for help
L45. In some city, they don't have technology like we do but they use beads to calculate
L46. For small children to calculate using beads
L47. They can be used as unique tools to have a clear picture about what you are being taught. They can be used as a mind explorer
L48. They can be used to illustrate the structure of elements in the periodic table
L49. They can be used to do some practicals
L50. We can use beads to represent the atoms of a compound
L51. I can use beads to do some calculations in mathematics and in physical sciences in making many compounds

L52. To classify the use of beads in elements and compounds

6. **Should teachers use beads to teach in the classroom yes… No…**

L1. Yes! Because I think it is easier and understandable when using beads.
L2. Yes! Because we will know which bead represent hydrogen and which bead represent carbon.
L3. Yes! Because they can teach us many things with beads that we do not know
L4. Yes! It's because beads are more understandable
L5. Yes! Learners would be easier for them to identify elements and so that they can remember easily in examination
L6. Yes! If they don't have something to present with it can be helpful
L7. Yes! Because they are some learners that are slow in learning so they didn't learn well in primary
L8. Yes! They can use them for learning purposes.
L9. Yes! So that we can get a clear vision
L10. No
L11. Yes! Because they make our lives easy because some children in school they don't learn things first so the beads will make them understand more better
L12. Yes! They can help learners who don't understand by making it look easy and simple and also fun
L13. Yes! Because as learners we are not the same some learners may find it easy to understand the teacher when the teacher is teaching using beads
L14. Yes! Because when teachers are making examples it will be easy for us to understand when seeing the demonstrations they made with those beads
L15. Yes! Because they have to teach us how to use them and tell us more about what is happening within them
L16. Yes! I think that is a great thought because as learners we can be able to different according to their colour and can see what each bead represent.
L17. Yes! Because sometimes there is no need to illustrate but only to read, write and draw. Sometimes you may find that those beads are too small to accommodate everyone eyes, it won't be clear and sometimes others can be confused because they don't see clearly or they don't understand the use of beads
L18.Yes! Because we understand better.
L19. Yes! Cos people will be attracted to them and may concentrate better
L20. Yes! I think learners should be the ones using the beads so that they can be constructive and be able to think and work on their own
L21. Yes! Because most of the learners are interested on the lessons where they use beads
L22. Yes! So that students can understand things better in class and make is simple for student who don't understand quickly

L23.yes! To make an experiment like using the colour of the experiment and to differentiate them
L24. Yes! Using object to explain things, it makes it more clear that what is meant by something, so that we children can get a clear vision
L25. No! Because it will be difficult to give children class works and home assignment because the children will steal from each other because the thieves in class because they are poor
L26. Yes! Because it becomes more easy for children to complete their assignment and home activities
L27. They can use them when they give us the work to do if that work needed beads
L28. Yes! Because some kids do not understand the book but want they o an experiment they can remember the colours by beads
L29. It is easy for the learners to catch up easily
L30. It would be useful in cases such as balancing equations and making compounds
L31. Yes! Because they sometimes make us learners to understand easier/better because some of learners in the classroom they are slow learners
L32. Yes! Because other learners or other people are colour blinded so maybe beads of different colours can solve this science
L33. Yes! So that children could know what beads are for doing what and so that children have more information about them?
L34. When the teacher play around with the colours children will start exploring a lot about the lesson and they will easily understand the procedure
L35.Yes! Teachers can use beads to learn in classrooms because they are learning and they are able to make experiment with them
L36.Yes! Because some of my friends can’t calculate in Maths and it can help us to get more 80% in class
L37. Yes! Because others children won’t understand while you are teaching so you can’t make example about the beads to understand
L38. Yes! Because they will be doing it practically and it’s easier to understand practically than using theory
L39. Yes! Because they can help in order to use to see the difference of and oxygen, hydrogen, carbon in a life science test or practical
L40. No! If you are using beads, you need to have patience and take time so we as grade 190’s cannot be taught with beads because we do not have enough time
L41. Yes! Because i think is the easy way to make us learn to understand in class. Because some teachers are understandable in the class so it’s hard for us to concentrate
L42. Yes! Because it is going to be easy for learners to understand the elements in the periodic table
L43. Yes! Because the beads are used at the tailor and also at the classroom to calculate Maths

L44. Yes! But not in high school learners because high school earners know how to do numbers though we use calculator when counting so actually beads would be a waste of a lot of time in high school
L45. NO! Because they are something that need a calculate and it is impossible to solve the problems so No
L46. Yes! Beads are used in traditional clothes and also in classroom to calculate and mixing colors beads
L47.Yes! Because thy can give a clear picture about what we are being taught.
L48.Yes! Because children learn better when they are shown examples
L49. Yes! I think it will be convincing to learners
L50. Yes! Because when they teach they can use beads to show examples of what they are teaching to make learners understand better
L51. Yes! We will understand easy and better and then are not forgettable and then are even more attractive then need attention.
L52. Yes! Teachers can use beads in the classroom because using beads is more understandable if you are learning about elements.

Appendix: I

Mr. Brighton – Video Stimulated Recall Interview

Participants	Discourse
Joshua	Can you send me this video to my email Yes, but I am to first attach it to my email. I can send it. I have this one and the normal one Di I need to put it on a speaker. I just want us to compare what happened in this intervention class and the other normal class You know in this type of class
Mr Brighton	Hmm
Joshua	There is emm
Mr Brighton	There is the teacher area, there is the student area
Joshua	Yes
Mr Brighton	You were able to handle your class properly because of you expertise
Joshua	Yes Like in mr. musa s class, some of them were sleeping in the class
Mr Brighton	This type of way of teaching shows you had a grip You were given them more oxygen at intervals to make them alert and so on It is very important Because you know that a 45 minute lesson Only a content can be taught in the first 20 minutes. After 20 mins they would concentrate again, so you just make them alert by cracking jokes. We are trying to stimulate what we would have taught them in the first twenty minutes That is why they say after teaching for 20 minutes, they have to leave 5 minutes So teach them content for 20 -25 minutes then the other ten minutes for revision with jokes But if you are not doing the lecture method like we have here, you have to interrupt the serious business with jokes So that they can pay attention This is a lecture method

	And do you think the lecture method is the best for this The lecture method is always good for the higher learners But for the grade 8, 9 , 10 you cannot use the lecture method They would not understand that Thays why you have to use the demonstration, experiment and observation method Because their cognitive skills still have to do with developing Alright Let me go to the intervention class And lets compare what has happened In this class, I discovered that some of them where dancing, smiling, speaking to each other They were happy at what they did, we saw excitement, they were alert It kept their attention span You see these students were brilliant This one and this one They were number two and number three from that girl What I am saying is what is the difference between this way of teaching to the other way of teaching And which one do you prefer between the two Every method has its pros and cons This one where we use demonstration and experiment Is good for learners to understand concepts After they have practiced and done them themselves. They will always remember what they were doing It quickly makes them assimilate the content and it also captures even the less academic less gifted Oh ok This method It capture the And the beauty of it is that those smart can also assist those who are less gifted =that is this method So it has got advantages Because we are activating so many senses Senses of touch and visual senses You know Those are the main senses and they are so important as far as learning the concept is concerned What is the bad part of this method

	If the teacher is not supervising them table b y table There are others who are going to be completely lost And disenfranchised from the lesson A teacher must supervise and see what is happening It requires constant supervision So that the teacher can see all the groups Why do you think they were smiling Like in said, this ones were taught these things before you came But then we had not done a model so they are now excited at seeing it fir real They are excited to see how it looks like in terms of real structure They were stimulated because the know glucose was a moNoSaccharide But they were even more excited because they are seeing how it looks like for real Whether it is linear or cyclic They were seeing the real structure Exactly Yea You were saying that its get their attention Exactly They are excited here because they are now seeing the real thing Of what they were taught So because they were not introduced to the real structure , they on it have wild thoughts about the structure But now they see it That's why they were excited So I think it's the Aha moment The eureka moment\that was y they were excited Can someone else come to the class and take them through those process , is it independent of the teacher or Is because you were there It is not independent of the teacher because as I am saying I did chemistry and biology so it has to be knowledge taught, skills taught, prior knowledge And then the you know, not everyone should be able to do this have then to do two lessons Unless you

	One lesson where you teach them the content and the other lesson or say we are now going to show you So you saying it can be done in two lessons Two lessons If it has to come into the curriculum , it says it must be a special period for this Yes You know why The first lesson you would be saying introduction, we are telling you how these compounds are found and we are going to show you how they for m these lesson so if you have to do it at the same time. They have been taught the theory first giving them what we call schema into their brain so that we can then expose what they have into real life So it must always be this one of models following this one we taught in class Or if you are not teaching them, if you ask them if about the prior knowledge, when they tell you glucose they know, fructose they know then you can go ahead. Do you know how they look like? That they must tell you elements that make up glucose, correctly, the three of them And they say lets show you different colours for different elements Ok Em, I heard them speaking their dialects but in you so called normal class, they were not speaking their dialect Why do you think they were Of course they were using it to explain to themselves Your question is going to support what the department is talking about To say science is to be taught in vernacular So obviously by speaking their own dialect, someone was not understanding what was supposed to be done so they had to speak their own language Why didn't they speak it in your class May you did not give them , or there was no space or time to do it Lecture method , you remember we have talked about it The cons, the disadvantaged The disadvantages of a lecture method

	The reason why they did not talk about it is because a lecture method, the teacher thinks that the learners are tabular rasa They have no prior knowledge Which is not necessary correct\ They know something Even if they do not have the correct effects, they know something And lecture method is like A teacher is like a preacher Where you don't raise your hand to say mr preacher , don't you think this is this That lecture method No opportunity to do that So its them just been attending, and assimilating all that is being given to them That's why they were quite Because the learner The lecture method you can control You can control the learners But some tea hrs can also not control because they will be talking, Is actually looking at lecture theaters at the universities You know how they are that the chairs are going down the The lecturer will be visible to everyone And they will be seeing everyone So that way you have everyone under control That's the beauty of everyone under the lecture method That is why they were appearing as if they were well behaved But is because two of the learners or two were not there that day If we had used this method at that class and they were they we would have not known. We would not know whether anybody is stubborn or not Like by using the demonstration method, by experiment You are taking them at the same level Including like I always say Those who are not as gifted they would want to be seen to be participating Now if it is lecture method know you will see after giving the lecture for 10 mins this is when you see the learners weak point ,

	when you open it for questions So you see Can you explain further this or that I have not understood this that This is the lecture method Which one will you prefer most If we had a material in would prefer demonstration method You see this skeleton here, I can teach them all the skeletal parts but if they do not see them they would never know what is tibia, fibular, what is so and so But the moment they see it in class, this is what is hidden under your skin , then the understand it more It also makes understanding of a concept quicker not on it is it quicker, it is long lasting Like I always say to learners, if I ask a question and any learner choses to come close to the front to explain. I am always telling them, come November, this learner will never forget Because they will remember because they would remember that on this day I was asked this and I said this And the teacher said this So demonstration have got better results than lecture The lecture method is not user friendly to grade 8 -9 even grade 10 They will be totally lo\st You will see even grade 10 They will be totally lost Lecture methods are only used in upper grades where they are s little bit more matured Unknown academically And their brain are sharpened up At university we were doing spectroscopy, and dissection of animals, we were doing direct Ourselves, and lecturer will supervise It does not have a limit, but from the lowest of levels, Up to the highest you can use demonstration method, but lecture method you cant That why if you have a child, maybe who is three years old.\, if they do something wrong, you cannot d]say sit here my daughter Let me tell you how you are suppose dto behave in life and you expect them to understand you

	And they wont They only way to demonstrate like caning' Here if you cane learners you are doing it at your own peril. If in a class you see there are not resources, what do you do instead of a lecture method Do you innovate? Like what you are saying now, do you innovate, or what You have got a laptop.and the beauty of it is that grade 10s do not have a smart board But with the apto and the lessons on its own, let d]=see what this … was doing You think do, em parertns will go home to tell them they did thid and that Yes Some will even want to do it as home The only time I have seen that the parents are interested is when they are given report cards. This one was saying this one looks the real deal And he is one of the weaker learners It will even capture those less gifted academically So the grouping of this class you think the dull ones went to a group[And the most intelligent learners sit in the front The dull ones sit at the back.

Appendix: J

Brighton's Learners' Video Stimulated Recall Questionnaire

1. Which one would you prefer: the activity class teaching mode or the lecture mode of teaching and why?

L1. Activity class. Because we need to know our mistakes

L2. Activity class

L3. Activity class. Because it is fun

L4. Activity class. So that we understand more in the class

L5. Activity class. It helps in terms of not forgetting what you have learnt

L6. Normal class. Because you get to ask, anything from your teacher if you don't understand, so in activity class they tell us what to do and we don't get to ask question.

L7. Activity class. Because we will not fall asleep
L8. Activity class. Because we don't fall asleep.
L9. Activity class. Because there are many funny activities
L10. Activity class.
L11. Activity class. Because it is fun than the normal class most sleep
L13. Activity class. Because it is fun
L14. Activity class. Because it is fun
L15. Activity class. Because we enjoy communicating together
L16. Activity class. Because everyone will know what we are doing
L17. Activity class. To exercise our brains and gain knowledge.
L18. Activity class. It's more hands-on and better for slow learners.
L19. Activity class. *It is understandable and fun.*
L20. Activity class. It is fun and I can express myself creatively.
L21. Activity class. It's good for the mind
L22. Activity class. Because activity class is much fun and hyper
L23. Activity class. Because it is physically active.
L24. Activity class. Because we all have more options.
L25. Activity class. Because we do what we know.
L26. Activity class.
L27. Activity class. Because we want more activities.
L28. Activity class.
L29. Activity class. Because it is very interesting.
L30. Activity class. Because you can be creative.

L31. Activity class. Because it makes learning easy

L32. Activity class.

L33. Activity class. Because we learn in class with other learners.

L34. Activity class. Because there are lot of activities.

L35. Activity class. Many activities.

L36. Activity class.

L37. Activity class. Because you can easily answer questions

L38. Activity class. Because there is different activity to do.

L39. Activity class. Because it is having few work.

L40. Activity class.

L41. Activity class. Because there is an excitement going on.

2. Which one do you prefer? Group work or learning individually and why?

L1. Work in group, because we understand better than working individually

L2. Groups

L3. Groups, because we come up with different ideas

L4. Individual, To avoid people who take credit for other learners.

L5. Group class, because we will advance each other share the ideas

L6. Group class.

L7. Group class-sharing of ideas

L8. Group class, because we share many ideas enjoy

L9. Group work- because we share our knowledge, assisting each other

L10. In group, because we can come up with different ideas

L11. Group class

L12. Group, because we can help each other and do something big

L13. Groups-because it is ten times faster

L14. I would like to work in groups

L15. Group class-because we want more activities

L16. Group class

L17. Group class, because we help each other

L18. Group class, because we learn from others in groups and we help

L19. Group

L20. Groups

L21. Groups –because 2 or more people are better than 1 person.

L22. Group work- I get to hear other people's views

L23. Group activity- we share ideas and help each other.

L24. Groups- we get to share all of our views on the subject.

L25. Groups

L26. Group class. We share many ideas

L27. In groups

L28. Group class. We assist each other and understand better

L29. Group class, because we can help each other where we don't understand

L30. Group class

L31. Group. Because we work together

L32. Groups, we can communicate better than individual.

L33. Group- so that we understand and have different knowledge

L34. Individual. Because you get to do what you want not what others in groups' wont

L35. Group class. You will be confident to tell your idea or answer

L36. Group class. Because we should share ideas

L37. Group class- because we will have so much fun.

L38. Group class. Because we pitch different ideas which makes great work.

L39. Groups-because we like to discuss in groups explore more

3. Which language would you prefer the teachers use to teach you? Why?

L1. English
L2. English-because we pitch different ideas which makes great work
L3. English, because it's understandable
L4. English, because when they teach using our home language some of us won't understand
L5. English, because it's the international language used to communicate
L6. English, because we understand it better than other languages
L7. English, because we speak different languages
L8. English, because it is the first additional language (most important)
L9. English, because I understood it better
L10.English
L11. English, we all understand the language
L12. English, because it is the language we can all understand
L13. English, because it is common
L14. English, because English is an easy language
L15. English, because it is the first additional language
L16. English, it is understandable and reliable to everyone
L17. English, it is better to understand easy
L18. English, it is easier to understand
L19. English, it is a language that connect different people
L20. English, because other home languages are not understandable so English is good for learning
L21. English, because we can help each other where we lack
L22. English, because I understand better in English class
L23. English, because it's the first additional language
L24. English, because we understand it much better
L25. English, because it is easy to understand
L26. English, because I understand better than in my home language
L27. English, because we understand it better than in our home language
L28. English, because it can be understandable and easy to communicate
L29. English
L30. English
L31. English, because it's a common language
L32. English, because it is easy
L33. English, because we all understand

L34. English, because we can socialize with English while speaking with people who speaks English
L35. English, because it will be easy for every learner to understand
L36. English, because it is easier to understand and write
L37. English, because it is simple to understand
L38. English, yes, because it is the first additional language in SA
L39. English, because it is more understandable
L40. English, because we understand better in English more than our home language

Appendix: K

Ms. Mbali’s Interview Transcript

PARTICIPANTS	DISCOURSE		
Joshua	you are very fast I am trying to be will the kids be happy to do this		
Ms. Mbali	ah I think they will Instead of us just talking about it that this is galactose, carbohydrates , so that they can see and do them and they won’t forget hydrogennn		
Joshua	 That is what they do with their hands I don’t think they are gonna forget Like I did that of the fatty acids This one Use the big ones or the smaller ones I had forgotten I don’t know the structure and I remembered there where sixteen carbons		
Ms. Mbali	 Yeah Sorry	01:50	
Joshua	 The white is hydrogen		
Ms. Mbali	right?		
Joshua	Pardon? The white beads is		
Ms. Mbali	hydrogen I think so I forgot But it is fine if I put the oxygen like this right?		
Joshua			

Ms. Mbali Joshua Ms. Mbali Joshua Ms. Mbali Joshua Ms. Mbali Joshua Ms. Mbali Joshua Ms. Mbali Joshua Ms. Mbali Joshua Ms. Mbali Joshua Ms. Mbali	This one is what Oxygen –pink right? So you gonna add an hydrogen to that Yeah I am sure it's not complex Not at all. Will they be able to get it? Yeah What's that gonna be You are looking for something Never mind I was told the agric teachers Sorry I was told the agric guys They do this also Yeah They do this organic compounds And I am sure its also gonna be good for them Y do you think the learners will be happy to use this Y hmmmm I think To them it might be fun Yeah Cos in the classes we just talk and talk and talk So that's y it is something they are doing You can even tell them to do it as an assignment and bring it back yeah You are done right? Beautiful I guess Yes Can you grade yourself A 10 /10		

Appendix: L

Ms Karabo's Interview Transcript

Participants	Oral	Activities	
Joshua	There you have the		
	cellotape.		
Ms Karabo	exactly		
Joshua	you know		
	And if you still want		
	to ask any question ,		
	please ask		
	But at least, those are		
	simple molecules		
	organic compounds		
	that they (learners)		
	can use beads to do		
	and they will not		
	forget. I did fatty		
Ms Karabo	acids		
	mnnnmm		
	and about 16 carbons,		
	a whole lot and I did		
Ms Karabo	not know until when I		
Joshua	did it myself.		
	Okay		
	Yea , until when I did		
	it myself		
	Till now I could not		
	forget		
	{pause}		
	Do you think the		
	learners would be able		
	to do it now, it is as		
	simple as anything		
	and I am sure when		
Ms Karabo	they do it they would		
	not forget		
	Yeah		
	they won't		
	because now they can		
	see that this two		
	colour represent two		
	oxygen molecules and		
Joshua	then let me just try out		
	this big one here		
Ms Karabo	Oh you want to do the		

  Joshua Ms Karabo Joshua Ms Karabo Joshua Ms Karabo Joshua Ms Karabo Joshua Ms Karabo Joshua Ms Karabo Joshua Ms Karabo Joshua	glucose own right? I will first join the carbons to make a chain You see the beads are every where Yeah Which grade do you take Wao Grade 10 and 11 How many classes in 10 I have 2 grade 10 and I grade 11 and natural sciences as well. Can the students find it easy while doing it? Yes {inaudible talk for minutes} Do you find it tiring No But now if you make the hydrogen smaller and the carbons big because we have to attach the hydrogens to the carbons on four sides. It's hard for me to connect a whole lot of big beads to the smaller one. These white ones are smaller beads. Okay, okay, yeah yeah, I think that would work much better. yes Try using the big blacks The big black beads Okay You know what, I don't want to kids to		

Ms Karabo Ms Karabo Joshua Ms Karabo Joshua Ms Karabo Joshua Ms Karabo	feel the carbons are bigger in size than the hydrogen. You never know what they can think of. {laughs} Maybe you remove the big ones, those white ones The pink one is oxygen, So the oxygen is attached to the hydrogen ……. {pause} So how would they learners be able to identity the double bond Anywhere you have that single pink, it will be a double bond. Now I get what you are saying. The last one, we have OH, H, So here one hydrogen would be attached to the carbon, another hydrogen would be attached to the oxygen Is it complex I am just trying to figure out the last part here cos I have one oxygen and three hydrogens. I have already attached one So this one will come here then this one comes here. And then I am left with the last		

Joshua Ms Karabo Joshua Ms Karabo	one Is it interesting Yeah Very very Can you recommend it for students to learn Very well Can you use this cello tape to stick it down with the paper? Yes. Hope it was not boring? Nooo Laughing You get to think the learners don't think a lot about these things when they right them down. so now they got to think I need so many numbers of oxygen , so many numbers hydrogen and so many numbers of carbon and then next time they know that alright 6 black beads for carbon		

Appendix: M

Mr. Brighton’s Interview Transcription

	Oral	Activities	Time
Julius	at is a complex one	He is drawing both	
Brighton	It is the same because	linear and cyclic	
	this is glucose	structure of glucose	
Joshua	Yes		
Joshua	The same with this		
Brighton	This is linear and this		
	is cyclic		
	So so		
	I want to do it cyclical		
	so that it is different		
	from the linear one		
Joshua	That’s right		
	That’s very good		
	Alright sir		
	This is your own		
	instruction		
Brighton	Ok		
Joshua	Your experience		
	should be written		
	down on the interview		
	sheet		
	So the beads now I		
Brighton	will explain to you		
	They are written here		
	very clearly		
	it’s not a problem		
	but I don’t need the		
	blue beads because I		
	am not using nitrogen		
	no nitrogen in glucose		
	I only need the white		
	beads, black beads		
	and pink beads.		
	Unfortunately, I am		
	color blind		
	So you have to show		
Joshua	me which one		
Brighton	This is white		
Joshua	White I could tell	He picks the beads	
Brighton	This is pink	himself	
Joshua	Oh its pink not blue		
Brighton	No not blue		

Joshua	Okay		
Brighton	This is black		
Joshua	Black is for carbon		
	Then this blue		
Brighton	You put them together		
Joshua	Okay		
	And what else oo		
Brighton	What do we need		
	again	Joins the six carbon	
	That's what we need	atoms together to	
	These are three	form the cyclic	
Joshua	elements	skeleton	
Brighton	It is fine		
Joshua	So we start with black		
	This is black		
Brighton	We need five black		
	12345		
	We need six		
	123456		
	That's why I have		
Joshua	written it here		
Brighton	Oh		
Joshua	Then this is pink		
	Yeah		
Julius			
	we can start		
Brighton	We put one here		
	Why don't you put it		
	like this		
Joshua	Why don't you allow		
Brighton	him to sort it out		
	No its fine…		
	Then another one here		
	to make	Still joining the	
	This is the first carbon	carbons together.	
Joshua	That's first and		
Brighton	second		
Joshua	We are going to the		
Brighton	third carbon		
	The third carbon is		
	this one		
	We use this one		
Joshua	This is oxygen right		
	Yeah that is oxygen		
	So oxygen is pink		
	We supposed to make		

Brighton	it bigger Its fine This one is okay straw We taught we are to use the straw for the links Where is the oxygen Oxygen is pink Where are we to put it here We are going to put it here And put it also in these ones		
Joshua	Each one will have oxygen Okay		
Brighton	The C-O-C bond here is what we call glycolytic bond. That’s the one present in carbohydrates It is only found in carbohydrates. Glycolytic linkage So Here we have got a carbon	Adding the oxygen to the carbon	
Joshua and Julius	We attaché it to that		
Brighton	To the oxygen Press it tight okay		
Joshua	On the next one		
Brighton	We have another carbon Which is the last carbon Which is this one We attach it to this oxygen After that we have got a bond here which is this one. Then we have got the skeleton of the cyclic yeahhh	Joining hydrogen to the skeleton CH_2OH	

       Julius Brighton Brighton, Julius and Joshua	The first one here we have two hydrogen and oxygen and another hydrogen Yes So what colour is the hydrogen White This is hydrogen are joined white Hydrogen is white So we must have a hydrogen Two hydrogen are joined together Ok Before we put a ... They are not joined together in the actual fact There are two atoms Then next one we join this one here to one of the hydrogen to oxygen and then another hydrogen Oxygen is… pink Oxygen is pink which is this one Then we do it like these To this oxygen it is combined to another hydrogen It means that one is fine The hydrogen we said is white Put it here This is white Yeah Maybe a smaller one to the oxygen we indicate these are joined together like	to the oxygen atom on the top of the structure	

Julius Brighton	that Then we have made this one On this oxygen there is nothing Yes Then on the next carbon here There is oxygen and one hydrogen Our oxygen is pink Yes Pink and white We join them together Because they are joined together There is a bond It is a hydroxyl bond put it here The other one is an hydrogen which is white Join it to the carbon which is next to this carbon Do it like that It can be anywhere It can be anywhere Here they have to alternate Here we have oxygen and hydrogen So white and pink Here is white and pink is this one They are together They form this one Then we have one	Completing the alternate hydrogen and hydroxyl atoms	
Julius and Joshua	Hydrogen is white hydrogen which is on the other side are Yes this has completed this carbon atom and this one has also completed this carbon atom		

Julius Brighton Julius Brighton Julius Brighton Julius Brighton Julius Brighton Juluis Joshua Brighton	Because the valence of carbon is 4 So for it to be correct there must be four bonds around each carbon. That's how we check Then we go to this one Because we said they are alternating so we are going to start with the hydrogen in the inside. So the reason why we alternate is for the glucose molecule in cyclic form to be stable Yeah To avoid what we call stearic effect Don't worry my degree was biology and chemistry Okay In Zimbabwe where I come from I was teaching chemistry while I teach biology in south Africa. Right Its pink and white For the hydroxyl I join them together Put them here Carbon atom is there The last one we start with white on the outside which is hydrogen To alternate yes Then the inside is white and pink Hmm	Completion of the structure and wanting to confirm	

         Julius Joshua Brighton Joshua Joshua Brighton Joshua Brighton	And ….white and pink Here I need more to separate these Hmm So, that it will Cos I am left with one hydrogen So put more It is not one hydrogen and an OH outside The hydroxyl So I am saying here So if we are to confirm the hydrogen which white are twelve agreed Counting 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 Let me do it again 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 No there is a problem Somewhere I think its on this side CH_2OH The hydroxyl Yea I have seen the problem That’s it Now this is glucose cyclic This is wonderful Do you think it’s good for learners to. No it is Because it aids their understanding, because they are actually playing and seeing how the bonds are being formed between elements and atoms. So it is		

	actually good for them Because the moment they have done these they are very unlikely to forget Hmm Ohh Because they have done it themselves They have done it themselves Let me give you an example I am 42 years old I have not tasted alcohol Wao When I tell my learners they say that is not possible For me to tell people what alcohol does to you when I have not tasted it is a problem I have to ask those who have tasted it before How does it feel Any reactions whatever and sometimes I have to observing those who are drunk So that I am fully equipped to do explain So if they do it, It gets into them because this is practice and it helps them assimilate Then are there other hands on you do in the classroom?		

Joshua Brighton	This one we do it for grade ten So you use beads Nooo We have not been using them But I am saying the content, organic compounds, carbohydrates, proteins, lipids this is		
Joshua Brighton	grade ten and they have to see this. it will help them a lot for grade twelve, we have to look at the structure of DNA for example, with that one we can do. RNA, DNA, and maybe even the nucleus and maybe the nucleus To show them what is inside the nucleus, the chromatids network , and how the threads of chromosomes are arranged there and that they are having in DNA, I think that can be done be I am thinking		
Julius	reproductive systems, yeah that can be done Then gametogenesis Especially the female		
Brighton	one Yes If we go to gametogenesis, we are supposed to be looking at that.		

Joshua Brighton	I am looking at the reproductive system of the female, and we have to show them with beads the fallopian tubes and ovary system in different colour and when the rapture opens one ovary will actually show them that an ovum is being released in the fallopian tubes and we show them the uterus and how the endometrium is, we use maybe red if we have red beads Yeah we got We indicate the increase the endometrium, in preparation for the implantation, And we show them the virginal When we are teaching them human reproduction, they tell me teach us the theory, the practical we already know even better than you. And they tell you that Yes , they tell me that Because I have always told them I want you to understand, you are my learners, you don't have to be shy None of you is my wife here So I am only your teacher and you have		

	to be as free as you can be. To the extent that when I teach them the male reproductive system, I tell them other call it the penis, combined with the scrotum it is testical In my shone language we call it machete Then they tell me can we tell you what we call it in isiZulu language Yes do it Then they tell me That's part of bringing the values from their cultural system In isiZulu it is called mazembe, then they say mazambe and mach Te is almost the same. This is shone and zulu, so lets move on. You guys have not talk about natural science grade 9. Do they do this also? Yeah They do it It is basically introduction to a more advanced learning in higher grades but not as deep as we do in grade 12. And organic compounds, the food types, and gaseous		

	exchange. I think that one we can come up with a model especially for breathing in inhalation and exhalation, and also for gaseous exchange in the alveoli, We can come up with something to tell them this is now this is the capillary, the pulmonary vein which is carrying oxygenated blood after exchange. All with the use of beads.		

Appendix N

Mr. Kagiso's Interview Transcripts

Participants	Discussion	Time	Activity
Researcher	You are the expert and I am just a novice.		Teachers first draws the linear glucose and water structure on the paper given. Then she glues the black beads on the point where the carbon atoms are.
	I taught we will first of all do this one.		
Mr Kagiso	Oh ooooo Ok its fine This one	00:51	Researcher suggest to the teacher to first of all start from the simplest structure of water before going on to the more complex glucose structure
Researcher	I thought we shall go from the simplest to the…		
Mr Kagiso	Oh ok		
Researcher	I think when you do that one first then it will be easy to.		
Mr Kagiso	Ok its fine	01:03	
Researcher	You get it so That one now would be.		
			She first does the CO2
	then oxygen two oxygen		
			She sticks the black beads as against carbon and takes the pink beads which represents two oxygen, and she pastes it on the oxygen atom.
	She sings slowly and quietly Is it done like that Yes I guess so But if it's done like that won't it tell the learners that … Because this oxygen is joined to this carbon	02:01	

Mr Kagiso Mr Kagiso Researcher Mr Kagiso Researcher Mr Kagiso Researcher Mr Kagiso Researcher Mr Kagiso Researcher Mr Kagiso Researcher Mr Kagiso	But here, the oxygen is not joined to the carbon Do you get it now Yes You know its not joined to the carbon The oxygen is separate, this one is separate So how do we do it because it has to show it is joined to the carbon I taught because here there is ummm You know the glue is the bond Oh The glue is the bond ohhoooooo because that is what is gonna join oxygen to carbon so it's supposed to be like this so its supposed to be like this you know you have not joined oxygen to the carbon, you have only joined oxygen to the paper, this to this, this to this So, I think it's supposed to be …. Remove this Yes Yeah There is a glue on this right Hmmm Right On the black Join it with oxygen Yes Mhnmmm Then join the other oxygen on the other side	 03:27	The carbon was a distanced separate from the oxygen and noting indication the bond. She is pointing to the space between the carbon and oxygen atoms Pontiac is demonstrating how it's supposed to be

Researcher Mr Kagiso Researcher Mr Kagiso Researcher Mr Kagiso Researcher Mr Kagiso Researcher Mr Kagiso Researcher Mr Kagiso Researcher Mr Kagiso	You know you have done this on this side so do the same on the other side Ohhhh Like this Isn't it not looking good like this The concept of bonding that oxygen is joind , carbon is joined to two oxygen Now I get it Ohhhh You can now put a glue somehow to make it stick In this way so that the learners don't feel You know so many misconceptions can go into their brain Okkkk I now understand Ok So I should do this one Ok lets go Ummmm This beads Hydrogen is white Yeah Two white And Is it difficult No its not Yeah you got that now right Yeah good Smiles So I should continue Yeah Do you think the learners can do what you are doing now Yeah Its not difficult But you know some. Can you speak a little loud I think they can Since you know you are given the instructions They know that carbon is black	 07;27	

	For hydrogen they will use white beads And we use pink beads for oxygen		
Researcher	Is it showing what you are doing That’s is the skeleton of the carbon		
	How do you think it will help them to learn		
Mr Kagiso			
	How do you think? Why do you think we should we should use beads to teach		
	I think its better for learners to understand more when they are hands on than when they are just being taught like orally So at least it they are hands on, they can see so this is the bonds which they are talking about	09:59	She holds the carbon skeleton in her hands
	Other will remember since they will remember from what they did from hands on So they will always remember that okay in this glucose, there is a double bond, So we have the O, the O which are six,		
Researcher	we have carbon which is six so meaning		
Mr Kagiso	the hydrogen is times two of the oxygen		
Researcher	and also the carbon.	10:34	
Mr Kagiso			
	Okay		
Researcher	Yes So you think they would not forget right Yes		
Mr Kagiso			
	You know in the caps documents, it was written there they should use beads		
	Do you know Noo		
	Sometimes the obstacles you can find is		

Researcher Mr Kagiso Researcher Mr Kagiso Researcher Mr Kagiso Researcher Mr Kagiso	that there is no resources For example those beads are not in school I have not seen the beads in the school Who do you think is to provide them I think the department should provide the since the department is the one who provides the text books So they should also provie it for them So that they will be able to understand more, hands-on not just for life science but also for other subjects So if the department had provided it, don't you think they have to teach you teachers how to use them to teach to the students? Yeah, I think that's a very good one, because you cannot go and teach something you do not have any idea about so for example, as I was doing here, I was not noticing it would be more easier for the learners to understand where there is a Bostic glue, they see the bond between those atoms. Yeah If you have to teach them, will you tell them to go do it at home or you tell them to….. You know you have just 45 mins to …or how many minutes do you have to teach a lesson 45mins Alright Now you have to. and you are teaching this organic compounds Yes	11:45 12:01 13:48	She holds the under-construction model in her hands and she continues to pick f rom the bag. Because the beads are round and can roll off I think it should be put in a small transparent container.

	And they say you should use beads to teach it, would you do it in the class, would you create a practical session, a special practical session for that? Or you ask them to go home for No I won’t ask them to go home. May be to do it as an assignment To do it as an assignment I think that one is a good one To let the learners think on their own, okay Some times this teaching is not all about telling but about letting the learners use their own ideas, see what they can come up with.		
Researcher	You can never know some of them can come up with something you did not think could happen	12:53	
Mr Kagiso Researcher	You feel learners should explore their own ideas. Learners should explore. they should not feel limited to only their teacher who is to tell us to do this and this and this		
Mr Kagiso Researcher	Alright Is this a double bond? Yes How		
Mr Kagiso	Is it looking like a double bond because is we have to teach the learners and we say this structure is ... You see this structure is. There is a double bond here Alright		
	Yes And we have been putting one oxygen , one hydrogen and so on on it , it is one one one one, the learner will	15:42	

Researcher Mr Kagiso Researcher Mr Kagiso Researcher Mr Kagiso Researcher	just feel this is a single oxygen where as there is a double bond here so how do you think they can maneuver their way Since we can see that these ones are more attached, so how about if we put more glue to that it can be … they may be different between the attachment of the glue to this ones and attachment of the glue to this oxygen Yeah Do it the way you feel If it might be good, so that they are will just know it is a double bond Or maybe you follow the instruction there right? That anywhere there is a single oxygen there is a double bond I think anywhere with the ink beads , it's a double bond That would be a better way to illustrate I think it will be a better way What other way You know that's just an assumption That's just an instruction On what we think , there could be other ways which we can use to illustrate a double bond I think another example is that we can do this They can see that the bond of this one and the bond of this one are not the same so this bond is only single and the other is double meaning it would take much more … I can say forces to break this bond than	 16:09 17:11	

Mr Kagiso Researcher	the single. So this bond is small and the other one is bigger. Okay, that's a double bond, now the forces to break it would be bigger than the single bond which is one bond, the forces needed to break it would be little. you won't need that much but this one since it's a double bond, Which other advice will you give to ... Okay Which topic do you think…., which other concept in life science I think genetics Genetics What in genetics I think genetics, since we know that the learners get a little bit confused when they get to the homogenous and heterogeneous, if you can remember , So we have the homogenous genes and heterogeneous genes which have the same alleles for example it can be two dominant which will be for example RR and a Rr representing the recessive allele so we can do this in a way that for the big R, both of these can same colour of beads and the dominant in the recessive can be represented be big bead to show it is dominant on the recessive. Since it is the one that appears in the phenotype. and then for this one we use a small bead We can also use the same colour to show it is the same character for an example, if this one is yellow And also , for the… there is this guy from Eish I forgot the name, There is this diagram of sex linked disorders where you can see the ancestors where you got the disease from, so we can use it also in this case.	17:49 18:33 19:03	 Pontian pointing to the heterogeneous recessive allele.

Researcher	That concepts And also to explain the concept of incomplete dominance We have incomplete genetics whereby… for example, a white flower and a yellow flower give birth to a white flower so the phenotype is not like the father nor the mother Hmm Okay So there are a lot of concepts we can use these beads to do We can use these beads to teach the learners, like the concept of alleles and also that of disorders like the hemophilia, the colour blindness. Ok, that's good Thanks ehn Thanks for accepting the challenge to create beads as models to teach life science Alright thanks But this thing will not fall , It's not falling	20:03	

Appendix O

Wits School of Education Ethics Committee Approval

Wits School of Education

27 St Andrews Road, Parktown, Johannesburg, 2193 Private Bag 3, Wits 2050, South Africa. Tel: +27 11 717-3064 Fax: +27 11 717-3100 E-mail: enquiries@educ.wits.ac.za Website: www.wits.ac.za

16 August 2016

Student Number: 1307614

Protocol Number: 2016ECE011D

Dear Sina Fakoyede

Application for ethics clearance: Doctor of Philosophy

Thank you very much for your ethics application. The Ethics Committee in Education of the Faculty of Humanities, acting on behalf of the Senate, has considered your application for ethics clearance for your proposal entitled:

Possibilities of using beads and beadworks (cultural artefacts) as instructional models in the teaching and learning of life science.

The committee recently met and I am pleased to inform you that **clearance was granted**.

Please use the above protocol number in all correspondence to the relevant research parties (schools, parents, learners etc.) and include it in your research report or project on the title page.

The Protocol Number above should be submitted to the Graduate Studies in Education Committee upon submission of your final research report.

All the best with your research project.

Yours sincerely,

MMabeta

Wits School of Education

011 717-3416
cc Supervisor – Dr Femi Otulaja

Appendix P

Gauteng Dept of Education Ethics Committee Approval

For administrative use only:
Reference no: D2017 / 246
enquiries: 011 843 6503

GAUTENG PROVINCE
EDUCATION
REPUBLIC OF SOUTH AFRICA

GDE RESEARCH APPROVAL LETTER

Date:	30 August 2016
Validity of Research Approval:	30 August 2016 to 30 September 2016
Name of Researcher:	Fakoyede S. J.
Address of Researcher:	41 Kruis Street; Colosseum Building; Johannesburg; 2001
Telephone I Fax Number/s:	073 227 3614
Email address:	1307614@students.wits.ac.za
Research Topic:	Possibilities of using beads and beadworks (cultural artifacts) as instructional models in the teaching and learning of Life Sciences
Number and type of schools:	THREE Secondary Schools
District/s/HO	Johannesburg East

Re: Approval in Respect of Request to Conduct Research

This letter serves to indicate that approval is hereby granted to the above-mentioned researcher to proceed with research in respect of the study indicated above. The onus rests with the researcher to negotiate appropriate and relevant time schedules with the school/s and/or offices involved. A separate copy of this letter must be presented to the Principal, SGB and the relevant District/Head Office Senior Manager confirming that permission has been granted for the research to be conducted. However participation is VOLUNTARY.

The following conditions apply to GDE research. The researcher has agreed to and may proceed with the above study subject to the conditions listed below being met. Approval may be withdrawn should any of the conditions listed below be flouted:

CONDITIONS FOR CONDUCTING RESEARCH IN GDE

1. *The District/Head Office Senior Manager/s concerned, the Principal/s and the chairperson/s of the School Governing Body (SGB.) must be presented with a copy of this letter.*
2. *The Researcher will make every effort to obtain the goodwill and co-operation of the GDE District officials, principals, SGBs, teachers, parents and learners involved. Participation is* voluntary *and additional remuneration will not be paid; JcCccQD ð€ 36*

2016/

Making education a societal priority

Office of the Director: Education Research and Knowledge Management ER&KM)

9th Floor, 1 1 1 Commissioner Street, Johannesburg, 2001

P. O. Box 3340, Johannesburg 2000 Tel. (011) 355 5060

3. *Research may only be conducted after school hours so that the normal school programme is not interrupted. The Principal and/or Director must be consulted about an appropriate time when the researcher/s may carry out their research at the sites that they manage.*
4. *Research may only commence from the second week of February and must be concluded by the end of the THIRD quarter of the academic year. If incomplete, an amended Research Approval letter may be requested to conduct research in the following year.*
5. *Items 6 and 7 will not apply to any research effort being undertaken on behalf of the GDE. Such research will have been commissioned and be paid for by the Gauteng Department of Education.*
6. *It is the researcher's responsibility to obtain written consent from the SGB/s; principal/s, educator/s, parents and learners, as applicable, before commencing with research.*
7. *The researcher is responsible for supplying and utilizing his/her own research resources, such as stationery, photocopies, transpon, faxes and telephones and should not depend on the goodwill of the institution/s, staff and/or the office/s visited for supplying such resources.*
8. *The names of the GDE officials, schools, principals, parents, teachers and learners that participate in the study <u>mav not appear</u> in the research title, report or summary.*
9. *On completion of the study the researcher <u>must</u> supply the Director: Education Research and Knowledge Management, with electronic copies of the Research Report, Thesis, Dissertation as well as a Research Summary (on the GDE Summary template). Failure to submit your Research Report, Thesis, Dissertation and Research Summary on completion of your studies / project — a month after graduation or project completion - may result in permission being withheld from you and your Supervisor in future.*
10. *The researcher may be expected to provide short presentations on the purpose, findings and recommendations of his/her research to both GDE officials and the schools concerned;*
11. *Should the researcher have been involved with research at a school and/or a district/head office level, the Director/s and school/s concerned must also be supplied with a brief summary of the purpose, findings and recommendations of the research study.*

The Gauteng Department of Education wishes you well in this important undertaking and looks forward to examining the findings of your research study.

Kind regards

....

Dr David Makhado

Director: Education Research and Knowledge Management

DATE: 2016/08/31

2

[redacted] Making education a societal priority

Office of the Director: Education Research and Knowledge Management ER&KM)

9th Floor, 1 1 1 Commissioner Street, Johannesburg, 2001

Appendix Q

university of the witwatersrand private bag 3 wits 2050 Johannesburg sa t+27 11 7173414 f+27 11 7173259

Research Fellow: Fakoyede Sina

Phone: 717 3733; fax: 0865167237

e-mail: 1307614@students.wits.ac.za

Informed Consent to Serve as Participant in a Research Project

Project Title: Possibilities of using beads and beadworks (cultural artefacts) as instructional models in the teaching and learning of life science.

Research Student: Mr Fakoyede Sina, Marang Centre for Math, Science and Technical Education.

Phone: 0732273614 E-mail: 1307614@students.wits.ac.za

Invitation to Participate:

You are being invited to participate in a program of research study being conducted by me at Eqinisweni Secondary School. You are participating with me as a co-researcher, as we collaborate together in this project. As a co-researcher, you are not being researched 'on' but you are researching 'with' me. This study will run for 6 months, from June 2016 to Dec 2016, and involve you as a teacher teaching students in the school.

Purpose:

The purposes of this program of research study is to 1) help teachers to improve their teaching of science with the use of cultural artifacts as instructional tools and translate this knowledge to student successes in internal and external examinations; 2) help student enhance their learning of science concepts; 3) help in-service teachers continue to develop professionally and learn to teach better with the aid of cultural artifacts used as instructional materials.

Procedures:

During this study your image and voice will be recorded on video and audio devices during classroom activities as you interact with teacher(s), student(s) and other tutor(s) and with curricular materials. You will also be asked to take part in conversations and/or small-group discussions/meetings in and/or outside the classroom activities, which will also be video and audio-recorded. In addition, selected excerpts (clips) from the video recordings of classroom activities will be played and used for these small-group discussions/meetings in and/or outside the classroom and in the dissemination of what is learned from this study.

Risks:

There are no potentially harmful risks related to participating in this study, except for the possible embarrassment of seeing yourself and/or hearing your voice in video or audio recordings when segments (clips) are shown in small-group discussions/meetings.

Benefits:

There is no direct benefit from this program of study to you. However, as a result of your participation, your own awareness about school, science, teaching and learning may be increased. This program of study will provide you, teacher(s), students, researcher(s), the school, the University and the field of science education with valuable insights into the teaching and learning of science and how students and teacher(s) interact to enhance individual and collective successes in the science classroom.

Disclaimer/Withdrawal:

Your participation is completely voluntary and you may withdraw at any time without any prejudice or penalty against you. You are free to withdraw your participation from this study at anytime. Withdrawal from participation or refusal to participate in this study will not in any way affect you.

Alternatives:

You may choose not to participate in this study. If you choose not to participate, no references to you will be made in the reporting of this study. Your image(s), if it appears anywhere, will be blurred or silhouetted so that you will not be visually recognized; and your voice(s) will be muted or scrambled so that your voice will not be recognized.

Compensation:

You will receive no financial or any other compensation for participating in this study. This research is not for any grades or marks.

Confidentiality:

All information collected in this study will be kept private and you will not be identified by name. Confidentiality and anonymity will be maintained as pseudonyms will be used in place of proper names of individuals and location of study. The researcher will keep the audio and video recordings from this study in a locked filling cabinet. Only the researchers will have access to these and they will be destroyed by December 31, 2017.

Participant's Rights:

If you wish for further information regarding your rights as a research participant, you may contact: Human Research Ethics Committee (HREC) at 0117173055 or Ms. Matsie Mabeta via email at Matsie.Mabeta@wits.ac.za.

Conclusion:

If you have any concerns or questions about the conduct of this program of research study (project) you may contact the principal investigator at location stated above.

What signing this form means:

By signing this consent form, you agree to participate in this research project. The purpose, procedures to be used, as well as, the potential risks and benefits of your participation have been explained to you in detail. You can refuse to participate or withdraw from this research project at anytime without penalty. Refusal to participate in or withdrawal from this study will have no effect on you in any way, whatsoever. You will be given a copy of this consent form after you have signed it for your record.

I agree to be video-recorded	☐ Yes	☐ No	_________ (Initial)
I agree to be audio-recorded	☐ Yes	☐ No	_________ (Initial)
I agree to participate in conversations	☐ Yes	☐ No	_________ (Initial)

______________________________ ____________________________________ __________

Name of Participant	Signature of Participant	Date

Mr Fakoyede Sina________________ ____________________________________ __________

Name of Investigator	Signature of Investigator	Date

Appendix R

university of the witwatersrand private bag 3 wits 2050 Johannesburg sa t+27 11 7173414 f+27 11 7173259

Mr Fakoyede Sina

Phone: 0732273614

e-mail: 1307614@students.wits.ac.za

Learner's Informed Assent to Serve as Participant in a Research Project (Ages 12-17)

Project Title: Possibilities of using Beads and Beadworks (cultural artefacts) as instructional models in the teaching and learning of life science.

Student Researcher: Fakoyede Sina, Marang Centre for Math, Science and Technology Education

Invitation to Participate:

You are being invited to participate in a program of research study being conducted by me in your school at Equinisweni Secondary School. You are participating with me as a co-researcher, as we collaborate together in this project. As a co-researcher, you are not being researched 'on' but you are researching 'with' me. This study will run for 6 months, from June 2016 to Dec 2016, and involve you as a learner in a tutoring programme working with your teacher in your school. This tutoring programme will cover grade 11 learners in life science.

Purpose:

The purposes of this program of research study is to 1) help teachers to improve their teaching of science with the use of cultural artifacts as instructional tools and translate this knowledge to student successes in internal and external examinations; 2) help student enhance their learning of science concepts; 3) help in-service teachers continue to develop professionally and learn to teach better with the aid of cultural artifacts used as instructional materials. All of these purposes will be accomplished through After-school tutoring programme as the context-in-study. We intend to meet immediately after school for two hours from Monday – Friday for a ten-week block each time the programme is implemented in the school premise.

Procedures:

During this study your image and voice will be recorded on video and audio devices during classroom activities as you interact with teacher(s), tutor(s), other student(s) and researcher(s) and with curricular materials. You will also be asked to take part in conversations and/or small-group discussions/meetings in and/or outside the classroom activities, which will also be video and audio-recorded. In addition, selected excerpts (clips) from the video recordings of classroom activities will be played and used for small-group discussions/meetings in and/or outside the classroom and in the dissemination of what is learned from this study.

Risks:

There are no potentially harmful risks related to participating in this study, except for the possible embarrassment of seeing yourself and/or hearing your voice in video or audio recordings when segments (clips) are shown in small-group discussions/meetings.

Benefits:

There are no direct financial benefits from this program of study to you. However, as a result of your participation, your own awareness about school, science, teaching and learning and tutoring programme may be increased. This tutoring program and research study may provide you with an opportunity to improve your success in your examinations and will provide you, teacher(s), other students, tutor(s), researcher(s), the school, the University and the field of science education with valuable insights into the teaching and learning of science and how students and teacher(s) interact to enhance individual and collective successes in the science classroom and tutoring programme. Research findings from this study will be presented at local, regional, national and international conferences, in journal articles and in books or book chapters, and at Wits School of Education seminars and professional development for pre-service and in-service teachers. Participants who are interested will be welcomed/allowed to join university researcher as co-presenters and co-authors.

Disclaimer/Withdrawal:

Your participation is completely voluntary and you may withdraw at any time without any prejudice or penalty against you. You are free to withdraw your participation from this study at anytime. Withdrawal from participation or refusal to participate in this study will not in any way affect you.

Alternatives:

You may choose not to participate in this study. If you choose not to participate, no references to you will be made in the reporting of this study. Your image(s), if it appears anywhere, will be blurred or silhouetted so that you will not be visually recognized; and your voice(s) will be muted or scrambled so that your voice will not be recognized.

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You will receive no financial or any other compensation for participating in this study. This research is not for any grades or marks.

Confidentiality:

All information collected in this study will be kept private and you will not be identified by name. Confidentiality and anonymity will be maintained, as pseudonyms will be used in place of proper names of individuals and location of study. The researcher will keep the audio and video recordings from this study in a locked filling cabinet. Only the researchers will have access to these data and data will be destroyed by December 31, 2017.

Participant's Rights:

If you wish for further information regarding your rights as a research participant, you may contact: Human Research Ethics Committee (HREC) at 0117173055 or Ms. Matsie Mabeta via email at Matsie.Mabeta@wits.ac.za.

Conclusion:

If you have any concerns or questions about the conduct of this program of research study (project) you may contact the principal investigator at location stated above.

What signing this form means:

By signing this consent form, you agree to participate in this research project. The purpose, procedures to be used, as well as, the potential risks and benefits of your participation have been explained to you in detail. You can refuse to participate or withdraw from this research project at anytime without penalty. Refusal to participate in or withdrawal from this study will have no effect on you in any way, whatsoever. You will be given a copy of this consent form after you have signed it for your record.

I agree to be video-recorded	☐ Yes	☐ No	_________ (Initial)
I agree to be audio-recorded	☐ Yes	☐ No	_________ (Initial)
I agree to participate in conversations	☐ Yes	☐ No	_________ (Initial)

___________________________	_________________________________	_________
Name of Learner	Signature of Learner	Date

Mr Fakoyede Sina________________ ____________________________________ __________

Name of Investigator Signature of Investigator Date