Integrating Indigenous Knowledge (IK) Artefacts and IK Strategies in Teaching Mechanics: Insights from community elders, physics teachers, and learners in Zimbabwe

by

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DECLARATION

I, Edson Mudzamiri, hereby declare that this thesis is my own original work and has not been submitted to any university or other tertiary institution for the award of a degree.

Signed: Date:...........31 Dec 2019.....................................

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This research project is submitted to the School of Education, College of Humanities at the University of KwaZulu-Natal for the award of the Doctor of Philosophy Degree.

Supervisor

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ABSTRACT

The study is an exploration of how physics teachers can integrate indigenous knowledge systems (IKS) through using indigenous artefacts when teaching Advanced Level concepts in mechanics. It adds to the growing body of research on decolonizing indigenous curricula. The researcher was motivated by the negative effects of colonization in physics education, lack of contextualization when teaching Advanced Level physics, both of which make the subject difficult for learners resulting in low pass rates, high dropout rates, and loss of interest in the subject. The study also seeks to empower local communities of elders, teachers, and learners to participate in their education. The study was conducted in Masvingo District, a rural area in Masvingo province in Zimbabwe. It identified and explored a variety of indigenous artefacts that can be integrated in the teaching of physics. The artefacts are thus cognitively valuable in providing culturally sensitive scaffolding or meditational tools that facilitate deeper understanding of mechanics concepts.

Theoretical frameworks of Vygotsky‟s sociocultural theory grounded in an indigenous research paradigm and humanity/*Unhu/Ubuntu* were used in this study. A transformative participatory Research (TPR) design was employed. Qualitative data were generated from a purposefully selected sample comprising 18 teachers, 15 learners from each of the three high schools and 22 elders from the community. The following research instruments were used in the study: observations, questionnaires, individual interviews, and focus group discussions.

The findings revealed that the twenty indigenous artefacts identified in this study could be used in physics for conceptual teaching. The findings pointed to a culturally aligned, decolonizing, and contextualized and community acknowledged pedagogical science-IKS model which allows enrichment and understanding of physics concepts through IK artefacts, without challenging the fundamentals of traditional physics principles. The study implies that physics concepts can be understood through the indigenous knowledge systems of teachers, learners and the community together with the associated IK artefacts.

The researcher recommended that IKS and associated IK artefacts should be integrated in all the components of the teaching processes and the school infrastructure should also promote the integration of western science with IKS.

KEYWORDS

Indigenous knowledge, Indigenous science, Indigenous technology (I-Tech), indigenous artefacts, Mechanics, Integration, Physics

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To my family members, I thank you for all the sacrifices that you have made for me.

Dedication

This work is dedicated to my wife and children for their unwavering support.

ACRONYMS AND ABBREVIATIONS

BEPAZ	Business Education Partnership of Zimbabwe Program
BEST	Better Environment Science Teaching
IK	Indigenous Knowledge
IKS	Indigenous Knowledge Systems
PCA-IK-IPM	Physics Concepts Attainment-Indigenous Knowledge-Integrated Pedagogical Model
P-IKS-ICM	Model Physics-IKS-Integrated Content Model
QUEST	Quality Education in Science Teaching Project
SEITT	Science Education In-Service Teacher-Training Program
STS	Science and Technology in Society
UNESCO	United Nations Educational, Scientific, and Cultural Organization
ZIMSEC	Zimbabwe Schools Examination Council
WBT	Whole Brain Teaching
STI	Science, Technology, and Innovation Policy of Zimbabwe

Chapter 1

INTRODUCTION

1.1 INTRODUCTION

The way that Physics is taught often makes it far removed from the daily life of learners. This can be a challenge when they try to access the concepts in physics and so they experience it as a difficult subject. This study is about Integrating Indigenous knowledge (IK) artefacts and IK strategies in teaching mechanics concepts like force, momentum, torque basing on insights from community elders, physics teachers, and learners. It concentrates on the integration of IK artefacts in the teaching of mechanics concepts in Advanced Level (A level) physics. The study concentrates on the artefacts and knowledge that are rooted in indigenous knowledge systems (IKS) in Zimbabwean culture, which could enable learners to understand mechanics concepts. It does not focus on everyday knowledge in general, but rather is focused on teachers helping learners to understand physics concepts through relating their indigenous knowledge (IK) to the physics content. The study attempts to carve a space in the physics curriculum and pedagogy by rediscovering, re-enacting, reclaiming, and revitalizing lost culture; thereby exploring different ways of knowing. The study is also aimed at advancing useful educational ideas and pedagogical styles that are already used in Africa, and in Zimbabwe, in particular, while not rejecting or being opposed to western science and knowledge systems. Accordingly, this study while noting the hegemonic influences of IKS, avoids enslavement by such a knowledge system, with the corresponding displacement and suppression of western scientific ideas.

Physics is the most fundamental of all learning areas in science and Pauloekee (2010a) argues that people understand broader sciences through the concepts developed in physics. Physics forms the basis of current and future technologies. Science in general and physics in particular, forms the foundation on which indigenous technology is built (Banigo, 2000). Pauloekee (2010a) also argues that many of the tools on which the advances of science and technology depend are direct products of physics. Banigo (2000) contends that no indigenous technology programme can exist without a good knowledge of science in general, and physics in particular. Furthermore, the application of physics principles to develop indigenous technologies helps in the production of valuable goods or artefacts that can conform to modern standards and can be marketed even beyond traditional communities. Zingu (2004) posits that creators and users of new technology, as well as adapters and users of acquired (transferred) technology, need significant physics skills.

Kofi Annan, the former UN Secretary General, pointed out that throughout the developing world on-going tragedies that are directly tied to outbreak of diseases, poverty, and environmental degradation are due to lack of access to physics (Pauloekee, 2010b). Physics can be used to design ways of combating climatic change, and to develop cleaner energies and technologies that will decrease the damage to our planet. Potvin and Hasni (2014, p. 100) adds that a strong schooling in science and technology is often perceived as a good way to be spared from poverty.Zimbabwe therefore requires a scientifically literate society, with scientists and technologists who can sustain its developing economy and address a wide range of social, economic and environmental challenges (Gudyanga, Gudyanga, & Mutemeri, 2013). The failure by Africa to produce the critical mass of scientists needed to keep abreast with technological and industrial developments that are taking place elsewhere is due to teaching of science out of context (Gwekwerere, Mushayikwa, & Manokore, 2013).

Physics is required for many important careers in the sciences (Angell, Guttersrud, Henriksen, & Isnes, 2004). Passing the subject at school can ensure access to tertiary and technical education. Science education is a key indicator of a country' potential for producing a scientifically literate society, which is a prerequisite for development of a physics tradition and technological and economic advancement(Zingu, 2004). Zingu (2004) adds that a physics culture is crucial for the successful development of technology and advancement of any society's economy. The teaching and learning of physics in schools must, therefore, be properly planned and executed. Evans (2013) argues that learning occurs in different contexts in different parts of the world. Each context has its own different conditions, systems, contents, and methods of education; hence physics as a subject should not solely depend on the western world for input into its teaching and learning. Phenomena associated with Physics occurring in a particular context can be viewed using the eyes or cultural lenses of the people in that particular context. This indicates that

Physics as a discipline can be viewed and understood through different ways which can beI believe that if the content and pedagogics of the physics curriculum are well selected and contextualized in terms of the learners‟ cultural background, learners should be able to understand concepts better and so pass both internal and public examinations. Learners in high school are expected to develop an interest in learning the ideas and skills from physics and applying them in their general life. At the same time, they are expected to know appreciate their culture and acquire their community‟s historical indigenous science and technologies. They are also expected to solve their community‟s problems, using both western scientific and indigenous knowledge in creative ways for local contexts. According to Emeagwali (2003), high school learners should acquire sufficient knowledge and skills to be able to participate in their societies.

However, this is generally not the case among learners emerging from the advanced level Zimbabwe Schools Examinations physics curriculum. My teaching experience suggests that the physics content and pedagogy are too abstract and are based on only western science examples, which have little connection to the everyday lives of African Zimbabwean learners. At the 6th Southern African Association for Research in Mathematics, Science and Technology Education annual conference held at the University of Zimbabwe in 1999, Southern African science educators unanimously agreed that science was being taught out of context (Gwekwerere et al., 2013). I believe that, to connect informal home learning with formal academic learning, some contextual aspects of the physics curriculum need to be adjusted so that learners understand the concepts through their own culture and indigenous experiences. Physics learning can be enriched by contextualizing the curriculum so that it is infused with local knowledge, by integrating culturally based artefacts, activities and teaching materials into instructional media, classroom activities, and the school environment, while using familiar cultural pedagogical styles and assessment tools. Such integration should go beyond simply taking the current school physics pedagogical styles and punctuating them with few examples of IK artefacts. It should involve placing knowledge, power, identities, or culture in general of indigenous people on the physics discourse table. Integration should enable indigenous perspectives to engage with classroom pedagogy, instruction, and curriculum theorization. In this regard, Bishop and Glynn (1999) add that science teachers should use culturally responsive teaching or culturally based pedagogy to improve the understanding of concepts by learners.

In this regard, Ogunniyi (2011) concludes that for school science to be socially relevant, it should reflect aspects of IK that shape the lives of indigenous communities. In the same vein, Mavhunga (2008), Gwekwerere et al. (2013), STI (2012) and Tanyanyiwa (2019) point out that integrating the native Zimbabweans‟ IK into the conventional school science curriculum would enhance the curriculum‟s relevance and lead to better understanding of the concepts among learners. Learning should have a geographical, historical, and social context for them to be effective.

This study explores the integration of IK artefacts into the teaching of mechanics concepts in A level physics in Zimbabwe because mechanics lends itself to many applications of artefacts used in indigenous technology in Zimbabwe. The relevant indigenous artefacts that have mechanics concepts embedded in them are identified and described. A description of how they can be used to teach the concept is also given in the form of a pedagogical model.

The remender of this chapter outlines the purpose and significance of the study, background to the study, a statement of the problem, the research questions, and objectives, limitation of the study, definition of terms and concepts as well as the debate on indigenous science and indigenous physics.

1.2 PURPOSE AND SIGNIFICANCE OF THE STUDY

This study explores how physics teachers can integrate IK artefacts Artefacts and IK Strategies when teaching A level physics, with special reference to concepts in mechanics, and to develop a pedagogic (teaching) model for physics-IKS integration basing on insights from community elders, physics teachers, and learners in Zimbabwe. The researcher identified some IK artefacts and described them with the assistance of community elders, teachers, and learners through focus groups, interviews, and questionnaires. From this input, a learning package unit of examples has been prepared, with a teaching model on how IK artefacts and IK Strategies can be integrated, particularly in the teaching of Advanced level mechanics and physics in general. The model is given in this thesis.

The study will be beneficial to pre- and in-service physics teachers, policy makers, and learners. The study will add to the existing literature on the integration of IK artefacts in teaching of science at Advanced Level physics in particular. It will provide a platform for, and indicate ways in which, Zimbabwe‟s rich IK and practices may be integrated into the physics curriculum. This research may help the researcher and the participants to engage in reflective thinking about the integration of IK artefacts in teaching physics. The identified IK artefacts can be preserved, transferred or adopted and adapted elsewhere; thereby becoming global knowledge as has happened with the western European IK artefacts. The study will motivate researchers to identify more IK artefacts in which physics concepts are perceived and eventually significant physics concepts may be explained using indigenous artefacts and strategies. Learners will be able to connect meaningfully to school physics without losing their cultural identities or radically challenging fundamental physics principles. The study will also invoke some traditional or indigenous science instruction strategies, scientific ideas, skills, technologies and technological designs that have physics concepts embedded in them; such as have been taken for granted by indigenous people for many years, but which have more recently been ignored and delegitimised. This could, furthermore, ignite interest among learners and teachers to revisit traditional technologies and refine their efficiency so that they become equal to or better than those designed and refined over the years according to western cultural principles.

Generally the study will complement on other studies in promoting the nation‟s reconstruction efforts directed at improvement of educational access and equity, together with bringing the content, methods, and assessment of education, in line with the existing Zimbabwean context which are some of the postulates of national independence and virtues of balanced socio-economic development.

The ultimate goal is to improve physics education, not only at the selected schools, but in all of Zimbabwe and probably beyond.

1.3 MY BACKGROUND

I spent most of my early life in the rural areas of Zimbabwe, where I was born and raised. My contact with indigenous knowledge and technologies started in my early childhood. I had a strong connection with IK and indigenous people because my father was a peasant farmer, who used simple indigenous homemade equipment in his farming activities, such as hoes and ox-drawn ploughs. I started building indigenous knowledge when I assisted him in his daily chores at home and in the fields. My father was also a keen hunter, who would spend most of his summer time in the forests hunting. I still remember one cold summer day when he taught me how to make a snare for catching birds. I also used to admire the old man who lived in our neighborhood who used to make yokes (*majoko*) and mortars (*maturi*) for sale to people who lived in the, then newly established, resettlement area about 10 km to the north of our village. This man would hire my father‟s scotch cart to ferry his wares across the sandy river to the nearest bus stop. I would scrutinize the artefacts each time I had a chance to accompany my father. I liked the structure of the mortar (*duri*) most, although I wondered why the hole in it had a tapered end. There were also other people in the area that made different indigenous items. The list of my connection with indigenous artefacts and technologies is long. Even at school, in craft lessons we would make some small IK artefacts; I still remember the reed mats I made when I was in Grade 3.

At high school studying for Ordinary level, I met some topics in extended science, such as force, torque, stability, and instability. These topics were very difficult for me. I still remember my teacher holding a molded conical block trying to demonstrate stability. I also remember copying a diagram of a plum pudding to illustrate the structure of an atom. I did not know what pudding or plums were. All my peers were equally lost. Our teacher who had recently acquired a certificate in Education from a local teachers‟ college only had a vague idea of what pudding was. He mumbled through the description and then said "Something like that" without explaining further. This loss of words by the teacher indicated that he also had no knowledge of what pudding is. This cost him his trust from the learners. When I look at the topic today, I believe we could have understood this concept easily if the teacher had rather used an analogy of improperly prepared traditional mealie (maize) meal porridge, which had lumps of mealie meal (*bota rine mapundu*) in the porridge. One day one of our best learners burst out and angrily insulted the teacher, accusing him of always not explaining concepts clearly. He said "Last week you failed to explain the effect of application of force at a point away from the pivot." This was typical of the confusion and frustration we felt throughout the two years. We survived „the chop‟ at the end of the course by cramming; we could memorize facts, words, phrases, and procedures just to obtain correct answers to pass the tests and examinations. I continued to study physics at Advanced level, and pursued the subject up to Master‟s degree level.

I also trained to teach Advanced Level physics. I taught physics at a rural boarding school before transferring to another boarding school in an urban settlement. Both schools drew the majority of their learners from the surrounding communal areas. I have also taught Physics courses at two local state universities. These experiences brought me into contact with more physics content and teaching methods. However, I did not enjoy the job although I worked very hard. However, learners would devise ways to pass their courses by cramming rather than learning the content in a meaningful way. There was rote memorization of key terms, theories, and processes just as I had experienced at school. There were very low enrolments in the subject. Absconding from lessons was also rampant, but there was a disturbing dropout rate. For instance, in January 2017 the enrolment for physics at A level stood at 45, but only 32 wrote the examination in December 2018. Little meaningful learning took place, contrasting with the expectations of learning institutions and other stakeholders, and certainly not enough to be of benefit to their communities.

My vision of physics teaching started changing when I was requested to teach a course in pedagogical issues in physics at one of the local universities. When preparing lecture notes, I read a lot of literature on the teaching of science and IKS. I interrogated the way physics was being taught and its content and realized that there is a great need to make connections between school physics and the IK of the learners. I became more enthusiastic when I realized this link. I was particularly taken with the idea of using IK artefacts, some of which I used to interact with when I was growing up in the rural communities. I began to revisit some of these artefacts and realized that they had physics concepts embedded in their design, structure, and use. This fuelled my desire to explore more and more about how learners could understand school physics through the rich source of these indigenous artefacts that relate to the subject. I bemoaned the absence of these artefacts in the traditional teaching of physics because they appeared to be so effective for helping learners understand concepts easily. This led me to the proposal of the research study. The endorsement of the need to include IK in the physics curriculum by the Government through the Advanced Level Physics syllabus 6032, led me to approach the study with much enthusiasm. My personal background and some of the current trends in the teaching of Advanced Level physics have formed part of the background to this study.

1.4 BACKGROUND TO THE STUDY

My personal background outlined in Section 1.3 is only part of the background to this study. My personal background indicates that I was socialized in an environment where IK and IK artefacts made an immense contribution to the socio-economic development of the community. Added to this were observations in my community and in other indigenous communities in Zimbabwe that IK artefacts were among the tools used for teaching and learning. The current trends include those revealed in literature that is promoted by physics educators and those highlighted by science education researchers.

Physics educators are looking for way of making physics learning and teaching more interesting, more meaningful and more relevant (Shava, 2005). They are introducing innovations and pedagogy which they think would greatly improve the teaching and learning of physics in high schools. These innovations are believed to create greater interest among learners, and make them more motivated to learn with understanding and so to pass the subject more easily. These are also intended to improve, in the long-term, the effectiveness of physics graduates in solving their community‟s unique scientific and technological problems. These innovations include addressing issues on science, technology, and society (STS), integrating ICT into everyday life, using „hands on‟, and „minds on‟ approaches, creating awareness of environment sustainability concerns and using, and integrating, IK and artefacts wherever feasible.

The role and value of indigenous knowledge systems in enhancing and contextualizing education has long been recognized (Zazu, 2007). There is a noticeable growing interest in IK among educationists (Flavier, de Jesus, & Mavarirro, 1995; Mugwisi, 2017; Naidoo, 2010; Ndlovu, 2018; Nyota & Mapara, 2007). This is confirmed by an increase in publications on the subject e.g. (Barnhardt & Kawagley, 2005; Govender, 2009; Msila & Gumbo, 2016; Ndlovu, 2018). In addition to the publications several international conferences have been held to deliberate on IK and its place in socio- economic development processes (Ndlovu, 2018). Some governments have included issues to do with IK in their some of their policies, for example, The Zimbabwe Science and Technology policy of 2012. The increasing interest in IK is due to its assumed ability to create and sustain effective environment that benefit learners (Mugwisi, 2017; Naidoo, 2010) and its envisage positive contributions in the preservation of indigenous culture and sustainable socio-economic development. The government of Zimbabwe in its policy on Science and Technology of 2012 asserts that many of the traditions and products can still play an important role in the future developments. According to Kapoor and Shizha (2010), the use of IK in instruction is as old as human-kind. In early indigenous societies people could use the knowledge, skills, and technologies already acquired to effectively pass on new ideas, skills, and information to their citizens, from generation to generation. The indigenous people could also use their pre-acquired and familiar ideas, technologies, and artefacts for demonstrations, experiments and as examples during both formal and informal teaching and learning activities. They would re-use indigenous knowledge and related artefacts in order to build a new level of knowing. Oral narratives, myths, fables, legends, riddles, proverbs, as well as process of observation and participation were the instructional tools commonly employed by indigenous people (Kenyatta, 1965).

In such societies, mentorship was culturally sensitive and teaching approaches and methods were naturally suitable to the local context; anchored to a particular social group in a particular setting, and at a particular time. Africans had their own systems, contents and methods of education (Tanyanyiwa, 2019). Hence, the knowledge passed on was dynamic and the people solved problems of daily survival effectively. The teaching approaches and methods used by indigenous communities were so effective that most "learners" could successfully graduate from the informal schools and become active and productive members of their respective communities. Using these learnt indigenous skills and ideas, more efficient tools and further traditional technologies were also invented in response to technological problems. Old and inefficient traditional tools and methods of working were refined using tried and tested knowledge learnt through these mentorship and experiential approaches. This resonates well with the views of Baer (2002) who argues that science and technology are not the exclusive property of industrialized societies and who supports the idea that indigenous people are also inventors and custodians of technology and aspects of science. The use of IK in instruction by such societies was effective, meaningful, and relevant, as shown by these indigenous societies being self-sustaining in their needs. A combination of handed-down experiences and continuous learning

process using the IK and IK strategies helped people to learn to mold utensils, weapons and to concoct medicines for their wounded and sick (Dlodlo, 1999). Ogunniyi (2011) argues that indigenous knowledge sustained communities for many centuries.Semali and Kincheloe (1999) observed that prior to colonization, some local people sustained themselves better when they owned locally developed and traditionally shared knowledge than was the case after colonization. However, notwithstanding the above achievements, the worldviews and perceptions of Africans and other indigenous communities were often vilified as traditional, irrational, backward, and obsolete by colonial powers (Shizha, 2006a). Colonialism took anything traditional or
indigenous to be backward and inferior to western forms of knowledge (Giroux, 1996; Shizha, 2013; wa Thiong'o, 1986). In Zimbabwe the influence of colonization resulted in the denigration of IK and its associated artefacts from the 1900s. Colonization dethroned the indigenous knowledge of the Zimbabweans and replaced it with western science, with the widespread effect of hegemonising western knowledge and marginalization of many native learners. Colonial education led to the separation of individuals from their existential conditions and experiences, from their cultures and individuality (Giroux, 1996). wa Thiong‟o (1986) posits that colonial education annihilated peoples‟ beliefs in their names, their language, in their environment, in their heritage of struggle in their unity, in their capability and ultimately in themselves. Emeagwali (2003) argues that IK, along with indigenous teaching aids and strategies, were part of the knowledge that was swept aside and denigrated by the colonialists and were considered to be unempirical and superstitious. Quigley (2009) argues that, in both development and scientific circles, IK continues to be assigned a lower status than western based science and technology.

Emeagwali (2003) identified several strategies of disinformation that were still embedded in Eurocentric colonial and post-colonial education. The strategies she identified include the selective omission of African achievements, innovations and technologies, distortion of data and the surreptitious renaming of indigenous terms, concepts, places, and artefacts. A curriculum dominated by western-culture was implemented for those who studied science in formal western-type education settings in Zimbabwe from the 1900s. The education system was elitist in its deliberate bias, was marked by exclusively limited access and facilities as well as lack of relevance (Chitate, 2016).The Zimbabwean curriculum, teaching resources and learning space silenced the indigenous voices and their cultural forms from effectively participating in classroom science.

Emeagwali (2003) asserts that learners were educated to be misdirected, as they failed to realize the real purpose of education was to be in harmony with their communities. She adds that during the colonial period, while learners were admitted into schools, the school and tertiary curricula were designed and practiced to exclude cultural knowledge and skills that they acquired from their homes or were required in their communities. Science failed to teach scientific nderstanding within the actual world in which the learners lived (Cobern, 1996). The curriculum failed to recognize that „scientific knowledge‟ is itself a social construct of the western communities, as highlighted by Brayboy and Castagno (2008). The internationalized curriculum respected neither variations among people nor the different worldviews that learners bring to the classrooms (Howie, 2001). Science was presented as a micro-culture of western civilization and this was foreign and abstract to Zimbabwean learners. Jegede and Aikenhead (1999) admit that school science is a sub-culture of western culture and dismiss the usual portrayal of science and the process of generating science knowledge as being culture free. Generally, the curriculum, teaching methodologies, and assessment strategies associated with school science as it is currently taught, project and predominantly purvey one worldview; a western worldview that holds claims of superiority over other worldviews (Kawagley, Norris-Tull, & Norris-Tull, 1998).

According to Aikenhead and Jegede (1999), conventional school science seems highly disconnected from its intended practical ends. This means that the skills learnt from science are not applicable in the learners‟ context, in the sense that they are not suitable for solving the learners‟ or societal problems. This is because of the fundamental ontological and epistemological differences between western culture and science, and African indigenous cultures. In particular, the connections between school physics content and instructional approaches, and real life of African learners, make the former seems very remote from their daily practices (Moyo, 1988).

Aikenhead (1997a), posit that learners find science complex, because they are expected to construct specific science concepts meaningfully even when these concepts conflict with indigenous norms, values, beliefs, expectations and conventional actions of their life-world. In some cases, learners suffer psychologically when culturally insensitive approaches, aids, instructional technology, demonstrations, and examples are used in lessons by teachers. Added difficulties occur when they meet culturally non-contextual study materials and textbooks with no local reference to their culture. These factors jeopardize the self-esteem of the learners and make their understanding of concepts in science, or physics in particular, difficult. A further problem is the language of instruction. Shizha (2006a) asserts that the most common language for scientific investigations worldwide is English – the language of the colonialists. This is, furthermore, the medium of instruction in Zimbabwe, which also contributes to loss of IK and an identity crisis among learners. Cultural clashes with science and associated problems of its lack of relevance create learning and identity difficulties.

These issues then result in learners inventing ways to avoid learning science meaningfully, and instead just want to pass examinations. Physics being seen as irrelevant is also likely to be a factor contributing to the lower enrolments, irregular attendances and the higher rate of learners dropping out A level physics than happens with other subjects like mathematics and biology; all this results in lower achievement rates and high numbers of failures for the subject. Gudyanga et al. (2013) confirm that there is a decline in the number of learners enrolling for physics in Zimbabwe. Aikenhead and Jegede (1999), Ogunniyi (2000) and Gwekwerere et al. (2013) trace the cause of the low enrolments back to poor pedagogical practices and lack of relevance of school science and technology to leaners' worldviews. They argue that learners in indigenous societies around the world have for the most part demonstrated a distinct lack of enthusiasm for the experience of schooling in its conventional form: an aversion that is often attributed to an alien institutional culture rather than any lack of innate intelligence or lack of problem solving skills on the part of the learners.

Quiroz (1999) argues that high dropout rate, poor participation and irregular attendance in the science classes is due to the science topics taught in schools having little relevance to the learners‟ context. Manzini (2000) and Odora-Hoppers (2002b) attribute the high dropout rate to faulty pedagogy: teaching methods often fail to link the sciences with learners‟ prior personal knowledge that they have acquired from their indigenous scientific cosmology. Gwekwerere et al. (2013) argues that the pedagogical knowledge and curriculum materials used by the teacher may also pose challenges to learners‟ understanding of concepts. Learners tend to drop science, physics in particular, for perceived softer options in secondary school despite their awareness of the opportunities for employment and further study that physics creates (Fredicks, 1999).

Govender (2009) argues that a science curriculum that includes aspects of relevant indigenous knowledge, that recognizes learners" preconceptions and worldviews, that affords a platform for discussion of different ways of knowing and that encourages critical thinking is bound to attract and sustain more learners in science. Ways of understanding the interface between IK and western science, and thereby integrating IKS into formal academic disciplines are being sought. For example border-crossings have been proposed by Aikenhead (1996). I propose that the integration of IK artefacts into the teaching of physics is one of the strategies that can make border-crossing possible and enable learners to understand physics concepts more easily. Jegede and Okebukola (1991) argue that culturally sensitive curricula and teaching methods reduce the „foreignness" in the subject experienced by physics learners and teachers. The use of IK artefacts can also be a strategy for demystifying physics and eliminating physics" exclusive property as a preserve for a few people with western culture. By contrast, the inclusion of IK artefacts would make physics accessible, practical, less abstract and of greater relevance to all who want to study it at A level. The use of materials the learners are familiar with will promote meaningful learning, as the learner"s existing knowledge will interact more readily with the new learning and avoid rote learning (Upadhyay, 2006; West & Fensham, 1974).

According to Baker and Taylor (1995), the integration of IK in the teaching of physics enables learners and teachers to preserve what is good in the learners" personal and cultural traditions, while at the same time allowing them to benefit from western science and technology. The learners would be able to borrow or adapt and incorporate content and aspects of the western science culture that are useful to them. It would allow for autonomous acculturation (Aikenhead, 1997a). These positive effects of using IK may have influenced the contents of the current Zimbabwe policy on science and technology education.

In the A level Zimbabwe Schools Examination Council (Zimsec) Physics Syllabus (6032) (ZIMSEC, 2015), aim 5.1 indicates that IK should be integrated in the teaching and learning of physics. The syllabus also indicates that the study and practice of physics involves co-operative and cumulative activities, subject to social, economic, technological, ethical, and cultural influences and limitations. Topics like forces emphasize the need to use IK in the teaching of physics where learners should be able to describe everyday application of forces in equilibrium. Shava (2005) observed that although much has been written and said about the need to include

IK in the school curriculum, there is limited use of IK artefacts in formal physics education in Zimbabwe. Most of the physics teachers in the Zimbabwe high schools were educated under a curriculum that was biased towards western culture. Thus their notion of schooling, the curriculum content, the teaching and learning styles which they acquired during their training, all of which they then transmit to learners, run contrary to the sociocultural realities that they face in the science classroom. Thus physics remains dominated by western cultures, as evidenced by their western culture loaded teaching approaches, methods, and instructional technology. For example, they use English language as the medium of instruction, and rarely tried using indigenous languages like Tonga despite the benefits of using indigenous languages.

Foreign National languages (European) have become the medium of instruction while vernacular languages (Chishona & Ndebele) are sidelined (Dziva, Mpofu, & Kusure, 2011). Even in the physics examinations, learners are reminded to write their answers in good English (ZIMSEC, 2016). Dlodo (1999) argues that the very low national pass rates in the final year at secondary schools in Southern Africa can be ascribed to, among other things, the failure by learners to grasp scientific concepts that are explained in English. Cummins (2015, p. 35) attests to the idea that learners who have language deficit lag behind others in their learning and in social interactions and exchanges with others. Meyer and Crawford (2011) also argue that school science language practice is largely responsible for distancing marginalized learners from science while providing support for the privileged. Lewis (2000) posits that many problems of science learning may be associated with lack of language proficiency because, more often than not, for disadvantaged learners, science is taught through a medium of instruction that is not the learners‟ mother tongue. Magwa and Mutasa (2007, p. 7) add that learners who do not understand the language used in teaching science cannot receive new ideas and knowledge. By contrast, Cronje, de Beer, and Ankiewicz (2015) posit that the use of an indigenous language allows learners to assimilate information faster than when the official language of learning and teaching (LoLT) is used. This mirror the views of Shizha (2007) who observed that learners taught in their home language perform better than those taught in English.

Teachers need good knowledge of pedagogy, content and knowledge of learners including language in order for them to do their job well (Gess-Newsome, 1999).Unfortunately in

Zimbabwe, very little effort has been made to bring IK and indigenous languages into the school curricula (Dziva et al., 2011). Shizha (2006a) observed that formal education in Zimbabwe continues to be Eurocentric in outlook and academic in orientation, reflecting western industrial and scientific cultures rather than the cultures of their learners and teachers. Mpofu (2016) adds that classroom science in Zimbabwe remains western-oriented, as it has been for 35 years since independence, and remains irrelevant and inaccessible to indigenous Zimbabweans. For instance, the recommended textbooks listed in the syllabus are dominated by western illustrations and examples such as the plum-pudding model for describing atoms. Most laboratory equipment and apparatus in the high schools is related to western culture; for example, ripple tanks are used to demonstrate properties of waves where as natural ponds in school grounds could also be used. Romanowski (1998) elaborates that in some cases there is heavy reliance on improvised teaching resources that are dependent on the teacher‟s enacted scientific views to define, select, and organize information to deliver to learners. Learners may thus fail to understand and construct concepts that are congruent with what scientists believe (Novak, 1977).

The recommended teaching approaches and methods are all conspicuously western. Science teachers do not even use the methodologies inherent in IK in their teaching of school science which include folk stories, riddles, music, songs (Kroma, 2000) or include consultation of IK specialists. Kazembe and Nyanhi (2010) observed that most conventional lesson planning models are based on the verbal explanations or visual demonstrations of a procedure or skill by the teacher. Teachers do not consult verbal specialists like old indigenous people from the communities that surround their schools. Such teaching methods greatly affect learners‟ border-crossing in physics. Border-crossing occurs when the science experienced at home or the worldviews of learners are different from those expected or experienced in the school science. In this case learners are expected to cross the boundary between the worldviews. Indigenous learners continue to receive the least interesting, most passive form of instruction and are rarely given opportunities to participate actively in their own learning. Shizha (2014) notes that school systems ignore the cultural capital that learners bring to schools and fail to provide supportive school learning infrastructure and environments. The prevailing situation in the teaching of science is also at odds with the requirements of the National Policy on Science and Technology Education in Zimbabwe which requires that science be taught in context.

The literature review supports the use of IK and its associated artefacts and strategies in instruction in Africa and indicates that its inclusion can improve understanding of concepts, improving the effectiveness and efficiency of teaching and learning if integrated in learners‟ learning of science. Webb (2013) argues that IK and its associated artefacts should be included in the science curriculum to highlight the relationship between science and the culture of the learners.

1.5 CONTEXT OF THE STUDY

The study is located within Masvingo District which is one of the 59 Districts in the Republic of Zimbabwe. The district encompasses metropolitan Masvingo in Masvingo Province in Southern Zimbabwe. The district has a population of over 211,215 people according to the 2012 census (Zimbabwe National Statistical Agency, 2012). The population is dominated by Shona people who speak the Shona language. People in the rural part of the district are mostly communal farmers. Other indigenous or traditional practices include fishing, music, crafts of pottery and basketry etc. The people who live in the urban part of the district often visit their rural areas.Zimbabwe has a developing economy, which requires a guaranteed supply of scientifically literate people for it to be sustained. It needs people with knowledge of the major principles, laws and theories of science, and who can apply them appropriately in the country‟s industrial and commercial sectors. The country requires people who can use the processes of science suitably in solving problems, making decisions. It needs people who use scientific ways of thinking for individual and social purposes.Masvingo District being the district where Masvingo Provincial capital city is located, the schools located in the district could be expected to offer better learning facilities s than would schools located in other, more remote, parts of the province.

Two of the three high schools where the research was conducted are managed by churches and are located in the rural areas in the periphery of Masvingo town. The other school is managed by the government and is located in Masvingo town. The three schools have similar modern learning facilities and resources, although these are not adequate. The equipment in their laboratories is dominated by imports which are normally supplied at exorbitant prices by the local suppliers. The bulk of their physics textbooks are imported. The teachers and learners in these schools are highly disadvantaged in terms of facilities and resources that are conventional and familiar elsewhere for teaching Advanced Level physics. Nevertheless, teachers in these schools are expected to ensure that teaching and learning of Advanced Level physics is as exciting and informative as possible and also that learners pass their examinations. Teachers in all the schools where the research was conducted share the similar cultural background as their learners. The teachers and learners are mostly Shona speaking and come from various districts of Masvingo, Matebeleland, and Manicaland Provinces. This homogeneous context perhaps facilitated the smooth integration of indigenous artefacts in the teaching of concepts in mechanics.

1.6 STATEMENT OF THE PROBLEM

The problem is that A level physics in Zimbabwe excludes the IK and cultural backgrounds of the learners in its instructional approach and strategy. This exclusion could be one of the factors causing learners to perform poorly in the subject. The exclusion of IK and cultural backgrounds of the learners in its instructional approach and strategy causes most learners to view the subject as abstract and so they perform poorly. The poor performance coupled with other factors has caused lower enrolment in physics than in other subjects, irregular lesson attendance by learners and high dropout rates. According to the analysis for the 2014 November examinations, a total of 217616 candidates wrote the examinations, but only 1795 passed with grade E or better. In 2015, 2639 wrote the exam and only 2140 learners passed with grade E or better. In 2014,163 private candidates sat the exam in November and only 68 (less than half) candidates passed with grade E or better. Generally the quality of passes was always poor. The pass rates for 2014 and 2015 were 89.68% and 83% respectively. However, these figures do not portray the real situation as they were calculated from a grade E and above. On the other hand, the percentage pass rate from grade C and above was well below 45%. Results released by ZIMSEC from 2014 to 2016 show that students are shying away from Science subjects and many of those who sit for such exams fail dismally (Machingambi, Oyedele, Chikwature, & Oyedele, 2018). Unfortunately this is happening at a time the country is expected to be building a base for innovation and technological advancement with the STEM initiative under the government's Zimbabwe Agenda for Sustainable Social and Economic Transformation (ZIMASSET) philosophy. Harris and Sass (2011), Dilshad (2010) and Muzenda (2013) concur that, learners' poor performance in Science subjects globally is basically due to the lack of qualified teachers as well as unavailability and/or insufficiency of materials in the laboratories. Fadaei and Mora (2015) and Saleh (2014) argue that poor performance of learners is due to the learning processes that involve understanding of physics which require learners to deal with different types of representations, such as fomulas, calculations, graphic representations, and conceptual understanding at an abstract level. Machingambi et al. (2018) give reasons such as not using laboratories effectively and teachers' qualification among other reasons.

Chiromo (2010) confirms the existence of conflicts between learners" home background and school science. This is similar to the finding by Shava (2005) that the Eurocentric nature of the physics curriculum in Zimbabwe causes under-achievement among black learners. The delivery by the teachers of concepts in the subject is also abstract (Gudyanga et al., 2013; Gwekwerere et al., 2013; Kasembe 2011), which Kazembe and Musarandega (2012) indicate, can also be a major source of learning problems.

There have been proposals for ways to improve the learning and teaching of the subject as indicated in the Advanced level ZMSEC physics syllabus 6032 (Zimsec, 2011), which highlights the need to integrate indigenous knowledge (IK) artefacts into the teaching of the subject; however, the document is not explicit about how the integration should be done. Since independence in Zimbabwe innovative projects have been put into place to improve the delivery of science teaching in schools. Included among these, in addition to the new curriculum, are the Zimbabwe Science Project, Quality Education in Science Teaching, Science Education In-Service Teacher Training programme (SEIIT) and the recently launched STEM, which later became STEAM, initiative, In all these initiatives there was mention of the need to use locally available materials in the teaching of science. The general view appears to be that the integration of indigenous artefacts in the teaching of physics can be a scaffolding strategy for learners to grasp and understand concepts more easily.

Although much has been said, written, and done about the challenges haunting physics education in Zimbabwe, very little has been said about the opportunities that exist to take it to higher levels through the use of IK artefacts. There is no evidence of, or research on how integration of IK artefacts in the teaching of Physics is supposed to be done. The zimsec physics syllabus 6032 and the Science and technology education policy of 2012 make only brief reference to IK and IK artefacts, and leave the teacher with the responsibility of deciding which IK artefacts and IK strategies to integrate in the teaching and learning of the subject, and how this should be accomplished. In this regard, Mpofu (2016) observed that the policies in Zimbabwe are clear on the purpose of reforming education, but do not provide guidelines on what IK to integrate, where this should happen in the existing curricula and how to do it. There has also been no deliberate effort to integrate IK artefacts in the teaching methods courses of teacher training programs. Therefore even teachers who may have adequate IK are not guided in how to integrate it into their teaching. The teachers were trained in systems deeply entrenched in western paradigms. The teachers have consequently had thoroughly assimilated and had been modeling the habits of western scientists.

Consequently, despite all the initiatives and programs, advanced level physics remains abstract in nature and removed from the learners‟ cultural context in its delivery. Learners continue to struggle to understand concepts and so perform badly in examinations. This has influenced the researcher to explore how physics teachers integrate IK artefacts when teaching advanced level concepts in mechanics to improve learners‟ learning. Issues arising from the integration process were also explored. The intention is to align teachers‟ lesson delivery and learners‟ learning with their sociocultural and science experiences.

1.7 DELIMITATION OF THE STUDY

The study was done in Zimbabwe in the Masvingo District (see Figure 1.1).

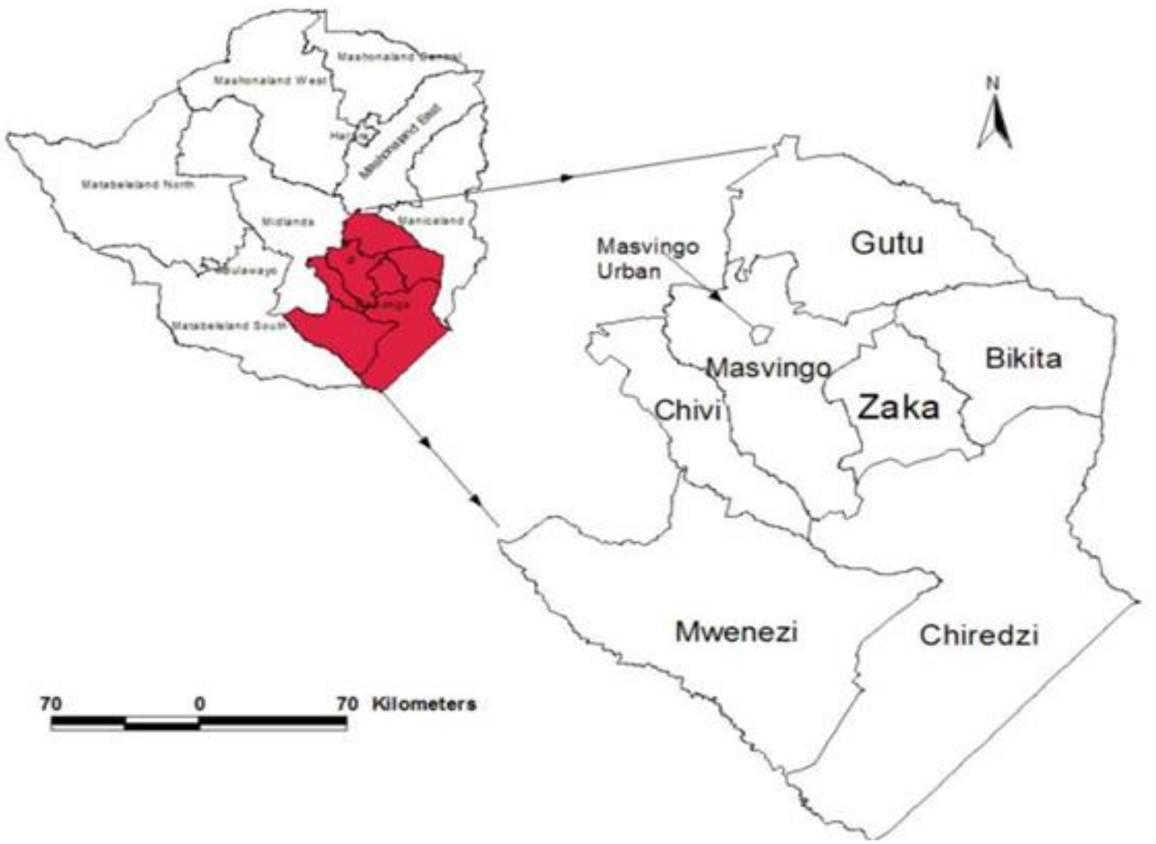

Figure 1.1 Map of Zimbabwe

Data were collected from the three high schools that offer physics at advanced level in this district along with part of the communal area forming the high schools" catchment area. The three high schools and the communal area were chosen for convenience. In order to explore experiences in a large number of topics in mechanics, the teachers of lower and upper sixth forms (Forms 5 and 6) A Level physics at the selected high schools were considered for the study together with their learners.

The study looked at Integrating Indigenous knowledge (IK) artefacts and IK strategies in teaching mechanics basing on insights from community elders, physics teachers, and learners. The study did not focus on everyday knowledge in general; it rather focused on everyday knowledge that is rooted in indigenous knowledge system (IKS) and its associated artefacts. The thesis is concerned with enabling learners to understand the curriculum physics concepts through their IK and is not about teaching of indigenous physics. Data were collected from January 2017 to September 2018.

1.8 OBJECTIVES

There are three objectives to the study, as follows.

1. To identify the indigenous artefacts with Advanced Level physics mechanics concepts embedded in them that can be integrated in the teaching of mechanics in Forms 5 and 6 in Masvingo District, Zimbabwe.

2. To identify Advanced Level physics concepts in mechanics embedded in the indigenous artefacts in Masvingo District, Zimbabwe.

3. To describe how Advanced Level physics teachers can integrate indigenous knowledge

   artefacts when teaching concepts in mechanics in Forms 5 and 6 in Masvingo District, Zimbabwe.

1.10 RESEARCH QUESTIONS

To accomplish the research objectives five research questions were framed

1. What are the indigenous artefacts that can be associated with Advanced level mechanics found in Masvingo District, Zimbabwe as percieved by Elders, teachers and learners?
2. What are the Advanced level mechanics concepts that can be associated with these indigenous artefacts identified in Masvingo District, Zimbabwe?
3. How can indigenous artefacts be integrated in the teaching of Advanced Level Physics mechanics as perceived from the elders, teachers, and learners?
4. What feasible pedagogic model of teaching and learning can be proposed regarding the integration of IK into physics, considering the views of elders, teachers, and learners in the Advanced Level physics in Zimbabwe?

1.10 LIMITATIONS OF THE STUDY

Indigenous knowledge and associated artefacts were not documented and were not readily

available. Furthermore, some issues and artefacts related to sacred and secret knowledge. There were also issues about who has the right to speak, about what and to whom. Some knowledge was possibly shared only with men or only with women or only with people of a certain age. To avoid such problems, I had to find out the local protocols for visiting indigenous people to talk with about their IK. Another issue was that people were also not overtly aware of indigenous knowledge that exists in their area, or were unaware of what was being sought. Hence, I anticipate the need for a few pre-investigation workshops. Another limitation for this research study is the prevalence of intricately interwoven factors at play in the teaching and learning of physics. As such pin-pointing evidence exclusive to intergration of IK artefacts in the teaching impact becomes a difficult exercise. Financial constrains limited the number of visits to the schools. Informing the school early about my plans reduced problem of disturbance of data collection by schools' programmes.

1.11 DEFINITION OF TERMS AND CONCEPTS

1.11.1 Indigenous Knowledge (IK)

The concept of indigenous knowledge (IK) has been proposed from different perspectives and several researchers have attempted to synthesis its meaning. For example, IK is knowledge that is unique to a given culture or society and is acquired through the accumulation of experience, informal experiments and intimate understanding of the indigenous environment. Zazu (2007) refers to IK as content (facts, processes, methods) and processes (applications) relating to communities, their knowledge, associated daily practices and the cross-generational mechanisms of transmission of all of these. Onwu and Mosimege (2004) see IK as a variety of knowledge that covers technologies and practices that were used and are still being used by indigenous people for existence and survival in various situations and environments.

Khupe (2014) indicates that IK originates in oral cultures and abides in the hearts and minds of elders and specialist knowledge keepers in particular areas. The knowledge is considered to be a special heritage that is supposed to be passed on from generation to generation for practical and survival purposes. As shown by those who hold it, such as elders in the community, either orally or through apprenticeship.

The commonality among these definitions is that IK is generally the knowledge generated, developed and used by people in a certain area. Generally it involves all forms of knowledge; that is technologies, know-how, skills, artefacts, art, beliefs, teaching and learning approaches etc. that enable the community to achieve stable livelihoods in their environments. The inclusion of IK in curricula can be in terms of both content and context.

1.11.2 Physics

Physics involves the study of matter and energy in its different forms and the transformation of matter to energy. It involves the study of the physical world, matter, energy and the interactions and relationships between matter and energy. Concepts that are found in physics include force, torque, mass, centre of gravity as used in mechanics. The application of physics principles in the development of indigenous technologies will help in the production of more valuable goods that conform to modern standards and can be marketed beyond traditional communities (Stephen, 2010b).

1.11.3 Indigenous Technology (I-Tech)

Mensah (2008) views indigenous technology (I-Tech) as traditional approaches or methods and skills used to transform locally available materials into products either for trade or for family consumption; it is concerned largely with the production process. Maluleka, Wilkinson, and Gumbo (2007) define indigenous technology as the use of technical knowledge, skills, and resources developed and transmitted by indigenous people to their young ones in their cultural settings and used to manipulate the environment in order to meet their everyday needs and wants. Considering the definitions above, it can be contented that indigenous technology includes practices, crafts, artefacts, methods, or techniques employed by local or indigenous people to transform locally available indigenous resources or raw materials into products and services for personal or community usage and trade. These include the use of indigenous tools and techniques like needles to make reed mats, or making of stools (see Figure 1.2). The artefacts used in the study are manufactured using indigenous technology. Handayani, Wilujeng, Prasetyo, and Tohir (2019) observed that physics knowledge is manifested in these indigenous practical skills and knowledge.

Figure 1.2 An old man making an artfact using indigenous technology

However the focus in this study was not on the production process, but rather on the physics concepts that could be drawn from the process of making and using it and also its shape and design.

1.11.4 Artefacts and Indigenous Artefacts

Keil, Greif, and Kerner (2007) define artefacts as simply things or objects that were intentionally created to help achieve some sort of goal which can be physical, such as hand tools, or non-physical like poems, stories and social conventions. Keil et al. (2007) add that pieces of art together with performances are part of intangible artefacts. Therefore artefacts are both tangible and intangible things created for a purpose of meeting peoples" needs and wants.As stated, Keil et al. (2007) define artefacts as simply things that were intentionally created to help achieve some sort of goals, IK artefacts can be defined as those indigenous things created intentionally to meet the needs and wants of indigenous people. Considering ideas from Keil et al. (2007) they can be tangible or intangible. The tangible ones can be defined as objects that are made by a person; especially those of historical or cultural nature (Hornby 2010). Therefore IK artefacts are things made by people belonging to a particular place, especially those of a cultural nature and which have specific meaning in these communities. According Mensah (2008), they are part of indigenous technology (I-Tech) and are produced by traditional approaches or methods and skills. Examples of the indigenous artefacts found in Masvingo District include a reed basket, named *tswanda* in Shona and shown in Figure 1.3.

Figure 1.3 Reed basket (*tswanda*)

IK artefacts reflect the wisdom of people who have lived a long time in a place and have a great deal of knowledge about their environment. They are made from local materials, which may include wood, leather, cane, fibre, bamboo, animal horn, and other durable materials.
Intangible indigenous artefacts may include traditional performances, games, and stories.

Ingigenous artefacts can be modified in order to improve their efficiency, appearances, and effectiveness. Mensah (2008) asserts that this modification can be achieved by acquiring technological literacy and capability in school. In this view the school should employ contextually relevant or everyday activities and indigenous artefacts as a starting point for teaching technology rather than starting with abstract processes and model

1.11.5 Science

Abrusscato (1998) says „science" is the name given to a group of processes through which we can systematically gather information about the world. It involves all the systematic efforts by humans to investigate, organize, and manage the natural world. It involves the search for explanations, patterns, regularities, and irregularities in nature through actions, reactions, causes and effects in the environment. Science is knowledge acquired by careful observation and by deduction from experiments to formulate laws which govern changes and conditions. Science as a body of knowledge includes facts gathered, the concepts defined, and the generalizations that unify these facts and concepts as a set of principles and laws, as well as hypotheses and theories

that can be used to make predictions.The processes of science are the procedures or activities carried out by scientists in the creation and acquisition of knowledge. These include observing, measuring, predicting, and experimenting. Learners acquire scientific skills (like thinking skills, practical skills, and social skills) and attitudes (like curiosity, objectivity, creativity) and values (like truth, order, freedom, and scepticism) when carrying out scientific processes. Overall, science is characterised by those values and attitudes possessed by people who use scientific processes to gather knowledge. Humans engage in science to transform the environment and improve the quality of their lives and make the world better for them to live (Samuel, 1996).

1.11.6 Mechanics

Mechanics is an area of science concerned with the behaviour of physical bodies when they are subjected to forces or displacements and the subsequent effects of bodies on their environments. Topics which fall under mechanics include force, torque, and moments of forces.

1.11.7 Teaching

Teaching is a system of activities intended to induce learning, which as Curzon (1985, p. 14) explains, entails the deliberate and systematic creation and control of those conditions in which learning does occur. The definition shows that the teacher should have control of what is learnt and so plans the relevant activities for the learner. Mercer and Pettit (2001) are of the view that effective teaching occurs when a teacher provides guidance and intellectual support for the learners, to enable them to „swim out of their depth", and so go just a little further intellectually than they would be able to go alone. The guidance and the support can be provided by using IK artefacts and teaching strategies that are familiar to the learners. With the help given by the teachers, learners would then be able to swim alone into progressively deeper intellectual waters. Learners would be able to navigate through new areas on their own, using the skills and knowledge gained.

1.11.8 Integration

The Cambridge *Dictionary of English* defines integration as the process of mixing, joining, or combining one object with another (Procter, 1995). Mayor (2009a) defines integration as the combining of two or more things so that they work together effectively. It involves making a "whole" from many parts. Common among the definitions of integration, is an aspect of unifying a number of aspects into one. In the context of this study integration would involve infusing IK, IK artefacts and indigenous pedagogical practices with western science pedagogical practices and methods in such a way that they are indistinguishable or unclear as to where each of them begins and ends when combined together in the teaching process. Commonalities, overlapping concepts and principles of pedagogical practices associated with both IK and western science (physics) are brought together in a meaningful equitable way to enhance learning. Integrating IK in schooling is an efficient way of strengthening and maintaining a balance of social order, within an educational context (Handayani et al., 2019). It is a way which allows IK and its related artefacts to gain better space and access to school science.

The philosophy of integration in the context of physics as a discipline lies in understanding that the discipline can be viewed and understood in different ways, which can be interconnected to make them more effective. The idea and process of integration challenges an individual to analyse what is happening, so making him to reconsider what is already known, resulting in a new understanding based on complete interaction between prior knowledge and current experiences.

An integration model for education presented by Mpofu (2016) depicts integration as being a context-dependent process having four possible pathways or forms, given as divergent, parallel, convergent and substitutive (DPCS). Divergent integration occurs when the knowledge systems are kept separate and each knowledge system is taught in its own context. The parallel path is where the two knowledge systems are taught within the same laboratory space, but with each retaining its characteristic nature.

In substitutive integration one knowledge system displaces the other, such as happens when western classroom science replaces IK or vice versa. The fourth form is convergent integration, in which hybridized knowledge that is common to both systems is adopted in the teaching and learning prrocesses. With such a path, the good and useful aspects of knowledge from the western system are sifted and aligned with the valuable knowledge in the IK system, to form a new and worthwhile knowledge system. IK is integrated in a meaningful way and not token inclusions or mensioning in passing in designated units of the teaching and learning processes. The convergent integration approach is the one that has influenced the orientation of this study.

1.12 Indigenous Science and Indigenous Physics: the debate

Debates continue about whether IKS is science or not, and whether or not there is indigenous physics. Some researchers of IKS (Duit, 1991; Mintzes, Wandersee, & Novak, 2005) claim that the rationality of IKS is similar to that of western science and therefore may be equated with science. Duit and Treagust (1998) argue that IKS is science because it is practical and is applied for survival. Traditional knowledge also has the element of „systematicity" that science possesses. Arun and Joseph (2007) and Handayani et al. (2019) argue, they are the same on methodological and epistemological grounds.

Modern science is a context dependent body of knowledge just the same as traditional knowledge and, like indigenous knowledge; it is also conditioned by the ecological, economic, social, religious, and gendered contexts in which it develops (Agrawal, 1995). Snively and Corsiglia (2001) are of the view that IKS offers important science knowledge that western modern science is yet to fully understand. There are, however, writers who emphasize the differences between IK and western science knowledge. Ezeanya-Esiobu (2019) argues that the difference between the two lies in their approaches, which give each a distinct identity of its own kind. Ezeanya-Esiobu (2019) adds that the differences are philosophical in nature, arising from the discrepancies in social and cultural processes and worldviews as well as culture of research and intellectual inquiry. Scientific knowledge was constituted during the eighteenth and nineteenth centuries and it absorbed European folk knowledge and practices (Oguamanam, 2006, p. 14). Oguamanam (2006) argues that, westernization of knowledge led to the use of the term "scientific knowledge" interchangeably with "knowledge" itself, but in true sense of the word, science is only a variation of knowledge. Oguamanam (2006) cautions that the differences do not justify the exclusive appropriation of validity into western knowledge systems.

Knowledge is a complex body of several socially constructed ideas, validated by the dominant intellectual persuasion at each point in time (Lemke, 1994, p. 1). This indicates that knowledge is "always biased because it is produced from a social perspective of the analyst, thus reflecting his or her inclination towards certain interests, values, groups, parties, classes, nations" (Jackson & Sorensen, 2003, p. 248). Foucault (1969) shows that knowledge is not and cannot be neutral, not morally, not politically and not ideologically, because all knowledge reflects the interests of the observer. According to these views, science and IKS are two different bodies of knowledge, each with characteristics that are derived from the culture of those people who constructed and validated its contents and its creation processes. The two bodies of knowledge are relevant, useful, empirically testable, and valid in their respective communities and contexts, and also in similar contexts. The two bodies of knowledge can co-exist in harmony complementing each other in solving problems faced by people.

Ezeanya-Esiobu (2019) argues that the comparison between IK and western science is often made in a manner that favors the latter and ascribes to it the aspect of universality. Comparing western science to IK presupposes an „overarching" comparator in the form of universal reason or science, which is ontologically privileged (Oguamanam, 2006, p. 17). Such a comparison places western science on a higher pedestal as a superior form of knowledge. This comparison between IK and western science is not necessary. As Oguamanam (2006) argues, the baseline of universal reason exists in all traditions, enforced by shared human, economic needs, and cognitive processes; although advanced and expressed in different cultural contexts.

The debate about IKS and western science seems to have no conclusion in the foreseeable future. However people have to assume a position that suits their unique context at a particular time and place.The debate also evokes other similar debates, such as whether there is indigenous physics or not. This debate then involves issues on the differences between indigenous physics and western physics. Ogawa and Aikenhead (2007) and Handayani et al. (2019) are among the people who argue that there is indigenous physics knowledge. They agree with Mapara (2009), who asserts that indigenous physics knowledge systems have not died as a result of colonisation. Ogawa and Aikenhead (2007) define indigenous physics as the experiential knowledge based on worldviews and culture that is basically relational. Handayani et al. (2019) add that it is also a way of life and knowing for the indigenous people. Ogawa and Aikenhead (2007) posit that indigenous physics relies on direct observation for forecasting and generation of predictions.

Shizha (2014) and Handayani et al. (2019) argue that indigenous physics is connected to the people, and their history, cultural context and worldviews. Stephen (2010) views the construction of indigenous physics as based on the historical and cultural worldviews that shape or influence peoples" consciousness, which in turn forms the theoretical framework within which knowledge is generated, critiqued and understood. Handayani et al. (2019) conclude that knowledge of physics and it's methods of investigation can not be separated from people' history, culture and worldviews Ogawa and Aikenhead (2007) take the position that indigenous physics, unlike western physics which involved controlling the natural environmental forces, deals only with finding ways of accommodating nature.

Driver (1989) and Horsthemke (2004) argue that all forms of knowledge are valid and should co-exist in a complementary relationship. This implies that both western and indigenous physics should be allowed to co-exist. Nicholas (2019) vies science as a multicultural enterprise that benefit from and indeed requires competing views. In this thesis, IK and IK artefacts will be used to unpack, enrich, reinforce and not threaten western science and vice versa.

Furthermore, Ezeanya-Esiobu (2019) emphasizes that deliberate effort should be made to ensure that science forges a symbiotic relationship with other bodies of knowledge; that it is rejecting and labeling them as backward, barbaric and unscientific and as reservoirs of myths, errors, misconceptions, and falsehoods.

Arun and Joseph (2007) advise that government should support co-operation between indigenous knowledge holders and scientists to explore the relationships between different knowledge systems and foster inter-linkages that are of mutual benefits. Having outlined some of the arguments in this contentious debate on whether there is indigenous physics or not, it is not the focus of this study. Instead, I am of the view that IKS as a general concept will cover all aspects of indigenous linked sciences

1.13 OUTLINE OF THE THESIS

This chapter, which is an introductory chapter, has outlined the background to the study, the purpose of the study, its research objectives and critical research questions, the statement of the problem and the location of the study. Chapter 2 is a literature review related to the study. It explores literature dealing with the integration of IK artefacts and IK strategies in teaching Advanced Level physics.

Chapter 3 covers the theoretical framework underpinning this research study. Chapter 4 explores the research methodology guiding the research. This includes the research paradigm, type of data collection techniques, sampling and sample size, validity of the research, data analysis, ethical issues and limitations of the study.

Chapter 5 focuses on data analysis and research findings. Chapter 6 discusses the key research findings. Chapter 7 gives the conclusion.

1.14 SUMMARY

In this chapter, the background to the study, the purpose of the study, research objectives, and critical research questions, statement of the problem and the location of the study were outlined. The purpose of the study was to explore how physics teachers can integrate IK artefacts when teaching A level physics, with special reference to concepts in mechanics, and to develop a pedagogic (teaching) model for physics-IKS integration.

The problem indicated is that A level physics in Zimbabwe excludes the IK and cultural backgrounds of the learners in its instructional approach and strategy. This exclusion is suspected to be one of the factors causing learners to underperform. Furthermore, an outline of the thesis is presented.

Chapter 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter examines the literature on the integration of IK in teaching of Advanced Level physics. The chapter also presents literature on physics and its pedagogy in Zimbabwe followed by perceptions of teachers on the integration of IK artefacts and IK strategies when teaching physics. The use of western indigenous artefacts with physics concepts embedded in them being integrated in Physics are discussed, with notable examples in the Zimsec Advanced Level Physics Syllabus and recommended textbooks. An overview of the National Science and Technology Education is given.

Studies reported in the research literature highlight the growing knowledge and interest within the educational research community in indigenous knowledge (IK), not only in Zimbabwe (Shava, 2005) but in other parts of Africa (Govender, 2009), and globally (Aikenhead, 1996). Studies by Malcolm, Gopal, Keane, and Kyle (2009), Cronje et al. (2015) and Keane (2008) all indicate the strong relationship between formal science learning and informal science, which in the African context is often linked to IK. One area of IK that is currently being explored is the inclusion of IK in science(Shava, 2016). There is some evidence of science and technology concepts embedded in IK artefacts and in apprenticeship practices used in indigenous communities in Zimbabwe and other African countries. In this regard, Dlodlo (1999) observed that African languages spoken today have a technological vocabulary associated with processing moulding, manufacturing, shaping, and carving, all of which require appreciation of technology. However, he cautions that part of the technological vocabulary has been lost because it is now sparingly used. Dlodlo (1999) also indicate that the instructional strategies of informal apprentices in the indigenous communities have been very effective in introducing new apprentices to the intended knowledge and technological skills.

Countries such as Nigeria, for example, have been shown by Le Grange (2007a) to be successful as a result of integrating their indigenous knowledge with the western science and technology. In addition, Ogunniyi (2007) observed that South Africa, Canada, USA, including Alaska, as wellas some South American countries, are among those that have attempted to include indigenous knowledge systems (IKS) within their science curriculum. In this regard, Deloria and Wildcat (2001) claim that native American learners radically transform scientific knowledge by grounding themselves in their traditional knowledge about the world and work this understanding into the western format.

The literature also indicates studies where western indigenous artefacts with physics concepts embedded in them have been integrated in the physics concepts explanations, demonstrations and descriptions. Kawooya (2006) discusses the absurdity of rejecting the worth of African IK, which happens through traditional acquisition and oral transmission of knowledge.

It has been argued that the delivery of school science and technology does not take into consideration the learner"s sociocultural background and ways of knowing (Ogunniyi & Ogawa, 2008). The education system does not acknowledge the incompatibility between the culture at home and immediate community and the culture of school science (Dlodlo, 1999). Science is being taught out of context as observed by (Gwekwerere, Mushayikwa, & Manokore, 2013).Familiar and every day experiences of learners are not sufficiently represented in science lessons (Na and Song, 2014). Formal physics education a and imported paradigms have redefined and socialised Zimbabweans out of their indigenous knowledge systems to suit western based scientific views. This has forced Zimbabweans to abandon their traditional strategies of teaching and learning and adopt alien western pedagogical approaches (Dlodlo, 1999). Consequently, school physics instruction sometimes disrupts the learners" worldviews by trying to force them to abandon and marginalise their life world concepts and reconstruct in their place new ways of conceptualising reality (Simasiku, Ngcoza, & Mandikonza, 2017). Physics concepts are being presented to learners as disconnected to the knowledge the learners bring into the physics laboratory from their homes.

These foreign teaching and learning strategies make the subject more abstract and difficult for both teachers and the learners. Science as a subject and Physics in particular is not readily accessible to learners because of its abstract nature and technical language which is different from everyday language (Lemke,1990).

When a Zimbabwean physics student thinks about physics, he or she moves beyond a locally supportive context, into something that is far-fetched, abstracted, and dislodged. There is no harmony between school physics and the culture at home that can promote transition of learners in the physics laboratory. There is need to refocus science teaching by using local contexts or materials to deepen learner's understanding of science and its relevance to the local environments(Nashon & Madera, 2013). Local contexts should be used to explain physics concepts and phenomena.

2.2 PHYSICS AND PEDAGOGY IN ZIMBABWE

After independence, the government of Zimbabwe put in place numerous innovative projects to improve the teaching and learning of science in schools (Gudyanga et al., 2013; Gwekwerere et al., 2013; Mtetwa, Makamure, Kwari, & Chipangura, 2003). Besides a new curriculum and the National Science and Technology Education, the innovations include the Science Education In-Service Teacher Training Programme (SEITT), the Zimbabwe Science Project, Quality Education in Science Teaching (QUEST), the Business Education Partnership of Zimbabwe (BEPAZ) and the Better Environmental Science Education (BEST) (Gudyanga et al., 2013) and the recently launched Science, Technology Engineering and Mathematics (STEM) programmes. The contributions of these initiatives are outlined below.

The Science Education In-Service Teacher Training (SEITT) programme

The programme started in 1994 (Gudyanga et al., 2013; Gwekwerere et al., 2013). Its overall objective is to improve the teaching of A Level sciences and mathematics in Zimbabwean high schools. To achieve this, SEITT used to run a two year in-service diploma through the University of Zimbabwe to educate resource teachers (RTs). SEITT used to organise and facilitate content specific and pedagogical workshops for science teachers (Mtetwa et al., 2003; Tambo, Mukono, Mushaikwa, Chavunduka, & Mtetwa, 1999). In 1999 SEITT produced contextualised teaching resources that included written contextualised science curriculum materials

(Gudyanga et al., 2013). Gudyanga et al. (2013) indicate that the printed curriculum materials like textbooks included examples that were derived from out of school every day experiences of the learners so that they can probably realise how school science is related to some aspects of their daily lives SEITT has also established ten regional science and mathematics centres (SMCs).It is through these centres that a number of programmes were being effected; that is, networking of teachers through cluster groupings and an e-mail facility, production of curriculum materials and a subject based workshop programme.

SMCs offer the following facilities to the A level teachers:

- Textbooks and programme kits for the teaching of A level science and mathematics.
- Resource files per subject that contains lots of teaching ideas extracted from journals.
- Journal titles with material specific to the A level syllabus.
- Video cassettes with a variety of recordings of A level topics.
- An overhead projector.
- A photocopier.
- A computer and a printer.

The programme has opened networks for teacher-to-teacher interaction that includes the sharing of practical teaching ideas through attendance at SEITT workshops and subject cluster meetings. SMC facilities are available for use by all A level science teachers (see Table 2.1).

The SEITT program is no longer in operation and currently there are no similar professional development efforts in Zimbabwe (Gudyanga et al., 2013).

Zimbabwe Science Project

The Zimbabwe Science Project (Zim-science) was an attempt to improve the teaching and learning of Sciences in rural areas of Zimbabwe (Gudyanga et al., 2013). Rural schools had no laboratories or electricity. The project sent kits to schools, which included basic science equipment, which ensured sustainable participation in science education for the majority of the country‟s secondary schools. The Nziramasanga report of 1999 said that the Zim-science approach attracted many schools because people found it more sustainable (Gudyanga et al., 2013). The project received world recognition and the World Bank used it as a model for educational development programmes in other countries. Botswana implemented a similar model using kits purchased from Zimbabwe Nziramasanga (1999).

Quality Education in Science Teaching (QUEST) project

Designed to decentralise the in-service training courses and empower teachers to make decisions about issues that affect them at school level, the Quality Education in Science Teaching (QUEST) project provides teachers with a platform for sharing ideas and discussing problems (Gudyanga et al., 2013). Nziramasanga (1999) reported in that 77 science district resource centres had been established (Gudyanga et al., 2013). These are managed by two trained advisers per district who, among other duties, fund-raise and determine the needs in their districts with the intention of finding strategies for solving them.

Science, Technology Engineering and Mathematics (STEM) Programmes

In 2016, the Ministry of Higher and Tertiary Education, Science and Technology Development launched the Science, Technology Engineering, and Mathematics (STEM) Programmes. STEM is an educational programme that aims to equip learners with scientific, technological, engineering and mathematic skills (Parawira, 2016; Raju, 2014). Tsupros (2008) defines STEM as an interdisciplinary approach to learning where rigorous academic concepts are carried out with real world lessons as learners apply science, Technology, Engineering and Mathematics in context that make a connection between school, community, work and global enterprise. STEM involves the integration of the four subjects (mathematics, biology, chemistry, and physics) into one cohesive teaching and learning paradigm (Tsupros, 2008).

The intention of STEM is to motivate Ordinary Level School leavers to take a combination of the STEM subjects (mathematics, biology, chemistry and physics) at Advanced Level, enabling them to enrol in STEM degree programmes at the country"s universities in 2018. The other objective is to stimulate interest in mathematics, biology, chemistry and physics as foundational pillars of STEM competences.The programme also renders to schools support in infrastructural development, teacher development and financial support to both schools and learners (Dekeza & Kufakunesu, 2017).The government ministry pays full tuition fees, levies, examination fees and boarding fees for such learners at government, mission and council schools. Other incentives are also offered to motivate those who have enrolled in the subject to remain in school. For instance, some learners, who registered at public schools in 2016, won a trip of their lifetime to Microsoft and other Silicon Valley STEM companies in the US. In lucky draws, some learners won STEM laptops and STEM iPads and some schools won money amounting to $ 100 000 and even a 30-seater STEM bus.

The Better Environment Science Teaching (BEST)

This was considered as the bedrock of science teaching at primary level. This program‟ activities included writing of a new primary science syllabus and in servicing of teachers, heads, District Education Officers and Education Officers (Gudyanga et al., 2013). It also focused on how the environment could be used as the laboratory for biological and physical sciences. The conceptual framework and implementation of the project was led by Zimbabwe while the funding was provided by the German agency for technical cooperation (Gudyanga et al., 2013). Its weakness was that adequate steps had not been taken to secure local funding in the event of the donor moving out.

The National Science and Technology Education

The second Science and Technology Policy was launched in June 2012 to replace the earlier policy dating from 2002. The main objectives are: Strengthen capacity development in STI; Learn and utilize emerging technologies to accelerate development; Accelerate commercialization of research results; Search for scientific solutions to global environmental challenges; Mobilize resources and popularize science and technology; and foster international collaboration in STI. The Ministry of Science and Technology Development has reviewed the S&T Policy of 2002 with a view of developing a more up-to-date one that takes into account new national and global S&T challenges, embraces national STI needs in order to address specific economic growth and wealth creation issues (Republic of Zimbabwe, 2013).

The policy requires that, every O‟ Level secondary student to study mathematics and at least two other science subjects; practical experiments should exploit the background experiences of students and encourage interest across gender; Science subjects must be taught in a manner that allows each pupil to undertake direct practical experimentation regularly.

The Second Science and Technology Policy indicates the government commitment to allocating at least 1% of GDP to GERD, focusing at least 60% of university education on developing skills in science and technology and ensuring that school pupils devote at least 30% of their time to studying science subjects(Republic of Zimbabwe, 2013). This confirms the high value attached to the learning of sciences by the government.The policy recognizes the important role IKS has traditionally played in daily life and development in Zimbabwe. The policy highlights that some aspects of IKS like soil cultivation, animal breeding herbal medicine are gradually phasing out of people‟ memory. Many of these traditions and products can still play important roles in the future development of Zimbabwe (Republic of Zimbabwe, 2013). Policies that will help Zimbabwe to benefit from the Indigenous Knowledge Systems should encourage development of a database on IKS with a view to identifying aspects that can be exploited using modern science and technology for national benefit and promote research on potential applications of IKS to future national developmental challenges (Republic of Zimbabwe, 2013). The policy also proposes the development of courses on IKS that is suitable for inclusion in the school curricula.

Teachers have also imbarked on Continuing Professional Development (CPD) programmes.
Schostak et al. (2010), CPD is a continuing process outside undergraduate and postgraduate training that enables individual teacher to maintain and improve standards of classroom practice through development of knowledge, skills, attitudes and behaviour.The progrommes include meetings,national or provincial conferences as well as accredited university courses. . Masvosve (2017) observed an increasing number of teachers enrolling for futher study at the country' main universities.

Despite all these innovations, Nyamanhindi (2014) notes that the number of pupils failing science subjects is ever increasing and most learners continue to shun the sciences. Gudyanga etal. (2013) observed that learners lost interest in science even when teachers adopted hands-on activities in their teaching. There is also an increase in the dropout rates and irregular lesson attendance amongst science learners. Nyamanhindi (2014) observed that the teaching of science and the performance of learners had continued to be affected by a number of challenges, which included lack of appropriate equipment, inadequate resources for effective practical activities, shortage of trained teachers and use of inappropriate teaching methodologies.

2.3 IKS AND PHYSICS ACCESS

In order to improve access, achievement and relevance in physics, researchers such as Barton (1998), Shava (2005), Shava (2016) and Handayani et al. (2019) proposed the integration of IK artefacts in the teaching of physics. In this regard, Barton (1998) had indicated that academic failure in science among learners from indigenous communities could be attributed to the learners struggling to understand, gain access to, and find relevance in the culture and practice of science as framed by the school. A publication from UNICEF (2004) contends that every child has the right to education, and to a system of education that values his or her culture, language and community, and access to and participation in schooling without discrimination or hindrance. These rights are enshrined in the 1989 Convention on the rights of children. Participation in science is accordingly taken to be a human right (Banks & Banks, 2005).

Fensham (2000) has identified three dimensions in access to science. The first dimension is about physical access, which involves access to teachers, facilities, courses. A second dimension of access is about outcomes that demand that access should involve both effective and meaningful learning. In this dimension, issues of purpose of learning and the content of learning are valued. Questions like „Which science? Whose science? and Why?‟ are asked. The third dimension is about pedagogy. The pedagogy should enable different learners to learn effectively, taking into consideration their backgrounds, context, learning styles and aspiration.

The are many opportunities that are inherent in the use of IK artefacts in physics instruction as observed by Shava (2005). Among such opportunities Grenier (1998) included benefits of adopting methods of imparting content knowledge (e.g. use of indigenous games, storytelling, use of artefacts in demonstrations), pedagogical content knowledge and aspects of subject matter content. Kapoor and Shizha (2010) argue that the integration of IK in instruction started very long ago in Zimbabwe. In primitive societies people would use the knowledge they had already acquired and pass this on along with new information or ideas to their fellows. Popular teaching methods would have included the use of songs, art works, participant observations, experiential learning, modelling, meditation, prayer, ceremonies such as rain making (see Figure 2.4), learning through authentic experiences, individualized instruction, and learning through enjoyment. Experienced elders from the society were used as tutors who would teach animal husbandry, agriculture, boat building, weapon making, and many other skills.

Figure 2.1: Rain-making Ceremony in Zimbabwe (Source: Photograph from one of the teachers)

Mapara (2009) mirrors these ideas that education in the pre-colonial period was offered by elders at different forums using different strategies. Shizha (2006b) also asserts that it was the mothers in the communities who were mainly responsible for ensuring that the children learned. Mapara (2009) posits that young men were taught skills at the *dares* (homestead meeting place for males) to make for example, *maduwo* (fishing traps) and implements such as hoe handles. Young women were taught domestic skills by older women in the cooking houses, for example, pottery etc.The content taught, instructional strategies, instructional technology and the instructional media were essentially traditional and rooted in the environment (Peat, 1996). There was no expert input in the sense of curriculum content and pedagogy, but everything was a result of lived experiences and a deep understanding of the prevailing needs with a desire for education that served a purpose in the community. Local artefacts were used as examples, in analogies and as instructional aids, in demonstration of skills and ideas.

The use of IK in instruction was therefore effective, meaningful, and relevant, since these indigenous societies were self-sustaining in their needs. Semali and Kincheloe (1999) agree that such a body of knowledge sustained people who, furthermore, relied heavily on oral and other traditional transmission methods of such knowledge for all their survival; that is until they were colonised and introduced to education through printed matter. Moreover, Semali and Kincheloe (1999) have also observed that some local people had sustained themselves better prior to colonization, when they owned locally developed and traditionally shared knowledge, than was the case after colonization. IK and its associated strategies helped indigenous people to adapt to and survive in a variety of habitates for thousands of years(Battiste, 2014). The model of education has been used as a way of acquiring life long learning and has been the basis for sustainable development in agriculture, food preparation, healthcare, conservation and other sectors for many centuries(Omolewa, 2007).

McDermott (1997) posits that the riches of indigenous languages, world views, teachings and ways of teaching and experiences were systematically excluded from contemporary educational institutions and from Eurocentric knowledge systems. Semali and Kincheloe (1999) add that this exclusion resulted in some nations losing their survival systems. In such an example, Thomson (2003) argues that the Republic of Congo experienced a decrease in its cereals production due to adoption of western farming practices during colonialism and noted that a threshold point had been reached where the country could no longer sustain its food requirements. In consequence, it was proposed that people revert to the use of some indigenous practices that had sustained them many years before colonization. Brokensha (2011) has noted a similar situation among Zimbabweans and the Science, Technology and Innovation policy of 2012 also enshrines this call for people to revert to the use of some indigenous practices that had sustained them many years ago. Zimbabwe like other African countries has a very rich body of indigenous knowledge systems which find their expression in their technologies, medicine, local education systems, animal husbandry, crop production, climatic control and management (Chirimuuta, Gudhlanga, & Bhukuvhani, 2012). Ogunniyi and Ogawa (2008) noted that the IK that existed prior to colonization in Zimbabwe had been devalued and eliminated from the school discourse. Science classes became a field site for the learning and practice of western science and scientific worldviews. Leon and Elias (1998) observe that schools were regarded as being in communities, but often not of the communities. They also observed that currently IK has been accorded a low status by many people, particularly in comparison with the status of western science taught in schools. According to Peat (1996) earlier theorists saw traditional knowledge and institutions as obstacles to development. These theorists perceived IK as being far removed from options intended to propel development and so solve pressing problems in communities.

Jaya (2011) argues that because of these developments, IKS and use of its associated artefacts were subdued by the colonizers. Colonisation has seen indigenous people watch their knowledge being eclipsed by western knowledge, imposed on them by western institutions(Handayani et al., 2019).

For IK, its lack of documentation, and its lack of clear ownership, or development processes or strategies made it easy for people to ignore it in favour of western science and strategies. In Zimbabwe, there was no effort by the colonialists to promote or preserve IK and its associated artefacts, which Emeagwali (2003) notes was in contrast with the situation in countries such as Ghana(Emeagwali, 2003). Furthermore, as Zazu (2007) notes, much African IK remain tacit, sacred and embedded in practices, relationships and rituals, by which it is often transferred orally between generations. In this regard, Nyembezi and Nxumalo (1996) unsuccessfully attempted to compile some of the indigenous vocabulary because of lack of written records.

Corsiglia and Snively (2001) reason that the persistent association of indigenous science with spirituality, cultural values, and myths has made people doubt its alignment with science, particularly due to the lack of evidence of this kind of knowledge. This is thought to be one of the reasons for western physics possibly missing out on areas worth understanding. As Siegel (2002) emphasizes, western science is not the only way of understanding the natural world. Kawagley et al. (1998) also argue that there is no single origin of science; instead, science has a plurality of origins and plurality of practices. They add that there is no single way to do or think science. As Ogawa (1995, p. 588) defines it, science is a rational way of perceiving reality. Drawing from his definition, a conclusion can be reached that science exists in many different legitimate forms. It is a human creation which involves human activities and is formulated and interpreted by the people concerned.

According to Mokuku and Mokuku (2004), argues that institutionalized formal physics learning has been decontextualized. At the Southern African Association for research in Mathematics, Science and Technology Education annual conference held at the University of Zimbabwe in 1999, Southern African science educators unanimously agreed that science was being taught out of context (Gwekwerere et al., 2013). It can be observed that the Advanced Level physics curriculum is poorly contextualised and shows little inclusivity with respect to local examples and cultures that informs pedagogy. It appears to have been lifted from external sources rather than adapted for Zimbabwe. Science has remained foreign to the majority of learners in the school (Aikenhead, 1996). The context in which teaching and learning of physics occurs is foreign as well as the content taught in class, which has an alienating effect on the learners. Several writers argue that argue that the feeling of foreignness comes from the differences between the worldview of the learners and the worldview generally embraced by the western scientific community (Cobern, 1996; Gudyanga et al., 2013;Jegede & Aikenhead, 1999). Aikenhead (1997b) claims that, even at firstglance, observation of the language of science, science texts and many scientific methods suggest systematic racism. Furthermore, Ogunniyi (1988) and Jegede (1988) argue that science textbooks and subtexts present western science as a powerful, objective, and reliable knowledge, with very little room for alterations.

The world is busy reorienting itself towards the democratization and equal treatment of all humanity, as entrenched in human rights, as Emeagwali (2003) asserts. Indigenous communities are struggling to maintain their rights, tradition and their knowledge (Handayani et al., 2019). Alongside this development, intellectual property of indigenous cultures has become the subject of research and debate. In this regard, Brokensha, Warren, and Werner (1980) argue that ignoring indigenous people’s knowledge is almost guaranteed to ensure failure in their development. Economic development in the global context requires understanding and application of western science and local development needs a mixture of both western and indigenous knowledge to complement each other. Such a combination involves the engagement of different cultures and acknowledgement of alternative ways of knowing and doing.

There has been growing awareness among non-western nations of the need to revive the science that is embedded in their IKS. In South Africa since the advent of democracy, IKS has been moved from the margin to the centre I policy, research, higher education and schooling(Naidoo & Vithal, 2014). Le Grange (2007a) argues that South Africa has to use western science as well as the ideas from IKS for social and economic development to occur. Ogunniyi (1995) argues that the Japanese never lost their cultural identity when they introduced western science and technology in the 20th century. Ogunniyi (1995) further argues that the Japanese did not introduce western epistemology or worldviews but only introduced the practical products of western science and technology. They continued to use their own cultural knowledge, language and values prominently in their schooling systems. They continued to present science within their whole cultural knowledge in a way that embodies their IK and IK artefacts. The Japanese have managed to maintain world science standards even though they have multiple IKS integrated in the curriculum. Similarly, among the First Nations in Alaska, there exist national laboratories in which indigenous and non-indigenous scholars get first hand experiences of integrating western science teaching and learning with IK (Barnhardt & Kawagley, 2005). Many countries are making effort to integrate their IK into their education system. Zimbabwe is striving to join other progressive countries in championing the reintroduction of the use of IK in the teaching of culture, of which physics is part. In Zimbabwe issues of relating school science to learners" real life experiences are still a challenge for most teachers (Gudyanga et al., 2013).

Brokensha et al. (1980) argue that the emergence of indigenous knowledge in the teaching and learning of science was partly triggered by ethnographic studies conducted in nations that were at one time colonised by Europeans under their expansionist agenda. Kapoor and Shizha (2010) notes that since independence, in Zimbabwe there has been an insignificant shift away from exclusively Eurocentric ideas towards the inclusion of traditional knowledge and pedagogy in the education system. The integration of IK artefacts in the teaching of science is one strategy that can be used and is discussed next.

2.4 TEACHERS AND THE INTEGRATION OF IK ARTEFACTS IN THE TEACHING OF PHYSICS IN ZIMBABWE

Knowing the content of physics does not necessarily mean that a person can teach the subject, as Chavhunduka (2000) argues. Chavhunduka (2000) explains that a good physics teacher should be able to make points clearer for learners and use analogies that help learners understand difficult ideas. The teacher should be able to acknowledge learners" ideas and use relevant multi-instructional media in lesson delivery. A good teacher is, therefore, one who has both the content knowledge and ways of communicating this knowledge effectively to the learners. Chavhunduka (2000) also indicates that physics teachers should be able to modify the textbook subject matter content and his or her own subject matter knowledge in order to communicate and interact with the learners in a way that brings the content to life. Physics concepts are easier to understand if the explanations are carefully illustrated. The illustrations make a good impact if they are accurate and contextually appropriate.

Teaching and learning should tap into IK to facilitate learning among learners coming from particular backgrounds that may block the understanding of physics concepts (Aikenhead, 1996). Holiday (2000) adds that most educators agree that effective teaching involves use of learners‟ prior knowledge, which include ideas, concepts, data, and even the learners‟ IK artefacts.A more realistic and comprehensive education system should contain IK of learners(Assié-Lumumba, 2016). Chavhunduka (2000) argues that, there is little value in using illustrations of something found in America or Britain, when a similar artefact is available within the learners‟ environment. Teachers should illustrate physics concepts through well-known everyday experiences and artefacts. This can add humour to the related content, which also motivates the learners to want to learn more. This in turn would enable learners to interpret their own environment and also to apply physics in solving their community‟s problems.

The integration of IK artefacts in the teaching of physics, as Klos (2006) argues, lays a foundation for celebrating cultural heritage among minority cultural groups, which may result in motivation of indigenous learners. Kozulin (2003) emphasizes the use of knowledge brought by learners from home as being important for learning new concepts by supporting and complementing logical thinking. Hooley (2000) adds that this can lead to the reconciliation of traditional knowledge with physics. Okebukola (2012) is of the view that integration of learners‟ social-cultural background in physics teaching helps to demystify science, instead of seeing it as a preserve for the elite. By contrast, failure to incorporate learners‟ sociocultural practices into the teaching of science leads to the transmission of science content that Ogawa and Aikenhead (2007) refer to as socially sterile, impersonal, frustrating and intellectually boring. The exclusion of indigenous worldviews, knowledge and methodologies provides an incomplete picture of the world which is detrimental to all people(Battiste, 2014). Integration of IK facilitates subject matter learning and can make learners grab and apply subject matter knwledge(Abah, Mashebe, & Denuga, 2015). Shava (2016) adds that indigenous approaches can augment learning processes in the formal education contexts and make the curricula relevant to African context.Solomon (1999) argues that it is detrimental to ignore or down play the influence of home and families on the education of learners.

Generally teachers do not include IK in the teaching of science in schools in Sub-Saharan Africa in spite of the policy imperatives (Shizha, 2013). Many teachers in Zimbabwe have developed a negative attitude towards some IK, as a result of western influences (Shumba, 1999). The situation is exacerbated by most teachers in Zimbabwe having never been trained on how to teach a culturally appropriate curriculum. A majority of teacher education programmes in Southern African countries have not equipped science teachers with the necessary knowledge that would enable them to teach science in context through tapping on learners‟ out-out-of school or home (Gwekwerere et al., 2013). They know little about ways of enacting IK in the classroom. Teachers in Zimbabwe have adopted teaching and learning activities which do not suit their environment and context (Gwekwerere et al., 2013; Shumba, 1999). Teachers have limited skills on contextualisation of science teaching and also lack resources that would enable them to do that as noted by Gwekwerere et al. (2013).

2.5 SCHEME FOR CATEGORIZING CULTURAL KNOWLEDGE IN THE PHYSICS CLASSROOM

When implementing a science-IKS curriculum, there exist different categories of IKS, defined by the ease or difficulty with which they could be included in science. George (1999) has proposed a general scheme for categorizing cultural knowledge for use in the science classroom. She suggested four categories are described next.

Category 1: Traditional knowledge can be explained in terms of western science. For example, the practice of using a mixture of lime juice and salt to remove rust stains from clothes can be explained in conventional science terms of acid-oxide reactions. In this case IK artefacts can be used to explain western science concepts. The artefacts, or some properties of the artefacts, are used in demonstrations and examples or in some learning activities.

Category 2: Traditional knowledge can probably be explained by conventional science in the future. For example, a brew made from a plant „vervine‟ that can be used in the treatment of worms seems to have pharmacological properties, but these have not yet been fully tested. In this situation IK artefacts and their properties are explained using the western science concepts. This may effectively bring out physics concepts embedded in the artefacts. ***Category 3: A conventional science link can be made to traditional knowledge, but the underlying principles are different.*** For example, traditional knowledge states that sugars cause diabetes, whereas conventional science claims that when one is diabetic, the ingestion of sugars can worsen the condition. In this situation the knowledge systems complement each other and help to extend the knowledge base of each other.***Category 4: Traditional knowledge cannot be explained in conventional science terms.*** For example, there is no conventional science explanation for the claim that if one cuts one‟s hair when the moon is full, the hair will grow to an increased length. Categories 1 and 3 lend themselves to easier implementation in the classroom than categories 2 and 4 (George, 1999).

2.6 WESTERN INDIGENOUS ARTEFACTS WITH PHYSICS CONCEPTS

People use their own cultural experiences to explain concepts. For A level physics, the textbooks are mostly published in Britain so they adopt western cultural explanations. In Zimbabwe we use their textbooks without modifications. Shumbayaonda (2015) argues that western science treats all countries as if they were the same, yet there are a lot of differences which should be addressed individually. Shizha (2006b) argues that western science borrows its knowledge from western IKS, so the inclusion of our own indigenous knowledge in the learning of Physics is a form of reconciliation and social justice. It is an attempt to balance knowledge systems.

Consider examples given in two textbooks suitable for A level and beyond. In a textbook from the United states, Gibbs (1994) describes how J.J. Thompson, an English scientist, used an example common in England when explaining his model for the structure of the atom. He used the analogy of a „Plum Pudding‟ to describe his model of the atom; the positive charge being the pudding and negative particles being the plums. In another textbook, Hutchings (1996) also indicated that tuning forks are like forks used as kitchen utensils, which he uses to demonstrate the production of sound energy. Sports and traditional games common in western culture are often used to illustrate physics concepts, such as the path followed by a ski-jumper or surfer in describing projectile motion. Hutchings (1996) also used the game of basketball to describe projectile motion. Snooker balls are also used to describe relative motion, collision and conservation of momentum. Gibbs (1994) demonstrates circular motion using someone riding a big wheel at a fairground. Car steering wheels are also used to demonstrate the action of couples and torque. According to Gibbs (1994), the application and effects of Bernoulli effects can be demonstrated using aircraft wings and Bunsen burners. These examples are all western artefacts. They are supposed to help learners understand physics concepts.Western scientists have used many analogies from their cultural context to explain and describe physics concepts. For example, a photon was seen to be analogous to a „packet of energy"; bombs are used to show an application of the principle of conservation of momentum. Western scientists have also used letters from their traditional alphabet to represent the physical conceptsand quantities, such as the Greek letters Φ and B, which are used to represent magnetic flux and magnetic flux density, respectively.

The above examples illustrate how western artefacts and examples are used in physics but rarely local artefacts and examples. Clearly, there has to be a transformation of how local textbooks are written.

2.7 SUMMARY

The reviewed literature has unravelled the views and experiences of different researchers, policymakers and curriculum designers, among others, who advocate for a culturally integrative science pedagogy, which is heavily grounded in indigenous knowledge systems. Literature indicates that the integration of IK artefacts and instructional strategies were used long ago in traditional societies. These have proved to be effective in helping learners understand concepts and master some technological skills, and even in provoking creativity and critical thinking. The successful passing on of ideas and skills from one generation to another as well as the invention of new traditional technologies supports the idea that such an instructional strategy was effective. Literature suggests that if this strategy of integrating IK artefacts in the teaching and learning processes is employed in the teaching of Advanced Level physics it will also have unquestionable positive results. The reviewed literature did not show any attempt by researchers to look at the integration of IK artefacts in the teaching of Advanced Level physics, in general, and in mechanics, in particular. This is the silent gap that the researcher has identified and which this research study is intended to fill.

Chapter 3

THEORETICAL FRAMEWORK

3.1 INTRODUCTION

In this Chapter the Theoretical and the conceptual frameworks that guided the study are outlined. The theoretical framework of the study was influenced by ideas from Vygotsky‟s sociocultural theory of learning. The research framework was based on the social and cultural realities of the communities and schools that made up the sample of the participants. This influenced the researcher to locate the study within an indigenous research paradigm. The link between the theoretical and the conceptual framework was also highlighted.

3.2 VYGOTSKY'S SOCIOCULTURAL THEORY

Vygotsky identified methods that can be used to study and explain human activities. He adopted an approach in psychology that valued the essential relationship between an individual's mental processes and that individual‟s interactions within his or her cultural, historical and institutional setting. Vygotsky attempted to explain human consciousness development and represent it by a triangle of mediated action. The graphic presentation is shown in Figure 3.1.

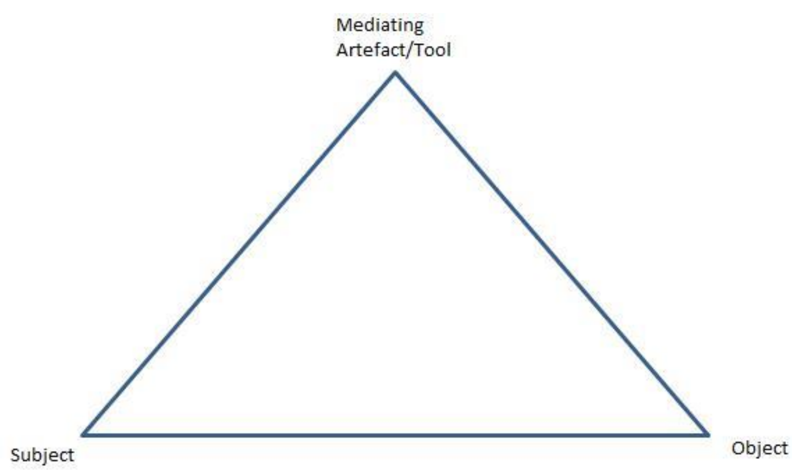

Figure 3.1 Vygotsky‟s basic mediated action triangle

The components of the mediated action include the subject, object and mediating tools. The subject is the individual or individuals engaged in the activity. Mediating tools include artefacts, social others and prior knowledge. Knowledge of the subject contributes to the subject‟s mediated actions and experiences within the activity. Actions refer to processes in which the subjects engage for them to achieve the objectives or goals. These could be a teaching or learning procedure or programme. Mediated action involves the interaction among the individual and mediating artefacts or tools, and the signs that result from the interaction. Signs are impressions made on individuals while interacting with artefacts or tools. These may assist individuals in the development of consciousness (Vygotsky, 1987). In a similar way Wertsch (1985) had earlier asserted that human activity is a process involving artefacts that act as technical tools and signs that act as psychological tools, both of which are available in the social environment. Signs do not have a concrete physical existence in the environment, but they serve as by-products of the interaction process between the individuals and artefacts or tools to mediate the thought process (Vygotsky, 1978). Signs facilitate internalization and appropriation in the thought process, which may indicate the level of understanding of concepts by learners in a learning program.The processes mediated by artefacts contribute to the formation of individual consciousness within their environments, and even in changing or dynamic environments. This is achieved through some "mediated actions". Mediated action is viewed as a means of interpersonal communication during the interaction among subject, tools, signs and objects, while the subject develops new signs that help make meaning of the world (Kozulin & Presseisen, 1995). In the physics class, mediated action may refer to all the forms of communication between the teacher and the learners as they interact with the pedagogical tools as they acquire new concepts in their learning process.

Once the sign materializes, the subject can transform the sign into an artefact or a cultural tool by way in which she or he decides to continue to use and share the sign. A cultural tool is an artefact that has gained value among participants, not only as a temporary tool for engaging in immediate activity but in many different environments, contexts and activities. It means that when a student has acquired some knowledge in the form of these signs he or she can use the acquired knowledge as a tool to understand other new concepts or apply the knowledge to solve problems in different situations. This confirms that the knowledge which learners bring into the physics class can be used to enhance learning of the new concepts by the learners.

Vygotsky used the concept of internalization to explain how individuals process what they learn through mediated action to develop individual consciousness. Internalization can be understood in one respect as „knowing how‟. Another component of internalization is appropriation, in which the child takes a tool or artefact and makes it his own, perhaps using it in a way unique to him or herself. Internalizing the use of an artefact allows the child to use it for his or her own ends rather than using it in exactly the same way as others in society have used it previously. Vygotsky (1978) argues that every function in a child‟s cultural development appears twice, first on the social level, and later, on the individual level; that is, first between people (inter psychological) and then inside the child (intra-psychological). This implies that learners learn things better when the concepts are first presented or displayed in a social setting such as a community. This may be during communities‟ economic or socio-cultural activities; it may also involve some community learning platforms like *dares* (Shona) where some elders in the community make presentations and lead discussions on important ideas and indigenous technological skills. The student then uses the experiences from the interactions to analyse and make sense of new concepts and contexts as individuals.

Vygotsky argues that mediated action and internalization take place in the "zone of proximal development" (ZPD). Figure 3.2 summarises ideas that are fundamental in Vygotsky‟ sociocultural theory. It also shows the location of the ZPD.

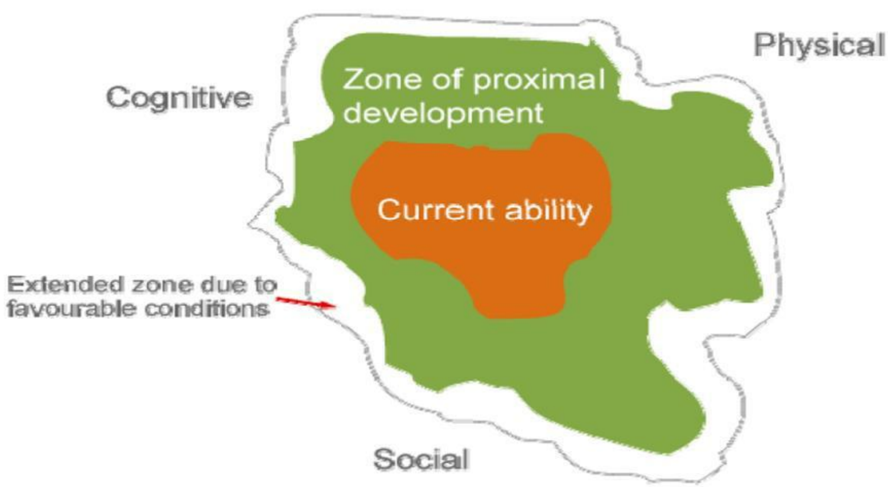

Figure 3.2 Vygotsky‟s Zone of Proximal Development

The ZPD is a metaphorical tool for understanding where and how interactions between individuals and their environments, including objects and social others, take place. In this particular study, the ZPD indicates where and why the IK artefacts and indigenous pedagogical strategies are of importance as scaffolding tools in the teaching and learning process. In this zone interpersonal and intrapersonal activities blend, fuse, and no longer exist as different entities. ZPD is that critical space where someone cannot quite understand something alone, but has the potential to do so through the guidance by an adult, peer, or a more experienced person. This zone is the area of exploration for which the student is cognitively ready to develop, but requires help and social interaction to do so fully (Bruner, 1996). Proximal means next. Donald (2002) clarifies that the Zone of Proximal Development is that space that lies just beyond a person‟s present understanding and goes on to explain that "the ZPD is the critical space in the person‟s current understanding, where through face-to-face mediation a new level of understanding can fashioned. Likewise, Lantolf (2000) indicates that the ZPD is about what a person can do with help, not as a permanent state but as a stage towards being able to do something on his or her own.

The ZPD is a conceptual tool for understanding the complexities involved in human activity wherein individuals engage in meaning-making processes and interact with the environment. Collaboration, modelling, and scaffolding are among the strategies for supporting the learners‟ acquisition of intellectual knowledge and skills acquisition. The teacher, or a more experienced peer, is able to provide the learner with "scaffolding‟ to support the learner's evolving understanding of the knowledge domains or development of complex skills. Wood, Bruner, and Ross (1976) define scaffolding as those elements of the task that are initially beyond the learner‟s capacity, thus permitting him to concentrate upon and complete only those elements that are within his range of competence. Scaffolding include modelling a skill, providing hints or cues and adapting material or activity (Copple & Bredekamp, 2009). Silver (2011) suggests that when teachers plan to use scaffolding in instruction they should first assess learners‟ current knowledge of and experience in the academic content. The teacher should also relate the content to what the student already knows and can do without assistance

Large tasks should be broken into smaller, manageable tasks with opportunities for intermittent feedback. This makes the tasks simple to accomplish. Teachers should also use verbal cues and prompt to assist learners. According to Wood et al. (1976), teachers should attract and sustain the learners' interest in the task at hand and also manage the level of learners' difficulties.

Vygotsky (1962) indicates that the teacher, or local topic expert, plays the very important role of facilitator; creating the environment where directed and guided interactions can occur. In the process of trying to create this environment, Vygotsky finds a significant role for what he called tools. Tools include artefacts created by humans under specific cultural and historic conditions. Vygotsky (1962) argues that humans do not act directly with the physical world without the mediation of tools. Lantolf (2000) indicates that these tools can be used as aids in solving problems that could not be solved in the same way if the tools were absent.

These show that tools can also be used in instructional scaffolding to facilitate learners understand concepts in mechanics for Advanced Level physics. Wood et al. (1976) view scaffolding as a tactic for helping the child in his or her ZPD in which the adult provides hints and prompts at different levels. Van Der Stuyf (2002) argues that a system of knowledge can also be part of the scaffold or tools. Mishra (2013) supports that; tools may include the resources used in demonstrations and analogies given as examples during lessons. They also include artefacts that can also be used as apparatus in experiments and investigations.

Therefore teachers can consider local culture, indigenous artefacts, and local ways of knowing as well as community knowledge as intellectual tools of adaptation that can move learners through their ZPD. These tools may also be employed by physics teachers to facilitate learners" transition into the unfamiliar zone, and to provide mediated action and internalization as well as appropriation of concepts by learners as they are being taught new physics concepts. The mediated actions in the ZPD enable teachers to enhance learners" understanding of mechanics concepts through interactions with their indigenous culture and its associated artefacts. A similar view is voiced by Maddux (1999), who asserts that technological artefacts can be integrated into the teaching process to enhance instructional scaffolding because they promote communication, contact and interaction. Handayani et al. (2019, p. 5) confirm that learners can acquire physics concepts through their cultural values and beliefs. According to Bruner (1996), the teacher should be trying to see how he could use what the learners already know in order to go beyond what they already know. In scaffolding, the teacher does not simplify the task, but the role of the learner is simplified through the well planned intervention of the teacher (Greenfield & Lave, 1982).

Teachers should regularly assess the ZPD of the learners even during the lesson. To this end, Wood et al. (1976) suggested this assessment could be done through the following three steps.

- The teacher should demonstrate solving a problem and observe whether the learners can imitate the demonstration.

- The teacher should begin by solving the problem and ask the learners to complete the solution.
- The teacher should ask the learners to cooperate with other more developed learners in solving the problem.

3.3 CONCEPTUAL FRAMEWORK - INDIGENOUS RESEARCH PARADIGM

The research framework was based on the social and cultural realities of the communities and schools that made up the sample of the participants. The social, historical, and cultural factors influenced the new knowledge and understandings of reality that emerged. This influenced the researcher to locate the study within an indigenous research paradigm. A paradigm is a set of beliefs that together guide actions on how to carry out a research study(Wilson, 2001). Jonker and Pennink (2010) define a research paradigm as a set of fundamental assumptions and beliefs about how the world is perceived, which serves as a thinking framework that guides the behaviour of the researcher.

Drawing from these definitions, a paradigm generally guides the researcher about, among other things, where and how to get maximum cooperation and reliable data from the participants in social research. Wilson, (2001) identified four components of a paradigm, which are our beliefs about reality (ontology); how we think about reality (epistemology); how we use our ways of thinking to gain more knowledge about reality (methodology); and a set of morals or ethics (axiology). Ontology is the view of how one perceives a reality.

In this study the ontological assumption is that reality is dependents on social actors and that individuals contribute to social phenomena. Epistemology includes beliefs about the way to generate, understand and apply the knowledge that the researcher considers acceptable and valid. In this regard, the methodologies that I employed in this research showed the ways of thinking of integrating IKS and physics (epistemology) to gain knowledge about reality where IKS was excluded in learners‟ everyday experiences (ontology). In this study axiology brings with it the role of values and the researcher‟s position in the research in terms of these values. In this study it was necessary that the researcher valued the cultural values in the designing of the research, interpreting the results, and even disseminating the research findings at the conclusion of the study. Throughout the study, the researcher adopted both objective and subjective points of view making the research value-bond.

Indigenous research paradigm

For a research study to fit within the indigenous paradigm, it should be guided by the assumptions of that paradigm, and must relate to indigenous methodologies and indigenous ethical practices. Indigenous research emphasizes the understanding and carrying out of research from the perspectives of people whose ways of knowing were previously marginalized and, therefore, should accord due regard to cultural protocols and values as an integral part of the methodology (Smith, 1999). It is participatory in nature and respects the well-being of the participants and provides a platform for the less powerful to be heard.

The values, beliefs and customary practices of indigenous communities should be embedded into the research, be thought about, be declared openly as part of the research design, be discussed as part of the final results of a study and to be disseminated back to the people in culturally appropriate ways and in a language that can be understood by them (Smith, 1999). Indigenous methodologies inherently recognize the importance of respectful and ethically sound relationships with participating communities (Louis, 2007). An indigenous paradigm views relationships as being central to the research process, thus knowledge and people are not seen as „objects " (Louis, 2007; Wilson, 2001).

Louis (2007) proposed four principles of indigenous methodologies, which are interconnected, as indicated in Figure 3.

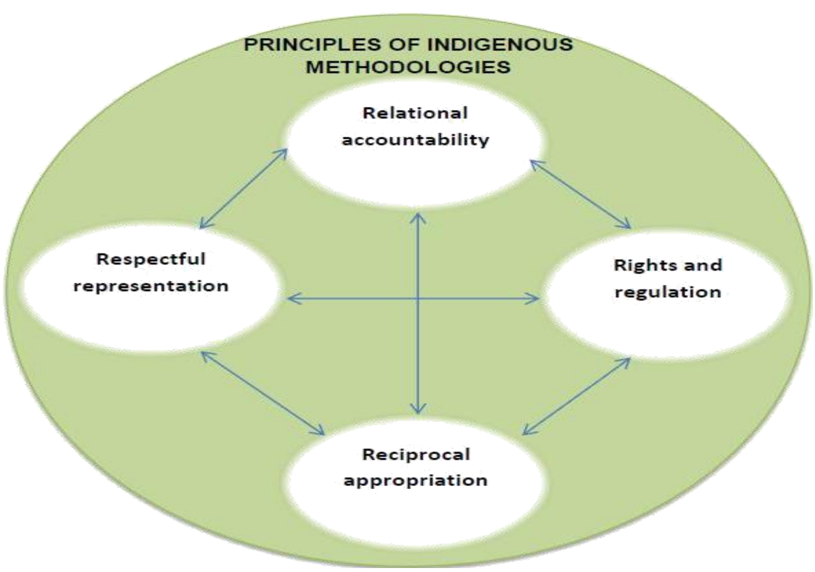

Figure 3.3 Principles of indigenous research methodologies [Adapted from (Louis, 2007)]

One principle behind indigenous research put forward by Louis (2007) is relational accountability, which describes the network of relationships indigenous peoples have with both their social and physical worlds. Relationships with participating communities are established and can last beyond the duration of the study (McIvor, 2010). Another principle is respectful representation. This principle requires that the researcher think about how he represents himself and community participants, and the events and phenomena in the study. Respect is about listening intently to others‟ ideas and ensuring that your ideas do not dominate the research process. The researcher thus has to show humility, generosity, and patience when interacting with the participants (Louis, 2007). This principle requires that the researcher represent and interpret participants honestly and truthfully.

The third principle shown in the diagram is about reciprocal appropriation; it requires that the research process benefits all the participants. Consequently, it is the researcher‟s ethical responsibility to report back and share the new knowledge in terms of the research findings with those who helped make it happen (Smith,1999). Furthermore, as suggested by McIvor (2010), reporting back the findings also helps the researcher to maintain relationships with participants.

Ethical rights and regulation require that the study respect local cultural protocols. The research process needs to be collaborative; proceeding in a manner that shows a balance of power among university, community researchers, and other participants.

I also deliberately incorporated the principle of humanity or *unhu/ubuntu* in the research process. *Unhu* or *ubuntu* is the quality of being upright and humble. Ramose (1999) defines unhu/ubuntu as humanness, characterized by respectfulness, politeness and sociality. *Unhu/ubuntu* is a philosophy that inspires, permeates and radiates high mental and moral attributes (Mdluli, 1987). *Unhu/ubuntu* is an African philosophy or worldview that emphasizes symbiotic relationships among members of African communities (Keane, 2008). Hamminga (2005) posits that *unhu/ubuntu* is manifested through respect, communalism, kindness, generosity, honesty, caring for others and participation for the common good of the communities. Venter (2004) echoes the same view; that it is for the common good of the society. *Unhu/ubuntu* encompasses the attention one human being gives to other human being as kindness, courtesy and a code of behaviour. Khupe (2014b) argues that *unhu/ubuntu* is neither an inborn quality, nor is it eternally present within an individual. She adds that the family and the community are responsible for cultivating it among the children. Generally *unhu/ubuntu* involves respecting and adherence to the values and acceptable code of contact of a particular society. These values and the code of contact for a society are socially constructed and shared by members of that particular society.

Unhu/ubuntu places strong emphasis on values and relationships. I deliberately incorporated *unhu/ubuntu* in the study so that I could establish strong, respectful relationships with the participants. This enabled me to interact with them in a relational manner. I applied *unhu/ubuntu* in making decisions on language of communication, attending cultural events, visiting a bereaved family, interviewing elders, teachers and even the learners or collecting materials that could be useful for teaching and learning.

The infusion of *unhu/ubuntu* within the indigenous research framework into the socio-cultural theory which guided the research resulted in a research framework with features that are summarized in Figure 3.4.

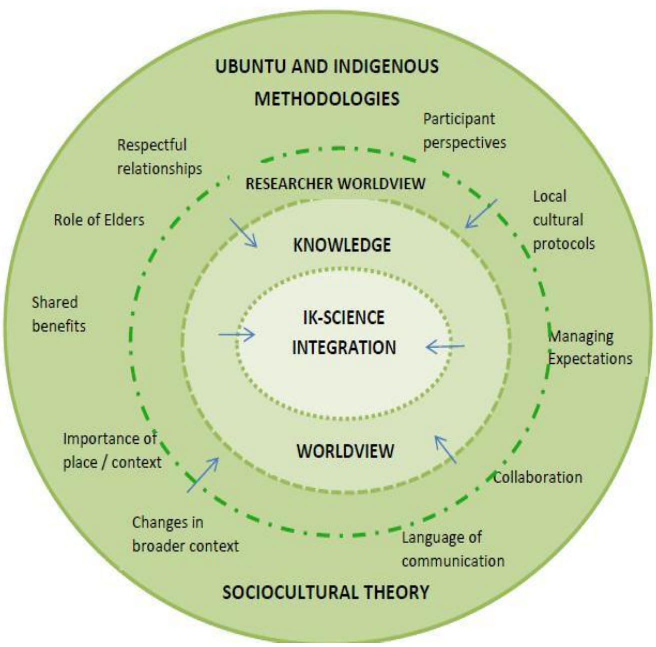

Figure 3.4 Humanity/*unhu/ubuntu*, indigenous methodologies and sociocultural theory [Adapted from Khupe (2014b)]

The Figure 3.4 shows a synthesized combination of *unhu/ubuntu*, indigenous methodologies and sociocultural theory. The diagram summarises the interaction among the three components for this exploratory study. It indicates how the three aspects interplay and complement each other in the research process. The arrows indicate the general progression of each component in the research. At the centre I have shown IK and science. IK encompasses IK artefacts and science represents physics and related western artefacts found in the physics class. The diagram shows that the research should yield benefits for all the people involved in the research. The context in which the research is conducted is considered important as it influences the responses of participants, the research methodology, and even the results. Views of all the participants are respected together with those of the elders.

3.4 LINK BETWEEN THEORETICAL FRAMEWORK AND THE CONCEPTUAL FRAMEWORK

Currently the Advanced Level physics classes are taught by teachers with little knowledge of the integration of indigenous artefacts in the teaching of physics. However, most of the teachers have some pedagogical skills, which they acquired either through their initial training at teachers" colleges or through workshops and in-service training courses. This means the teachers are able to work effectively as mentors while learners explore some new areas. The teachers bridge the gap that exists between the learners" daily experiences and their physics classroom experience. The teachers, as „cultural brokers", guide the progress of learners from their familiar zone of home across the ZPD into the unfamiliar zone, which includes classroom physics concepts and their everyday applications.

The equipment in laboratories, which is dominated by artefacts derived from western indigenous knowledge systems, is often unfamiliar to both teachers and learners in Zimbabwe. These artefacts are ubiquitous as instructional aids and instructional technologies used during practical demonstrations, as textbook illustrations and are also given as examples by the teachers in every section of the content. The teachers employ them as mediating artefacts or tools in the hope that they will effectively move learners from their familiar zone, into the ZPD, and through into their unfamiliar zone as indicated by arrow in Figure 3.4.

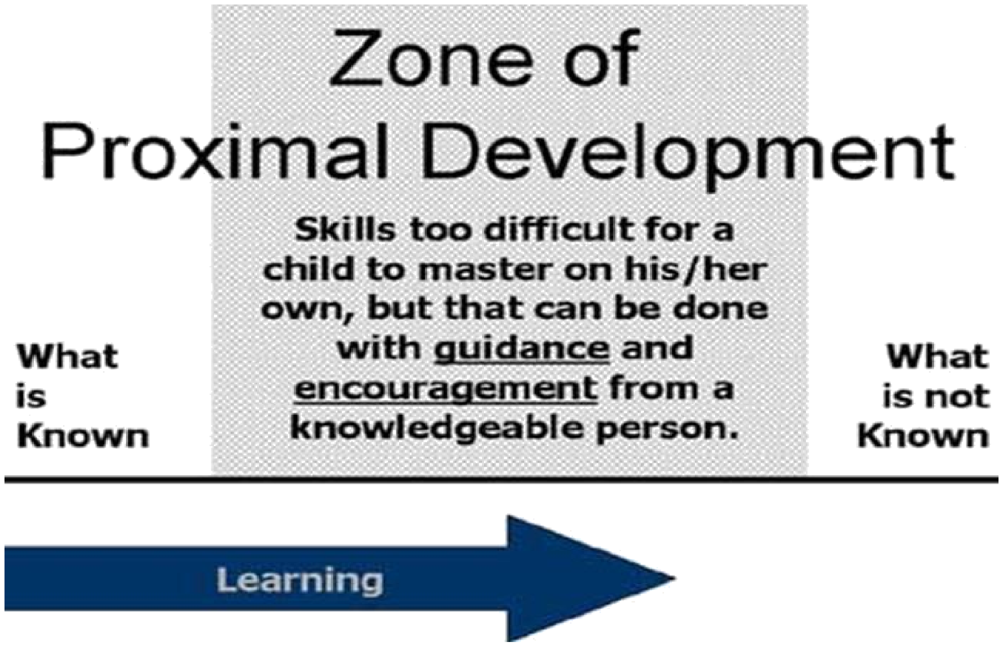

Figure 3.5 Expected effect of mediating artefacts (adopted from Wood et al. (1976)

Teachers generally use the western science equipment or artefacts with the intention of enabling learners to understand concepts and improve their performances and interest in physics. However, since learners continue to find the subject difficult and to perform badly in the subject, it is clear that this does not work. The equipment or artefacts that are currently in the laboratories and the pedagogical styles or strategies currently employed by teachers in the physics classrooms are not ineffective and probably irrelevant as mediating tools. It means that, the artefacts are failing to move the learners across Vygotsky"s three important zones; that is from the familiar zone through the ZPD and the unfamiliar zone.

Therefore, there is an urgent need for teachers to find and integrate familiar mediating tools for learners to interact with during mediated actions, together with their associated activities, which should embody the teaching and the learning processes. The tools can be derived from the learners" indigenous knowledge systems and the associated artefacts. IK and culture are tools that help learners to conceptualise experiences and assist in developing and enhancing their self-confidence and identities(Handayani et al., 2019, p. 1). This means indigenous artefacts can also be employed or integrated into the teaching of physics concepts, as they can serve as effective mediating tools. As Jegede and Aikenhead (1999) highlight, teachers need to have a good understanding of learners‟ cultures and be willing to integrate that understanding into their teaching.

Socio-cultural theory directs the researcher where exactly the research is to be located and provides a clear focus of the research, which in this study is the pedagogy or physics instruction and the associated instructional media and technology. In the context of this study, sociocultural theory helps the researcher to analyse data through exploring and connecting the repository of IKS that indigenous people have in their indigenous artefacts inventories, their communities and environment, which could help learners to learn physics concepts. The theory also gives a framework in which the appropriate transformation is expected to be implemented and the conditions necessary for it to be effective. Overall, the theoretical framework influenced the research design and methodology and was grounded in the indigenous research paradigm.

3.5 SUMMARY

The chapter discussed the theoretical framework, which guided the research. Vygotsky‟s sociocultural theory influenced the research. The idea of mediated actions in the process of moving the learners across Vygotsky‟s ZPD underlines the need for teachers to employ indigenous artefacts as mediating tools. An outline of Vygotsky‟s sociocultural theory was also included in the discussion. The link between the theoretical framework adopted for the study and the study was also described. The research was grounded in the humanity/*unhu /ubuntu* philosophy encapsulated in the indigenous research paradigm. Aspects of indigenous research paradigm and *unhu /ubuntu* philosophy were discussed. The next chapter will look at the research design and methodology, which emerged from this theoretical framework.

Chapter 4

RESEARCH DESIGN AND METHODOLOGY

4.1 INTRODUCTION

Chapter 3 presented sociocultural theory that is grounded in an indigenous research paradigm and humanity/*unhu/ubuntu* as theoretical pillars of my study. I described how I constructed a research framework which was used to inform strategy for the recruitment of participants, sample size, data collection, interpretation, analysis and presentation. This interactive research framework respected the importance of relationships and the context of the study. It also clarified the location of the problem and the research focus.

In this chapter, I build on that framework to describe the research design: that is, the procedures, participation, collaboration and activities that took place during this exploratory study. Kothari (2005) defines a research design as a plan or structured framework for how one intends to conduct the research process in order to solve the research problem. Research methodology, as described by Sarantakos (2005) is a domain or a road map that is a theoretical and ideological foundation of a research method. Wherein a methodology is a set of specific procedures, tools, or techniques used to gather and analyse data. Research methodology generally implies the theories behind the method (Le Grange, 2009).

In this chapter, I describe the research design giving its central foci clearly and outlining details of recruitment of participants and their roles, sources and forms of data that would be sought and how such data would be generated in the selected case studies. I then describe how the data would be analysed. As guided by Sarantakos (2005), I gave a clear domain or map, outlining all the steps, procedures, tools and techniques to be followed throughout the research within the context of the research paradigm and theoretical framework outlined in Chapter 3. I do not, as such, separate the methodology from the methods of collecting data; being influenced by Le Grange (2009), who asserts that methodology and methods are inextricably interwoven.

4.2 QUALITATIVE RESEARCH

A qualitative research design was adopted for the study. Qualitative research is difficult to define clearly (Denzin & Lincoln, 2011b).The separate and multiple uses and meanings of the methods of qualitative research make it difficult for researchers to agree on a definition (Denzin & Lincoln, 2011b). Those who have attempted to define qualitative research (Hatch, 2002; Lincoln & Denzin, 2005; Richards & Morse, 2007; Stake, 2010), revealed the following ideas in their definitions: Face to face research conducted in naturalistic settings, focus on rich descriptions and understanding of participants point of views or meanings, researcher is the primary data collection instrument, inductive analysis of data, flexible designs, purposeful sample selection and holistic understanding achieved through collection and analysis of data from multiple sources and perspectives. Denzin and Lincoln (2011b) add that qualitative research does not belong to a single discipline and do not have a set of methods and practices that are distinctive and entirely its own. The qualitative researcher relies on bricolaging. The qualitative researcher as a bricoleur or maker of quilts uses the aesthetic and material tools of his or her craft, deploying whatever strategies, methods, and empirical materials which are at hand. The research practices adopted in qualitative research depend on the research problem or question, context and settings, the need to help empower individuals to share their stories and enact meaningful social change and to generate theory where little information exist (Cresswell, 2003; Richards & Morse, 2007).

In this particular research qualitative research has been viewed as a naturalistic inquiry that seeks an in-depth understanding of the phenomena using multiple systems of inquiry such as case studies, questionnaires, and observations within a natural setting.

4.2.1 Case study

I decided to adopt a collective or multiple case study design. Yin (2009) defines case study as a research design that involves an empirical inquiry that investigates a contemporary phenomenon within its real life context; where the boundaries between the phenomenon and the context are not evident; and in which multiple sources of data are used. My choice of the type of case study is based on classification of case studies by Stake (2000), who identified three types of case studies, as follows.

Intrinsic case study is when the researcher has an interest in the case. It is undertaken because the primary and only purpose for the researcher is to understand a particular case better. The purpose is not to come to understand some abstract construct or generic phenomenon (Stake, 2000).

- Instrumental case study describes a situation where a particular case is examined to provide insight into an issue or to draw a generalization. The case is of secondary interest, playing a supportive role and facilitating understanding of the larger issue. The case is looked at in its depth with its context being scrutinized, its activities being detailed; but all in the interests of the researcher pursuing an external interest.
- Collective or multiple-case study is when the researcher may jointly study a number of cases in order to investigate a phenomenon.

I identified my study as instrumental in nature, since the study attempted to provide insight into a new and unfamiliar phenomenon; that is integration of IK artefacts in the teaching of physics with the aim of facilitating understanding of physics concepts by Advanced Level learners. The study thus included three individual cases, being the three high schools in Masvingo district, which made it instrumental-collective in type.

Case study, as explained by Cohen, Manion, and Morrison (2011), allows participants to freely share their ideas, views, perceptions, and experiences in a natural setting, thus making it possible for participants to provide in-depth information. These authors add that case study methodology uses multiple data sources to provide thick descriptions of participants‟ lived experiences or thoughts about and feelings for a situation. I also decided to embed featutures of Participatory case study in my case study. In Participatory case study participants are considered experts into the underlying causes of the issues within their social world and not incidental to the curiosity of the researcher (Reilly, 2010). Reilly (2010) adds that the research process becomes a means of moving their voices from the margins into a place of centrality (Reilly, 2010). It proposes radical change in social structures and processes, as well as reformulating the entire approach to research , voice, power, knowledge production and use (Reilly, 2010) of which this study has the potential to do.

4.2.2 Population and sample in the study

There were 36 Advanced Level physics teachers in this district of Masvingo province, from this population, 18 teachers were purposefully sampled and completed the questionnaires (Appendix B) prior to the focus group discussion. These 18 teachers also formed the group for the focus group discussion (Appendix I). From this group of teachers, eight were also purposefully sampled for individual interviews, based on their knowledge of artefacts. These eight physics teachers were later interviewed (Appendix D).

The population of physics learner in the three high schools was 110, from which 45 were purposefully sampled to participate in the study, and they completed questionnaires (Appendix C). They also formed the groups for the learners‟ focus group discussions (Appendix H). Ten purposively sampled learners were also individually interviewed (Appendix F).

In the community, 127 elders were identified. Of these 22 were purposively sampled to be part of the focus group discussion (Appendix G). Five of them were also purposively sampled for individual interviews due to their experiences with IK artefacts (Appendix E). Hence, the purposively sampled for this study comprised 85 participants.

I used the technique of convenience and purposive sampling in selecting the schools and community to work with as I am familiar with the people and area. The purposive sampling technique was employed in the recruitment of participants, whereby participants for the research were „hand-picked‟ as they were seen to be the most likely to produce valuable data (Denscombe, 2007). Purposive sampling was adopted to ensure that the participants chosen were relevant, accessible and had the requisite, relevant views and information for the study. In this respect, I chose to work only with schools that offered Advanced Level physics, and also which were adequately staffed. The schools selected were in close proximity, which avoided my spending too much time travelling to and from schools at the expense of time needed for data collection and analysis activities. I also selected a community that was close to the schools to cut on travelling expenses and time. Coincidently there were numerous people with knowledge on a lot of artefacts in the community that I could work with.

4.3 TRANSFORMATIVE PARTICIPATORY RESEARCH [TPR] METHODOLOGY.

The objectives of the study outlined in Section 1.8 influenced me to adopt transformative participatory Research approach (TPR). Transformative participatory research methodology proved appropriate for this study, because it required me to link up with the community where the IK artefacts were being designed, made, and used. This resonated well with the view that transformative participatory research requires the research to be linked to the community stakeholders (Kincheloe & Steinberg, 1998; Semali & Kincheloe, 1999; Smith, 1999). The approach is sensitive to cultural contexts and accommodates multiple methods. Khupe (2014b) argument that research carried out in an indigenous paradigm is naturally transformative also influenced me to adopt this approach since this was the chosen research paradigm and the research was also guided by the philosophy of humanity/ *ubuntu/unhu.*

In this study transformative participatory research is seen as a combination of transformative research (TR) and participatory research (PR) designs, which both originate from a critical perspective (Mertens, Sullivan, & Stace, 2013; Smith, 1999). Both designs emphasis sensitivity to cultural context, fluidity of approach, knowledge sharing, and collaboration and require researchers to be linked to community needs (Battiste, 2008; Smith, 1999). The two research designs advocate for community perspectives to be acknowledged.

I deliberately mixed aspects from TR, PR and the indigenous research paradigm to come up with a method that could answer my research questions. This pragmatic and ellectic approach to qualitative research is referred to as bricolaging (Denzin & Lincoln, 2011a; Rogers, 2012). The bricolaging approach, in its general form, involves the use of theories, methods, and researches drawn from a wide range of disciplines. Bricolaging research approaches are adopted where phenomena and contexts are viewed as complex and the data is presented in an unusual way, such as, in this study, through the representation of artefacts for use in physics teaching (Denzin & Lincoln, 2011a; Rogers, 2012). I adopted this approach because literature on the indigenous artefacts in the local communities was scarce and also my extensive review on science education literature for indigenous and western research did not reveal a straight forward, clear methodology that would neatly fit my study.

I could not adopt western methodologies as I felt that some indigenous communities and issues were not compatible with them. I suspected that if I adopted only western methodologies in my study, it could result in misinterpretations or misrepresentations of indigenous knowledge and its associated artefacts. This would conflict with the indigenous research ethics and *ubuntu/unhu*. In this regard, Lowan (2012) and Kovach (2010b) assert that it is culturally insensitive to investigate phenomena which involves indigenous communities and their knowledge from western perspectives. I needed a research methodology which was culturally sensitive.

The bricolaging approach allowed me to use my own personal history and experiences, gender, social class, race, ethnicity together with those of the participants in the TPR research process. I drew the idea of mixing approaches from indigenous researchers such as Martin and Mirraboopa (2003) and Lowan (2012) who developed their own bricolage researches. Lowan (2012), accordingly, describes bricolage research methodology as a mix of western research and indigenous aspects into an inseparable whole. Martin and Mirraboopa (2003) produced an indigenous research framework, which was a result of aligning aboriginal culture and ways of knowing with western qualitative research frameworks.

For clarity, transformative and participatory research designs are separately described and then their combination to form the TPR is explained and justified in the next subsections.

4.3.1 Transformative research (TR) design

Transformative research involves ideas, discoveries, or tools that radically change our understanding of an important existing scientific or educational practice, or which lead to the creation of a new paradigm or field of science, engineering, or education. It is also known as ground breaking or cutting edge, or frontier research. Transformative research causes changes in people‟s thought patterns regarding an area of scientific or educational endeavour. It challenges current and conventional understanding of concepts and wisdom. It provides opportunities for the extension of knowledge into new frontiers. In other words, TR redefines and extends the boundaries of science and education. TR also leads to generation of new or improved techniques or methodologies and technologies. It can provide a deeper understanding of the universe.

For this study, aspects of TR research design were found to be appropriate since the study involved engaging participants in the extension of both content knowledge and pedagogical knowledge of physics. The study was also found to be capable of generating a new understanding of physics as a subject with corresponding new pedagogical approaches and styles. This was, in a sense, a new understanding of the universe at large.

The TR approach is sensitive to cultural contexts and the associated approach is fluid. The research design values knowledge sharing and collaboration in the research processes. In TR, relationships between communities and their associated institutions together with their stakeholders are guided by cultural protocols of the communities and the participants. This was also in line with the expectations when the research is located in indigenous research paradigm described in Chapter 3 section 3.3.

TR has been applied in the cross-disciplinary co-ordination of investigations into cognitive simulation and pedagogical techniques that resulted in today‟s highly effective cognitive teachers. For example, it was applied in the development of the force concept inventory in physics (Hestenes, Wells, & Swackhamer, 1992), which set the direction for improvement in science education based on measurement of learners‟ conceptual understanding of scientific phenomena.

4.3.2 Participatory research (PR) design

In this study, some aspects of participatory research design were carefully incorporated into the transformative participatory research methodology. As Reason (1998) argues, participatory research is a methodology that is inclined towards both transformative and indigenous research orientations.

Lemke (2001) defines participatory research as a research approach that focuses on a process of sequential reflection and action, carried out by local people rather than on them. It consists of a range of methodological approaches and techniques, which have a major objective of handing over power from the researcher to the research participants. These participants are often members of the community or community based institutions.

In the PR process, local knowledge and perspectives are, not only, acknowledged and valued but also form the basis of the research and its planning. The approach sees the participants as not lacking solutions to the community‟s problems, neither does the researcher consider himself as having them (Gardiner, 2007). The approach respects a shared-power position between the researcher and the participants, so that both are actively involved in the creation of knowledge. The key to PR, as emphasized by Bergold and Thomas (2012), is the involvement of all the partners in the knowledge creation. PR has the intention of collectively investigating reality and transforming it. The researcher and the participants all come to the research process with knowledge and experience to contribute.

In participatory research, both the researcher and the researched are required to be open to personal transformation and conscientization. A democratic, social and political context is required for participatory research to be successfully conducted. There is also need for a „safe space‟ for participants to willingly participate in the research. Participatory research requires that the researchers take into considerations the pre-requisites of the participants.

Participatory research techniques applied in this study include focus groups, participatory inquiry, drawings, and participatory videos. The participatory inquiry technique was predominantly applied in this study, despite some critics‟ views on its usefulness. It has been criticized for sacrificing rigor because of its promotion of democratic processes (Kemmis & McTaggart, 2005). Participatory inquiry also fails when dealing with secret knowledge. Secret knowledge may include knowledge revealed to only certain people and for particular purposes in communities. Knowledge revealed by ancestral spirits, which in most cases can benefit the whole community, also falls into this category.

Participatory inquiry technique has not been widely used in science education in Zimbabwe. It has, however, been extensively used in health sciences (Cargo & Mercer, 2008). Furthremore, the techniques has been used for teacher professional development (Du Preez & Roux, 2008) and for research into relevant science for rural communities in South Africa (Keane, 2006; Malcolm et al., 2009).

4.3.3 Transformative Participatory Research (TPR) and IK Research

Numerous points of convergence among TR, PR and indigenous knowledge research motivated me to integrate aspects of all three in my research. The integration made my methodology a transformative participatory methodology. I adopted this transformative participatory (TP) methodology and intentionally grounded it in humanity/*unhu/ubuntu* philosophy and indigenous research ethics and orientations. I was aware that my study required me to get information from physics teachers and learners in selected schools, from elders and other indigenous people in the surrounding communities. From the beginning of the study, I was convinced that their support was key in the study. Without their participation it would be impossible to identify and describe IK artefacts and to confirm that the identified artefacts were indeed indigenous. This conviction influenced me to find an approach that was sensitive to cultural contexts and that also valued knowledge sharing and collaboration. *Unhu/ubuntu* proved to be important since ethical obligations could not be sufficiently met by adopting only conventional contractual agreements.

The components of both transformative and participatory research designs integrated in the TPR ensured that I could generate enthusiasm to participate among the participants. This was also done in a way that ensured that there was a strong flavor of both "Representative" and "Transformative "participation among the research participants both of which are empowering. Participants would value the reciprocal benefits from the research, such as the mutual learning for all the participants. It enabled engagement of participants and transformation of their practices and attitudes. Views from literature also gave me the confidence to apply TPR techniques. Malcolm et al. (2009) state that the approach affords communities and teachers as well as learners opportunities to be at the centre of knowledge creation. The technique moves them from the margins of epistemology to its centre. In my view, this factor and the honour accorded to the wisdom of the participants acted as reinforcements to sustain the zeal to participate among all those who were involved.

Malcolm et al. (2009) assert that TPR respects the wisdom of the participants and has an empowering effect. Furthermore, Moloi (2013) adds that TPR methodology allows the researcher to share his experiences and knowledge in a way that does not overlook or displace community knowledge, which I found very important in the process of my study. This was also important because the research study was located in the indigenous research paradigm, which required the researcher to respect the culture, experiences, and knowledge of the participants. Figure 4.1 gives a diagrammatic overview of the research design that I created to guide my study.

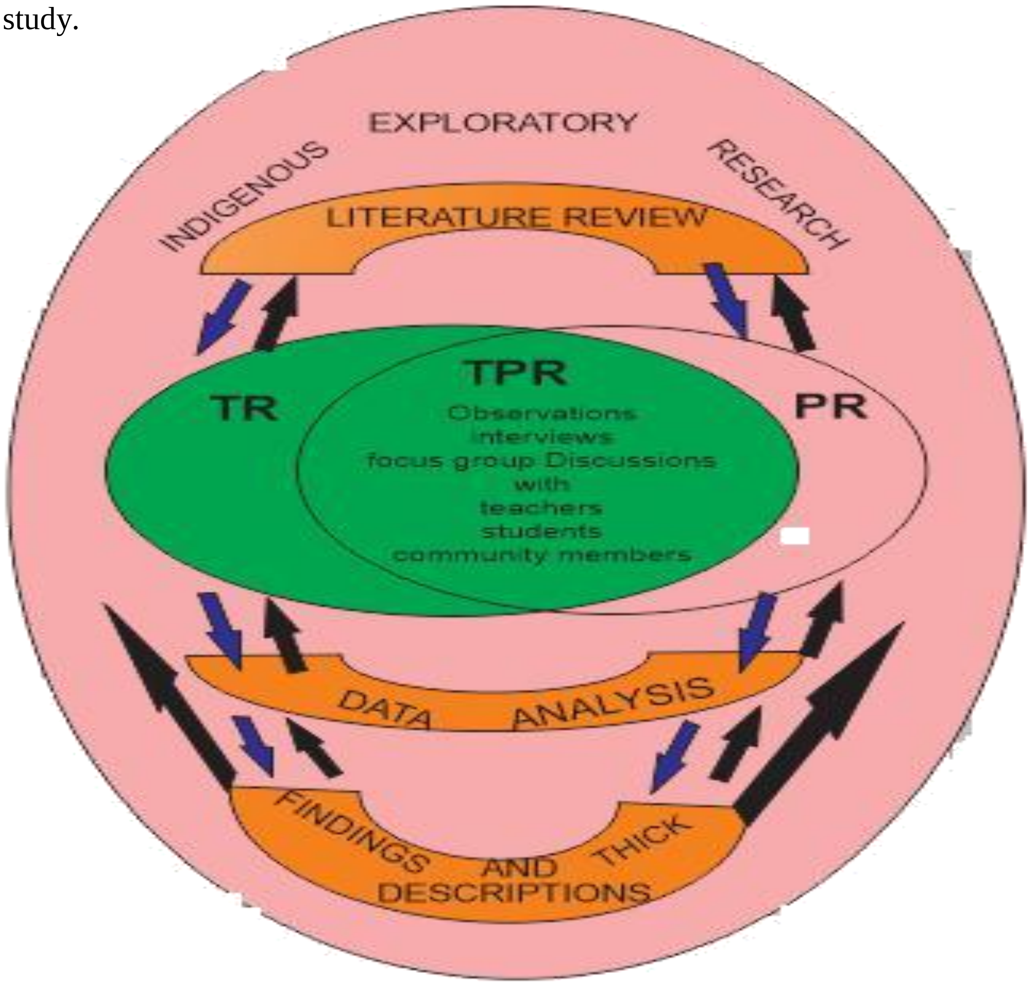

Figure 4.1 The TPR research design

The diagram shows relevant aspects of transformative research (TR) and participatory research (PR), which are integrated to form the transformative participatory research (TPR) approach, which is encapsulated in *unhu/ubuntu* along with indigenous research ethics and procedures. The larger circle symbolizes the indigenous research paradigm in which the whole research is located. The inner circles labelled TR and PR represent the two basic research designs from which the TPR design was derived. The intersection space for the two research designs denotes the TPR approach that was adopted in this study. The intersection space represents the zone where the interactions of the researcher with the community represented by the elders, the teachers and the learners guided by relevant components of TR and PR produce the findings. The arrows indicate the flow of information and data.

4.4. RESEARCH INSTRUMENTS

The research instruments employed in the study include: interview guide, interview schedule, observation schedule, and questionnaire.

4.4.1 Interview guide

An interview guide is a list of the high level topics that the researcher plans to cover in an interview with the high level questions that he/she intends to answer under each topic (N. Wilson, 2014). Interview guide indicates important stages of the interview such as introduction that indicates the topic and purpose of the interview and list of issues to be covered about a topic. Interview guide is normally made one page so that it is easy to refer to during the interview (N. Wilson, 2014).The interview guides can have both open and closed questions. Open questions allow gathering of in-depth responses and allows respondents to elaborate and explain their responses. Open-ended items put minimum restraint on the content and structure of answers given by respondents and their expression (Cohen, Manion, Morrison, & Morrison, 2007).

Interview guides help to develop the line of thinking and questioning of the researcher and pacing of the interview. Interview guides increasers the comprehensiveness of data and make data collection systematic for each respondent (Cohen et al., 2007).

Cohen et al. (2007) note that when using interview guides important and salient topics may be inadvently omitted. Interviewer flexibility in sequencing and wording of questions can result in substantially different responses that make it difficult to compare the responses. Interview guides are designed considering the research objectives, literature review, and the purpose of the research.

In this study, interview guides were designed for Interviews with Elders, teachers and learners and also for the focus group discussions with Learners, Teachers, and Elders. The interview guides designed for this study was one page in length and had both open and closed questions.

4.4.1.1 *Interview*

An interview is an interchange of views between two or more people on a topic of mutual interest(Kvale, 1996, p. 4). It is a move away from seeing human subjects as manipulable and data as something external to individuals, towards, considering knowledge as generated between humans often through conversation.

An interview is a conversation, the art of asking questions and listening (Lincoln & Denzin, 1994b). Dyer (1995) that, an interview is different from an ordinary conversation in that: It is purposeful and specific, often it is question-based with questions being asked by an interviewer, and interviewer alone may express ignorance (and not the interviewee), and the responses are explicitly and often detailed. Cohen et al. (2007) add that interviews are constructed rather than naturally occurring like every day conversations and have to follow specific rules when they are being conducted. An 'interview' is typically a face-to-face conversation between a researcher and a participant involving a transfer of information to the interviewer (Cresswell, 2012).

Interviews allow both interviewer and interviewee to discuss their interpretation of world in which they live and to express how they regard situations from their own point of views (Cohen et al., 2007). Interviewers can explain questions that respondents have not understood and can ask for further elaboration of replies (Seale, 2011). An interview is a flexible tool that allows multi-sensory channels (like verbal, non-verbal, spoken and head) to be used in data collection. Visual aids can also be used in the face-to –face interview (Seale, 2011). Cohen et al. (2007) argue that the order of the interview may be controlled while at the same time allowing space for spontaneity and the interviewer can press not only for complete answers but for responses about complex and deep issues (Cohen et al., 2007).

Gall, Borg, and Gall (1996) argue that interviews may introduce elements of subjectivity and personal bias into the data and that the rapport between the researcher and the participants may cause the participant to respond in a certain way in order to please the interviewer. Another challenge that the interview method poses for the researcher is that it is difficult to standardize the interview situation so that the interviewer does not influence the respondent to answer certain questions in a certain way (Gall et al., 1996, p. 290). This potential threat was alleviated through preparing an interview guide. Finally, interviews can hardly provide for anonymity (Cohen et al., 2007). However, anonymity in this study was not given much prominence, as the issues of interest to the investigator were not of a very sensitive nature.

In this particular study interviews were conducted with the physics learners and physics teachers and also with elders from Zimuto community.

4.4.1.2 *Focus group discussion*

A focus group, is defined by Babbie (2007) as a group of 12 to 15 people brought together to engage in a guided discussion of some topic under study. Williams and Katz (2001) explain that a focus group is a small gathering of people with a common interest or characteristics, assembled by the interviewer in a comfortable atmosphere where people can share their opinions, ideas, or experiences with the purpose of gaining information about a particular issue. In this study, a focus group is taken to be a small group of research participants with similar characteristics assembled by the researcher in a suitable environment for the purposes of sharing opinions and experiences about the chosen topic. Both the researcher and the participants or interviewees engage in a „focus group discussion‟ of the topic under study.

A focus group discussion involves interaction between one or more researchers and more than one participant for the purposes of collecting data (Parahoo, 2006 p. 266). Holloway and Wheeler (2002b, p. 110) add that in focus group discussions, researchers would interview participants with common characteristics or experience for the purpose of eliciting ideas, thoughts, and perceptions about specific topics or certain issues linked to an area of interest. In this case I wanted information about the community‟s IK artefacts. Parahoo (2006) advices that focus group discussions are a cheaper and quicker way of obtaining important data than individual interviews. A focus group discussion provides a more natural setting than other methods and the group members influence each other during the discussion(Krueger & Casey, 2015; Ritchie, Lewis, Nicholls, & Ormston, 2013). It can also bring out people’s perceptions, feelings, experiences or thinking about the issue of intrest(Ritchie et al., 2013). Moreover, participants are provided with opportunities to reflect on or react to the opinion of others.

4.4.*2 Questionnaire*

McLeod (2018) defines a questionnaire as a research instrument that consists of a series of questions for the purposes of gathering information from respondents.

Richards and Morse (2007) define a questionnaire as “a set of questions on a topic or group of topics designed to be answered by a respondent.” Questionnaires share some characteristics with interviews in the sense that respondents are required to provide information in response to a stimulus provided by the researcher. A questionnaire can use both closed and open questions to collect data. This allows collection of both qualitative and quantitative data (McLeod, 2018). Closed questions are standard and all respondents are asked the same questions in the same order and this ensures reliability. However responses to closed questions lack detail because the responses are fixed. Open questions allow people to express what they think in their own words. They also allow respondents to answer in much more detail as they like in their own words.

Questionnaires are widely used and useful instruments for collecting survey information, providing structured, often numerical data, which is often comparatively straightforward to analyse (Wilson & McClean, 1994). In the questionnaire open questions were used for complex questions that could not be answered in a few simple categories but required more detail and discussion to allow elaboration by respondents. Generally the questionnaires in this study (Appendices B and C) were used to obtain background information, as well as the attitudes, pedagogical beliefs and perceived difficulties of learners and teachers.

4.4.3 Observation Schedule

An observation schedule is a form prepared prior to data collection that delineates the behavior and situational features to be observed and recorded during observation in a study (Coleman, 2019; Given, 2008) . Coleman (2019) defines an observation schedule as an analytical form, or coding sheet, filled out by the researcher during structured or semi- structured observation. Coleman (2019) adds that an observation schedule is one of the many essential analytical devices that scientists can use to turn multifaceted and complex visual observations into useable data. It has a list of printed behaviors and conditions the researcher intends to observe and allows factual information to be recorded. Observation schedules specify in advance the categories of behaviors, events, or data under scrutiny and circumstances under which they should be assigned to those categories (Coleman, 2019). Observation schedules help to focus the attention of the researcher and provide a way of capturing and recording what the researcher sees and hear in the field.

Observation schedules are normally used in the fields such as education, psychology and speech (Coleman, 2019).In this particular study observations were guided by an observation schedule (Appendix J).

4, 5 THE FIELDWORK

Having familiarized myself with the demands of the research design, research framework and the theoretical framework, I then proceeded to conduct a pre-testing and pilot study to test all the proposed research instruments and the research design. Holloway and Wheeler (2002a) argue that pilot studies are not usually used in qualitative research. They add that novice qualitative researchers may conduct interviews as pre-exercise to get used to the data collection process. In this study, both pre-testing and piloting were done to orientate the researcher to the study and provide insight in the phenomenon under study.

4.5.1 Pretesting and pilot testing

Pretesting and Pilot testing are invaluable components of a research affording the researchers opportunity to reflect and revise their research designs before their full- scale administration. Pretesting is an important way to detect problem areas, reduce respondents burden, to determine whether or not respondents are interpreting questions correctly, and ensure that the order of questions is not influencing the way a respondent answers. I administered the pretest survey to my 3 friends (physics teachers), 15 Learners from my freind's form 6 physics class and my 6 elderly relatives. Bell, Waters, and Ebooks (2014) posits that administration of pretests to friends and colleagues is encouraged.

Pretesting brought to light those instances of obscure terminology, unfamiliar references, and ambiguous words, phrases, that I did not initially see as problematic in my questionnaires, interview schedules and observation guides but could confound and frustrate the respondents and affect data quality and response rate in my research. In this particular study pretesting also enabled me to assess "response latency". Response latency is the amount of time it takes to complete an individual item in the survey as well as the whole research process for example the time it would take to complete the questionnaire.

After pretesting, all the concerns about the process and the instruments were summarized; revisions were made to improve the research design. The complete reseach instrument was now

ready for pilot testing.

Pilot testing which Van Teijlingen and Hundley (2010) also called feasibility study is a small scale preliminary study conducted in order to evaluate feasibility, time, cost, adverse events, in order to improve the research design prior to performance of a full scale research project. Bell et al. (2014) posit that in pilot testing, interviews, final survey and some stages of coding and analysis are rehearsed prior to the actual reseach design administration. It is a trial run of the entire study from start to finish that increases the likelihood of success for the main study. Although I could have pilot tested the research design using friends and family members according to (Bell et al., 2014), I conducted pilot testing with a sample of three physics teachers, five learners and three elders, who were purposively sampled from the main samples. I could not hire experts to do the pretesting and pilot testing for me as advised by Presser and Blair (1994) and (Olson, 2010), because of financial constraints. I used ideas that I got from similar expert researches in the field and previous surveys on similar topic to compare my design to those in literature as advised by (O'leary, 2017). This increased my experience in interviewing and using interpersonal skills and ensured that I was conversant with the whole research design procedures. Noted errors were corrected e.g. ambiguous questions in the questionnaire were reconstructed. This also gave me a chance to build in more precautions in my research processes. Importantly the pretesting and pilot testing boosted my confidence.

The actual data gathering stage followed the pre-testing and pilot testing of the research design. Data analysis and report writing were the last stages.

4.5.2 DETAILS OF DATA GATHERING

The actual data collection started in January 2017 and formally ended in September 2018. Data was gathered from the three high schools in Masvingo District in Masvingo Province and in the Zimuto communal area. The data was collected from the Advanced Level physics teachers and learners and from elders from one of the schools‟ catchment area. This stage proved to be the most interesting part of my study. It involved collaborative engagement with the community members, teachers and learners, as required by the transformative participatory research (TPR) and indigenous research procedures. I had to be clear on my research questions and objectives to ensure that they would enable gathering of relevant information.

I had to make sure that my data gathering procedures were clear; tools such as interview guides and questionnaires were refined. All duplicate items, and those that were ambiguous and those that were too broad or impractical to assess were removed from the questionnaires and interview guides. I also checked whether the recording equipment was available and in sound working order (video cameras included). I also checked whether all the consent documents were still valid and the individual informed consent processes had not elapsed. My research assistant, a retired science teacher pseudonym Mr Moyo, designed a checklist of all that was required at this stage.

I had to rush to get a written informed consent to visit the communities from the District Administrator, which I had overlooked. Informed consent is a substantive ethical requirement between a researcher and the research subjects concerning the roles and obligations of each part in the study (Ronald, 2015). In giving their informed consent, it was inferred that all the study participants had personal autonomy; they fully comprehended the purpose, risks, and benefits of the research and so volunteered to disclose information. It confirms that participation is voluntary and is free of coercion and undue influence. When informed consent is not fully informed, research abuses may occur (Ronald, 2015). I had to take the issue of consent extremely seriously since my research was based on principles of unhu*/ubuntu.*

Throughout the data collection process, I continued to gather and review more literature related to my study and, in particular, the research questions. This literature enabled me to continue torefine my research and reinforced the vision of my research study in the context of other related studies. Reviewing literature continuously also enabled me to re-examine my field experiences in light of the new literature encountered. I was thus able to continuously compare literature with the categories and themes that were emerging during the data gathering process. This was in accordance with Glaser and Strauss (1967), who argue that when applying theory in research, literature can be used as „data‟ and can constantly be compared with the emerging categories to be integrated into the research findings.

4.5.2 DATA GATHERING IN ZIMUTO COMMUNITY

4.5.2.1 Ethnographic Description of Zimuto Community way of Life

A community is a grouping of people who reside in a specific locality and who exercise some degree of local autonomy in organizing their social life to fulfill their daily needs, as stated by Swanepoel and De Beer (2006). In this project, data were collected from Zimuto community. The community is found in the Masvingo district of Masvingo Province. It is a community founded by people of the Rozvi tribe of the Moyo totem. People of the Ngara and Dziva totems are also found in the area. The community is part of the catchment area from which the three high schools draw their day-scholars and some of their boarder learners. Two of the boarding schools are located right in the community and the third one is in the urban centre.

After the focus group discussion among the elders of the community, I conducted some informal interviews with some individual elders concerning the socioeconomic activities in Zimuto community. I gathered that the area is under the chieftainship of Zimuto. The paramount chief is Chief Zimuto and his headmen are Nemarundu, Gurajena, and Chidavarume. The land ownership is largely communal. Traditional leadership in the community is strong. The chief and the headmen oversee the distribution of land and other related issues. The majority of houses in the community are huts, constructed with bricks or poles covered with mud. A typical homestead consists of a main house constructed with bricks and several huts, a granary, a fowl run and a kraal for the cattle.

The community relies on small-scale subsistence farming for survival. They grow crops like maize, millet, and rapoko *(rukweza*), and for their farming activities they use traditional agricultural implements and methods. These implements include indigenous implements like hoes, ox-drawn ploughs, yokes, reed baskets for carrying crops (*sengendes*), and other baskets (*tswanda*). For processing their farm produce, they also use implements such as mortar and pestle (*maturi ne mitswi*), grindingstone (*makuyo nehuyo*) and winnowing baskets (*sero*).

The indigenous implements dominate over their modern equivalents since very few people can afford to buy and maintain the latter. Even those with modern implements like ox-drawn scotch carts also have indigenous equipment like reed baskets mounted on sledges (*sengendes*) to complement their use.

The community is located in region Five (V) of the natural ecological regions of Zimbabwe as indicated in Figure 4.2. Mugandani, Wuta, Makarau, and Chipindu (2012) indicate that Zimbabwe was divided into five agro-ecological/ natural ecological regions in the 1960s, although the increased variability of rainfall has possibly affected the agro-ecological region Boundaries.

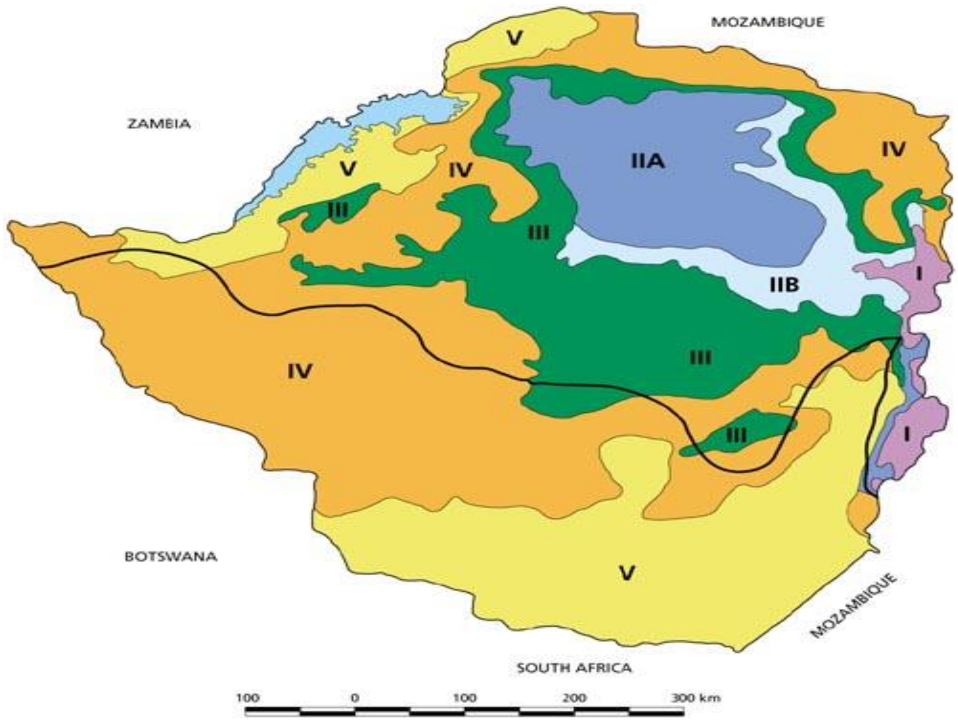

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Figure 4.2: Natural Ecological regions of Zimbabwe (Adopted from Moyo, 2000)

The characteristics of the five regions are given in table 4.1

Table 4.1.Natural Ecological regions of Zimbabwe (Adopted from Moyo, 2000)

Region	Areal Extent (Million ha)	Percentage of total area	Description
I.	0.6	1.6	Specialized and diversified farming: High annual rainfall (>1000mm). Temperature < 15 . Suitable for dairying, forestry, tea, coffee, fruit, maize, beef ranching
II.	7.31	18.8	Intensive farming: Annual rainfall 750- 1000mm. Ideal for rain-fed maize, tobacco, beef, cotton winter-wheat and vegetables
III.	6.85	17.6	Semi-intensive farming: Annual rainfall650-800mm mostly as frequent heavy storm. Severe mid-season dry spells. Marginal for tobacco, maize, and cotton. Favors livestock production with fodder. Requires good management to retain moisture during the growing Season
IV.	12.84	33.0	Semi-extensive farming: annual rainfall 450- 650mm. Subject to the seasonal droughts and severe dry spells during the rainy season. Found in hot low-lying land. Marginal rain-fed maize. Ideal for drought resistant fodder crops.
V.	11.28	29.0	Extensive farming: Annual rainfall <450mm and too low and erratic for most crops. Very hot and low-lying regions. Suitable for animal husbandry with drought Resistant fodder crops under irrigation. Zambezi escarpment this region is infested with tsetse fly

The region is characterized by erratic rainfall, seasonal droughts, and sometimes dry spells during the summer rainfall seasons. Rainfall received in the area is inadequate for the community"s agricultural activities. There are three major rivers in the area: the Shashe (which is the widest), Makurumidze and Muyambe Rivers. Another notable feature in the communal area is Huchu Plain (*Bani rekwa Huchu),* which is a low lying flat plain stretching from Makurumidze Dam in the north to Chikato Primary School to the south. Few exotic trees have been planted in the area. There are also a few mountains in the area.

Small gardens exist alongside the rivers from which they are irrigated. The Shashe River supports fishing, for which people in the area use traditional methods.. They use fishing lines (*zviredzo*), fish traps *(maduvo)* and fishing nets (*mambure)*. Hunting is also being done mostly by men, for which they use traps or a a firearm; Women normally attend to the household chores such as preparing food for the family and the processing of the farms produce. These processes include winnowing, and threshing of rapoko.

The majority of people in the community can produce the indigenous agricultural implements, fishing and hunting tools for themselves. These skills are learnt from elders in the community in traditional learning platforms (*dare*), which are normally attended by old and young men during the evening. At these learning platforms, elders make informal presentations and engage in discussions of, among other topics, important indigenous technological skills. The teaching and learning styles involved are traditional. Examples given in the discussions are taken from everyday lives. Artefacts are used to demonstrate skills of making or using different artefacts. Songs, drama, debates, analogies, idioms, and other language enrichment techniques are used in descriptions, explanations, and demonstrations to make points clearer and to make the teaching and learning process joyous.

The eldest man among those who would have gathered at the *dare* automatically becomes the one who would be in charge of controlling the proceedings. Those with interest in making some special artefacts would get informal tutorials and guidance from local experts in the production of those artefacts, such as an how to make yokes (*majoko*). Socioeconomic hardships have resulted in some people undertaking crafts fulltime, such as pottery, basketry, or carving, in which they produce the items for the local community market, neighbouring communities and for the urban market. Clay pots, used primarily for fetching water from wells and for cooking food, of different sizes and designs are molded. Other artefacts may be woven or carved.

The people in the area send their children to schools despite the social and economic hardships. There are more than 15 primary schools in the area, in addition to seven secondary schools and two high schools. Primary schools offer classes from ECD A to Grade 7, secondary schools offers classes from form I to Form 4 and High schools offers classes from Form 1 to Form 6. The children help their parents in the fields and other economic activities during weekends and school holidays. This enables the learners to grow up with a deep understanding of the indigenous implements and artefacts that are used in the social and economic activities in the community. Some children can even make some of the implements and artefacts themselves. Generally children grow up familiar with indigenous practices and artefacts in their sociocultural environment.

A number of learners, including those who have completed school and those who dropped out, have migrated to urban areas while others have remained and joined their elders in the community‟s traditional social and economic activities.

The people in the community respect their ancestors and sometimes hold cultural ceremonies in which they would worship these ancestors. Ancestral spirits (*mudzimu*) are respected by the people in the area. Ancestral worship in African indigenous communities often involves ritualistic prayers offered to the departed in seeking their guidance and protection in people‟s daily and social affairs (Govender, 2009). Some cultural ceremonies are attended by every member of the community including children and others are only for elders. I was warned not to expose much detail on this sacred topic.

The people would also engage traditional healers (*n'anga/sangoma*) for assistance during illness or rituals. Traditionally a *sangoma* or *n'anga* is an African spiritualist who practices traditional medicine; They wear unique attire when delivering their services, as shown in Figure 4.3. Their role is thus similar to that of a priest or medical doctor in western societies.

WHO (2000b) defines traditional medicine as the sum total of the knowledge, skills, and practices used in the maintenance of health and prevention, diagnosis, improvement or treatment of physical or mental illnesses, based on the theories, beliefs, and experiences indigenous to different cultures, which are either explicable or not.

Figure 4.3: Traditional healer (*n'anga*)

Every year the chief, with the assistance of his headmen organizes the rainmaking ceremony (*mukwerere*) to request rainfall from their ancestors. This rainmaking ceremony
(Mbiti, 1990). The term *mysticism* typically denotes a complexity of beliefs and is normally conducted at a reserved sacred place called Munyambe near the Forestry Commission Centre. Every community member is expected to attend.

Christians in the community are allowed by the chief to practice their religion. They are allowed to attend church services and follow Christian values and morals. The community"s spiritual ideas and ways are incorporated into their behavior patterns, traditional art, and craft and also in their daily practices. The community members hold some indigenous worldviews which can be categorized as African mystical cosmology based on God, spirits and man, magic and also as spiritism (animism) practices related to the personal experience of the divine. The people believe that there is a supreme God who is a creator of the universe and all that is in it (Mbiti, 1990). The presence of this God is acknowledged by and revered in indigenous praises, through libation, and proverbs. In addition to God, there exist spirits. These spirits are part of the creation, as are humans. Spirits are believed to have some powers and abilities. They interact with human beings and have agency in the world.

Mbiti (1990) explains that man as one of the mystical cosmology agents is created by God and coexists with the spirits in the world. Human orientation in the world is social, and action to uphold social ties and foster social cohesion is held in high regard and even seen as the primary goal of life. Humans can, through reciprocal affiliation with, and worship of, spirits gain access to their power and channel that power for positive or negative ends. Mysticism in indigenous African thought is distinct from conceptions of mysticism in Judaism, Christianity, and Islam. It is characterized by a social, worldly orientation; united with indigenous religious practices; primarily focused on interaction with spirits, rather than with the supreme God; preserved in and transmitted through oral traditions; and not aimed at unification with the divine through eradication of or purification of the self (Mbiti, 1990).

Magic is an art that purports to control or forecast natural events, effects, or forces by invoking the supernatural (Ogunniyi & Yandila, 1994). It involves power of influencing events and activities by using mysterious or supernatural forces. African magic is a form of magic developed and performed within the indigenous cultures and societies of Africa. Traditional roles related to magic in African society include rain making, divination, and works of the medicine men or herbalists. Like any other communities in Zimbabwe, the people in Zimuto community believe in witchcraft. This was also observed by Gee, Michaels, and O‟Connor (1992), who argue that witchcraft continues to play an important role in the lives of many African communities. People believe that witches use psychic witchcraft, which involves the use of an agent or familiar, as well as spirits and natural phenomena such as lightning, and medicines to cause illness or death (Layder, 1998, p. 141).

Spiritism is a belief that the spirits of the dead communicate with and manifest their presence to the living in many ways. It includes the belief that inanimate objects possess spirits. Generally it is an appeal to other world of gods, spirits, devils, ancestors, etc. (Ogunniyi & Yandila, 1994).

The availability of a variety of indigenous artefacts in the community influenced me to select it for my study. The availability of people who value education and send their children to school also guaranteed me maximum cooperation from members of the community. Some learners from the community were attending school at the three high schools selected for the study, and they had persuaded their elders to participate in the research.

4.5.2.2 The focus group (dare) discussion with community members

My appointment day with the community members coincided with the community"s Food for Work Project progress review date. The Food for Work program is a government program that assists rural people with food. The people are given tasks to accomplish before they are given some food parcels by the Government. The tasks may include repairing of public roads, bridges, or dip tanks etc. All the community members turned up for the meeting (see Figure 4.4).

Figure 4.4: Focus group discussion with community members (Source: Photograph taken during focus Group discussion with the community elders)

I initially intended to have 15 members in my focus group but I realized that including all of the 25 members who had gathered would enable me to access more IK artefacts and more information about them.I did not want to offend people by not including them since they were all covered in the consent letter from the District Administrator. I was impressed by the composition of the group, which had a fair representation of both men and women which enabled me to get information about artefacts associated with both genders at the same time. The composite group of participants enabled the understanding of different versions or views of reality and accorded me the opportunity to interview them to determine which view was most in accord with the research demands (Mertens, Cram, & Chilisa, 2013). Rifkin (2016) posits that demographic diversity strengthens the research. In this study, the researcher considered views that were relevant to the study according to the research questions and objectives.

Focus group discussion provided direct evidence on the similarities and differences in the participants‟ opinions and experiences, as opposed to reaching conclusions from ad hoc analysis of separate statements from each individual interview (Babbie & Mouton, 2001). Some research that promotes community participation can be messy, complex and time consuming (Adams & Faulkhead, 2012). The focus group in the study was not like that. Colleagues and friends were more comfortable about voicing their opinions in each other‟s company than they would have been alone. Participants were also able to build their contributions on other participants‟‟‟‟ opinions and answers.

The Zimuto community had no written protocol on how research was supposed to be conducted in their area. This was unlike some indigenous communities, who have written protocols that serve to guide researches in avoiding exploitation and in protecting their indigenous rights (Battiste, 2008; Mertens, Cram, et al., 2013; Mertens, Sullivan, et al., 2013). Although I had a consent letter from the District Administrator which allowed me to carry out the study in the community, the absence of Community Advisory Board to assist community participants of the informed consent process worried me at first. Ronald (2015) agrees that Community Advisory Boards facilitate research by providing advice about the informed consent process and the design and implementation of the research. In this situation, I had to rely on my own rural home experience and the literature about the community. I had also gleaned information about the cultural protocols of the community from my assistant researcher, who had once lived with a relative in the area. I undertook to be thoroughly professional and to conform scrupulously to the cultural protocols of the community throughout my interaction with the people.

When I was given the chance to meet the people, the focus group discussions preceded in line with the traditional Shona set up of a tribal council (*dare)*. I started with formal greetings for the elders. Everyone looked at me suspiciously; I expected to encounter problems in building relationships with the elders. It was only after I had introduced myself that they got relaxed. The ideas that I has gained from literature on indigenous research and *ubuntu/unhu* made this stage of introduction relatively easy. In particular, Smith (1999) and Wilson (2001) had provided me with important information about indigenous research paradigms and how to respectfully approach and engage community members.

I made sure that sufficient and correct information was disclosed to the participants and that it was conveyed in a manner they could comprehend. Accordingly, I communicated with them using Shona language, which was the first language of the most of the participants including the researcher. It was their community language. Communicating in their own language was not only respectful and contextually appropriate, but also created a better rapport between the researchers and community and led to more natural conversations, as endorsed by (Pryor & Ampiah, 2004). In addition, this vernacular communication also strengthened epistemological access to the participatory process as required by the research design. This enlightened idea is recommended by Vakalahi and Taiapa (2013), who say that language forms a repository of any culture‟s knowledge treasures. My interview guidelines allowed me to keep the interactions focused while allowing individuals to express their perspectives and experiences naturally.

Throughout the discussion I had to keep in mind that I had ethical and legal obligations to ensure that all aspects of the informed consent were honored. I adhered to the assumption that the views of the participants were all meaningful. Photographs and videos were taken only with their permission. I also jotted down some field notes of contextual observations and non-verbal clues (e.g. posters, and art on the huts) and observed the elders making their contributions. I recorded any small ear or eye catching incidents that occurred during conversations, in order to help me later in the analysis of data. I also referred to my observation schedule (Appendix J) that guided my observations.

More than thirty artefacts were identified and described during this focus group interview. I respected all the contributions even those on artefacts that appeared to be irrelevant to my study. In particular, the whole process was in line with the principles of a transformative participatory research approach. As already mentioned, indigenous research techniques were blended into the inquiry process. I carried out the research with the community members and not on them. In this way I was able to successfully gather rich data for answering the research questions. I made sure that all participants were involved in the knowledge creation and *unhu/ubuntu* principles were respected throughout the discussions. The focus group discussion lasted for over an hour.

The community members had not brought samples of the artefacts. They identified six members amongst themselves who made a living producing some of the artefacts for the local and surrounding communities. I made appointments to visit the identified specialists to see the artefacts and gather more information about their designs and how they are made. Because of limited time and resources I decided to visit one elder per artefact. I discussed with the elders the questions that I was going to ask them when I intended to visit them.

I knew that the philosophy of *ubuntu* that was embedded in my study mandated me to compensate participants for their generously given time and thank them for availing me of their knowledge free of charge. Goeke and Kubanski (2012) asserts that researchers should try to meet travel costs, food requirements and compensate for loss of earnings for the participants. It was all smiles at the end of the discussions when I gave all the participants food and beer. I also offered to drive two disabled members of the community to their respective homes.

I could not go to the elders" homes after the focus group-*dare* discussion without formally informing the village headman about my research intentions and seeking his permission. Acknowledging the role of traditional leadership enhanced the trust with the community elders that I wanted to visit. .

4.5.2.3 Visits at individual homes of community members

I tried to make the interviews of community members at their individual homes as interactive and conversational as possible. Babbie (2007) defines an interview as an interaction between the interviewer and the respondent in which the interviewer has a general plan of inquiry including topic to be covered. Chase (2005) and Kvale (1996) both describe interview conversation as an interchange of views between two or more people on a topic of common interest. Therefore, an interview is an interactive and guided conversation between two or more people for the purpose of getting information about a topic of interest. Three main types of interviews are proposed in the literature; namely, structured, semi-structured, and unstructured (Patton, 2002b).

In this study, the interviews were unstructured and took place at the elders‟ homes, where the elders were comfortable and relaxed. This allowed the elders to explain more on their artefacts. Pryor and Ampiah (2004) argue that open-ended questions allow participants to explain more on issues raised in an interview. I would re-word, re-order, or clarify questions to get more information on issues raised by the respondents. I noted that I should let the elders give their own narratives while I listened. It was interesting as they were unknowingly informing me of their concepts in mechanics in their own way, own language and according to their own understanding.

I took some photographs and videos of the interviews and also jotted down some field notes. Some of the photographs are shown below (Figures 4.5 and 4.6). My observation schedule (Appendix J) also reminded me to observe important aspects during the interaction with the elders.

Figure 4.5: A woman molding clay pots (Source: Photograph taken during an interview with the Elder)

Figure 4.6: Old man working on an artefact (Source: original)

4.5.3 DATA COLLECTION IN SCHOOLS

4.5.3.1 *Schools' Background*

The high schools that participated in this study are located in Masvingo District in Masvingo Province. The high schools have a mixture of both boarding and day scholar learners. Two of the participating schools are located in rural communities of the district under Chief Zimuto and one of them is in located in one of the low density suburbs of the provincial capital city, Masvingo City. The schools draw above 99% of their learners from African Zimbabweans. The majority of learners in the three schools have either rural background or have some links with rural communities. This means all the learners in the three high schools faced the same apparent conflict between western and indigenous ideas when learning physics concepts. The high schools all have high enrolments of more than 1000 learners, with an average of 60 teachers per school. The three high schools all boast of modern laboratories, with conventional apparatus. They all have high speed internet and a textbook to learners‟ ratio of one is to four. These schools all offer physics as a subject at both Advanced and Ordinary levels, along with maths, chemistry, biology , practical subjects and commercial subjects at both levels.

I had to involve both the physics teachers and their learners in the research so that we could generate this new knowledge together with the communities, as required by the TPR design. To this end, I adopted the recommendations of Kriek and Basson (2008), who emphasize that the views of teachers are important if an educational reform is to succeed. Similarly, Zipf and Harrison (2002) say that teachers‟ views can act as filters through which new knowledge and experiences are screened for meaning. Accordingly, the TPR ethics required me to involve the teachers in the research process, particularly by identifying artefacts together; by identifying the physics embedded in the artefacts together; and so they would be convinced that, indeed, there were some mechanics concepts embedded in the artefacts that they have previously taken for granted. This also involved confirming together that indeed the artefacts could be integrated into the teaching of physics, thereby making it easier for the learners to understand the concepts. We, together, proposed ways whereby the integration of the artefacts could be effected by the teachers.

4.5.4 The schools visits

The UKZN university ethics requirements were all met. This included ethical clearance, consent forms from the participants and gatekeepers‟ letters: that is from Masvingo Provincial Education Department and Masvingo District Schools Inspector. When I got to the schools, the headmasters would invite the schools‟ heads of science departments and physics teachers to their offices, where I explained the purpose of my study and clarified that I required their participation, which depended on their willingness to be part of the study. I was happy that everyone displayed enthusiasm for participating. For the learners, consent was elicited from the respective school heads through the District Schools Inspector (DSI).

When I entered into the schools to collect data, I had anticipated that teachers may not be comfortable meeting new faces in their schools. On the contrary, I was received warmly by the teachers, although they were hesitant at the beginning before I explained the purpose of my visit. The teachers and the learners responded to questionnaires (Appendix B and C) before focus group discussions

4.5.5 Participation by learners

Learners completed questionnaires and also participated in focus group discussion and individual face-to-face interviews. I considered the learners important in my study as they occupy the intersection between the classroom physics and the IK knowledge and artefacts. Their inclusion ensured balanced views, accommodating both the home and school worlds.

4.5.5.1 ***Questionnaire for learners from the three high schools***

The topics on which learners were asked to respond were carefully worded in English (Appendix C). My colleague who teaches English checked my questionnaire for grammatical errors. Learners were asked to reflect on their social and cultural experiences.

The questionnaires included artefacts that needed deeper discussion and investigation. Questionnaire responses allowed privacy of opinion, so this could potentially generate richer data than would open discussions (Cohen et al., 2011). The questionnaire was administered by the researcher before the focus group discussion so that focus groups could be used by the researcher as a platform for probing for more information on unclear responses to the questionnaires. A total of 45 learners who were part of the samples from the three high schools completed the questionnaires and retained them before the focus group discussion. Sketch diagrams and metaphors, proverbs , similes and ideoms were included in descriptions of shapes, designs, and structure of artefacts as part of their responses.

4.5.5.2 Focus group discussions with learners from the three high schools

There was a preponderance of male learners in the focus groups; in a focus group of 45 learners, only 8 learners were female. Dearing et al. (2012) indicate recent studies that show historical trend towards dwindling differences and increasing similarities in the cognitive performance of boys and girls. As a result, I valued contributions from both male and female participants equally. Figure 4.7 Shows photographs of learners skething IK artefacts taken during the focus group discussion .

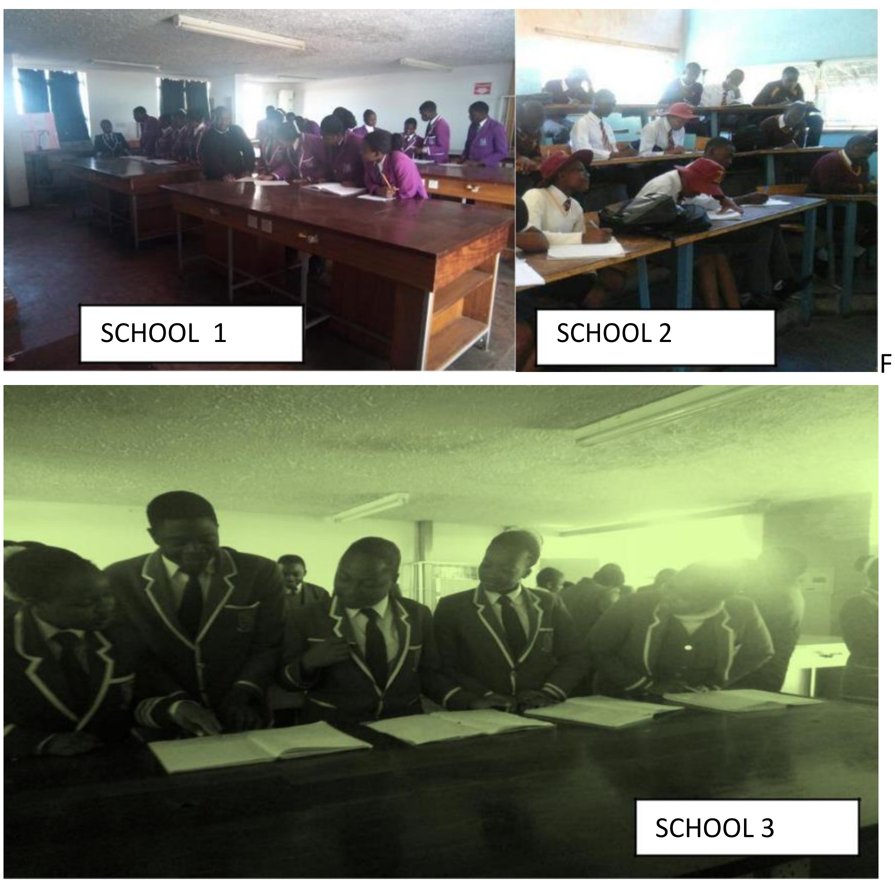

Figure 4.7: Focus group discussion with learners (Source: original photographs)

During the focus group discussions with the learners, I ensured that no individual‟s expressed views were obscured by the views of the group and also that no one person dominated the group discussions at the expense of the contributions from others. I ensured this by making sure that each of the learners was given time to make his or her own contributions. I would react to all contributions in almost the same manner so as to ensure all learners would feel that their contributions were important. The dynamic interaction during the discussion among the participants stimulated their thoughts as evidenced by their full participation. Although the learners having the opportunity to ask and answer questions generated more information than the questionnaires, I was nevertheless, aware that the group climate could inhibit or fail to stimulate some individuals. Consequently, I tried to make the discussions as natural and neutral as was possible. Like in the questionnaires responses, sketch diagrams, and metaphors were included in descriptions of shapes, designs, and structure of artefacts in the focus group discussions. All discussions were video recorded and later played back to the learners, as is required by indigenous research ethics (Odora-Hoppers, 2002b; Smith, 1999).

4.5.5.3 Interview with learners from the three high schools

Individual interviews were also conducted with the learners (Appendix F) in the laboratories at their respective high schools. Learners were allowed to converse in either Shona or English, or to mix the two languages. They used more Shona than English to identify artefacts and describe them in terms of their own understanding of the design, structure, and uses of the artefacts. Learners identified fewer IK artefacts than those that were identified in the community and the teachers. In their contributions, learners revealed the mechanics concepts that were embedded in the artefacts. I would give them guidance, ask probing questions, and use examples to assist them. Learners proposed their own ideas about how the indigenous knowledge artefacts could be integrated into their physics lessons.

4.5.6 ***Participation by teachers***

Teachers completed questionnaires and were also involved in focus group discussions and individual face- to -face interviews.

4.5.6.1 Questionnaire for Physics teachers

The topics on which teachers were asked to respond were carefully worded in English (Appendix B). Teachers were asked to indicate their personal information like professional qualification. They were also requested to reflect on their social and cultural experiences.

The questionnaires included artefacts that needed deeper discussion and investigation. The questionnaire was administered by the researcher before the focus group discussion so that focus groups could be used by the researcher as a platform for probing for more information on unclear responses to the questionnaires. A total of 18 teachers who were part of the Focus group formed by physics teachers in Masvingo District completed the questionnaires and retained them before the focus group discussion. Teachers included sketch diagrams, illustrations, and metaphors in their descriptions of shapes, designs, and structure of artefacts.

4.5.6.2 Focus group discussion with teachers

The focus group discussion with physics teachers was conducted at one of the three high schools (see Figure 4.8). The date coincided with a provincial workshop that had been organized for physics teachers. The eight teachers from the three high schools in my sample attended together with other fourteen physics teachers from other high schools. This made the focus group to have twenty two participants.

Figure 4.8: Focus group discussions with teachers (Source: original photograph)

4.5.6.3 Individual Interview with Physics teachers from the three high schools

Individual interviews were conducted with the teachers at their offices at their respective high schools using an interview guide. (Appendix D). Interviews were conducted after school to avoid disturbing the teaching schedules. The interviews were-face to face, in-depth semi-structured form since the intention of the researcher was to get information detailed information that could answer the research questions for the study. In-depth interviews encourage full disclosure of information by participants(May, 2002). Open-ended questions produced more information than closed questions. This agreed with Cohen, Manion and Morrison (2000) who observed that open-ended questions are flexible and allow the interviewer to probe. I was granted permission to video record the interview and also use the data in my research.

Teachers were allowed to converse in either Shona or English, or to mix the two languages. They used more Shona than English to identify artefacts and describe them in terms of their own understanding of the design, structure, and uses of the artefacts. Nearly all the artefacts discussed were among those that had been identified in the community. During the discussions, it was interesting to be part of the teachers‟ discovering the mechanics concepts that were embedded in the artefacts. I would give them guidance, ask probing questions, and use examples to assist them. Teachers further contributed by creating their own ideas about how the indigenous knowledge artefacts could be integrated into physics lessons. The teachers also advised me on the best time to meet the learners and also assisted me with the translation of some Shona words to English.

4.5.7 Researcher observations

Observations were conducted by the researchers throughout the data collection period. An observation schedule indicating items to be observed was used (Appendix J).Observation is a research technique that involves the collection of data without the researcher attempting to manipulate it. The researcher simply observes on-going activities, without making any attempt to control or determine them (Wray, Trott, & Bloomer, 1998, p. 186). Gordon and Marian (2011) maintains that observations show the researcher the phenomena without the filtering of language. However, Wilson (1987) xpounds that though observation may give researchers naturalistic data, “in observing or recording everyday interaction, one is contaminating the setting and modifying that very interaction by the procedures of observation.”

This is what Wilson (1987) referred to as “the observer‟s paradox”. Either a participant or non-participant observer can execute observations. A non-participant observer “records in detail as an outsider, all the behaviors which take place” while a participant observer is “an integral part of the observed situation as one of the subjects without the other participants being aware of the fact...” (Seliger & Shohamy, 1989, p. 161).

In the case of this study, the researcher carried out the observation in the capacity of a non-participant observer. During observations, I recorded clearly and legibly what I saw and heard in my observation schedule as soon as possible before forgetting. Items that were not observed but indicated on the observation schedule were indicated “Not observed” so that I would be reminded that the items were not ignored. My field notes contained both descriptive information and reflective information. My initial field notes were in cryptic form. I had to flesh them out immediately after the observation to make sure that important detail was not lost. Some of the observations were related to the information that was revealed in individual interviews, questionnaires, and focus group discussions. I had to remember that what people do may differ from what they say they do.
Observation enabled the researcher to examine non-elicited behavior and artefacts as and when they occurred and appeared respectively. Observations were more flexible than controlled experiments which may be affected by extraneous variables or unplanned events as also observed by (Wray et al., 1998, p. 187). One disadvantage of observations that I remembered during the process was that the presence of the observer may alter the subjects‟ behavior. This means that if subjects were being watched, they were likely to change their normal behavior. This is what is known as “observer effect.” Gall et al. (1996) define observer effect as an action by the observer that has a negative effect on the validity or reliability of the data being collected.

4.5.8 Additional community participants

I had to get views of outsiders; so I discussed my research data with a trader who buys reed mates and mortars from the community and sell them to some urban areas like Masvingo town and a retired school teacher to improve on its the authenticity and trustworthiness. Their objective commends, contributions and suggestions generally improved the accuracy and soundness of findings and conclusions.

4.6 WORKING WITH DATA

4.6.1 Forms of Data

The forms of data generated included:

- Photographs
- Learners" and teachers" questionnaire responses
- Field notes from my observations, formal and informal conversations. These helped to understand the context in which descriptions and explanations were given.
- Video and audio recordings of interviews with teachers and elders making artefacts, focus group discussions with teachers, elders and learners.

The naturalistic nature of my study enabled data gathering and analysis to be done concurrently during the course of fieldwork. As soon as I got the first set of data which was from questionnaires and observations, I tried to make sense of it while I was still in the field. Thus, from the outset I began qualitative data analysis processes. LeCompte and Schensul (1999) define data analysis as the process that a researcher uses to reduce data to a story with its interpretation. It is the search for patterns in the data and for ideas that explain why these patterns are there (Bernard, Wutich, & Ryan, 2016). Qualitative data analysis involves organizing data, reducing them through summarization and categorization, identification of patterns and themes in the data and linking them (Patton, 2002b). Corbin and Strauss (2007) add that data analysis is the process of examining and interpreting data in order to elicit meaning and gain understanding.

As data was analyzed, further ideas about directions of analysis occurred and possible categories and themes sprang to my mind and informed subsequent field work. I paid special attention to insights that emerged serendipitously and tracked analytical insights that emerged during the data gathering process. This also allowed me to identify issues that needed follow-up. Patton (2002b) argues that ignoring the emergent nature of the qualitative designs and analytical insights or in-the-field insights removes the opportunity to deepen data collection that would test the authenticity of those insights while still in the field. Nevertheless, I was cautious about not to overdoing the analysis in the field so as to avoid interfering with the openness of the inquiry process. I was conscious of not rushing to premature conclusions.

When data collection formally ended, I began the final analysis. I had to consider the two sets of primary data. These were, firstly, data that was generated directly in response to the research questions that were posed during the conception and design stages of the study prior to the fieldwork and then those analytical insights and interpretations that emerged later during the data collection process.

4.6.2 Data Transcription

Data transcription is conversion of data from one format to another; in qualitative research most commonly converting audio recording to text. Qualitative data collected as audio-visual recordings are transcribed as textual files for analysis, archiving and sharing. During the transcription processes, I repeatedly listened to the audio and watched the video recording of the focus group discussions in order to familiarize myself with the data. At the beginning of the transcription process, I concentrated on getting words right, I then listened to the tone, watched out for facial expressions and any other forms of non-verbal communication in order to get a clearer picture of the event being transcribed. I also noted how other participants reacted to the one speaking. I also relied on my memory and, in some instances, observation notes to relive the experience and understand the meanings of words gestures and expressions. I had challenges with situations where respondents gave incomplete and hanging sentences, or when they had been interrupted by new thoughts before completing the first sentence. I also made sure that the punctuation as indicated by the pauses in the audio and typing of words were correct, for if this is wrongly done the entire meaning of what the respondent said could be lost. Even during the transcribing phase, I continued to analyze data. In this regard I was influenced by claims made by Bird (2005) that transcribing is a key part of data analysis. I highlighted words, phrases, and actual quotes that reflected possible themes and findings. I tried not to recreate the events but instead merely represented the events, interviews, and focus group discussions. It was not easy; it was a laborious process that took me a long time.

The sketch diagrams of the indigenous artefacts that were included in some responses to by participants were not easy to analyze. Lowe (1995) contends that interpretation of photographs and diagrams is a highly demanding cognitive task that can lead to numerous misconceptions and incorrect ways of reasoning. The IK artefacts appeared ordinary in the sketch diagrams and photographs but on scrutinizing them, there was a lot of physics concepts that were embedded in the shapes, designs and the structure of the artefacts. This was clear, for example, with the ordinary axe that is used for cutting trees and gathering firewood, where the concept of pressure and surface area came out clearly. The cutting edge of an axe is sharp to increase pressure for very small amount of force applied. It is the ratio of force to cross sectional area which determines pressure, that is,

Interpretations of drawings were followed up by discussions. The analysis of data was done in two stages, just for the convenience of the researcher. The first stage of data analysis resulted in the bulk of my data in text form. This started in the field up to the transcription stage and pre-coding stage. This stage prepared data for the second phase of analysis.

4.6.3 Interview and Focus Group discussions data translation

Data were collected from the community in the first language of the participants; that is Shona. Learners and teachers mixed English and Shona languages throughout, which Fleisch (2008) calls code switching. Code switching is the use of more than one language to contextualize communication. Fleisch (2008) argues that code switching is caused by failure by the respondents to express their ideas clearly in English. Code switching and transliteration was evident in situations where the respondents could not find a suitable English term to use in his or her presentation and also where there were some cultural taboos about the use of certain terms.

To avoid misrepresenting the participants, I presented the data in the language used by the participants (Shona or English). Although words may be easily reassigned meaning from one language into another language (Squires, 2008), Ferrini-Mundy, Kim, and Sfard (2012) explain that different vocabularies project the world in different ways. This implies that in one language words may be interrelated quite differently from how they are interrelated when translated into another language. Translation is the meaning of something in language other than the one in which it was said or written. In this research, participants often made their contributions in their indigenous language, Shona. This meant that data translation was necessary before transcription. Shona words are given in italics, e.g. *rekeni* for catapult, followed by English translation of the participant‟s words. When I was translating the words, I considered the context of the discussion to ensure that the translation was as accurate as possible.

Data translation involves assigning meanings to words in both languages and is mediated by power relations and social contexts (Wong & Poon, 2010). Data translation is more than a technical process that any bilingual person can effectively do (Temple, 2002). Translation enables researchers to uncover the richness embedded in the research data and facilitate multiple ways of knowing. I believed that I should integrate my cultural interpretations of the participants‟ statements in my data analysis process as recommended by Temple (2002) and Temple and Young (2004). Thus, I became the producer of data and shaped the data analysis process through my experience in the field. This agrees with advice from Temple (2002), who discourages researchers from engaging professional translators.

In the context of research, a translator is defined as a person who transforms the research data from one language to another (Wong & Poon, 2010). A professional translator is a person who possesses certification from a professional translator‟s association as a proof of their language competency (Edwards, 1998). Temple (2002) argues that social world influences the views of the translator. Being similarly cautious, Wong and Poon (2010) argue that the omission or addition of a word or phrase in the translated text can have a significant influence on data interpretation and meaning construction and so on the final representation of the participants. Wong and Poon (2010) also argue that actual meaning of words and events can be lost in translation. An example is when a reed basket is referred to as either *tswanda* or *dengu* when talking, but these are two different artefacts. *Tswanda* refers to a reed basket that is smaller and lighter than *dengu*. Mistranslation therefore violates the ethics enshrined in indigenous research methodology, which has to be respectful and make true representations.

My translation was literal to ensure that I remained faithful to the essence of what the participants were actually communicating. My translation was checked by a colleague who teaches English language at a local high school in Masvingo District. In cases where quotes were in English, I did not correct the grammar; thus ensuring a better representation of the participants‟ views. In this thesis, participants allowed me to use nicknames of their choice to protect their confidentiality and anonymity.

4.6.4 Pre-coding of the data

Qualitative researchers disagree on the total body of data to be considered for coding and analysis. On the one hand, Lofland, Snow, Anderson, and Lofland (2006) and Wolcott (1999) feel that every detail recorded during fieldwork should be considered for analysis. They argue that the „patterned minutiae‟ of the collected data may generate significant insights. On the other hand, Seidman (2006) argues that only the most salient portions of the data merit examination. He adds that up to half of the total recorded data can be summarized or deleted, leaving the other half for intensive analysis.

In this study not all the collected data was analyzed with some parts being left out. I was, however, concerned about neglecting portions that could prove to be insightful data. The reason is that some data can still contain „valuable bits of information‟ or units of information that could pull everything together or include a particular negative case that could motivate rethinking of codes, categories, themes, concepts, or assertions (Poland & Pederson, 1998). When I was looking for pieces of data to exclude from the data, I was being guided by my research questions and objectives as I repeatedly re-read and re-looked at the data. .I considered those sections of my data that could provide sufficient, rich, thick, and quality qualitative data to work with, which I ensured was properly and appropriately transcribed, translated if need be, and formulated. I did this somewhat confidently because postmodern perspectives on ethnographic texts consider all documents and reports to be partial and incomplete (Poland & Pederson, 1998).

Data was pre-coded before subjecting it to the next second phase of data analysis that included the actual coding. Layder (1998) advises qualitative researchers to never forget to pre-code data. Pre-coding in my case involved circling, highlighting, bolding, underlining, and capitalizing rich and significant quotes and passages from participants. I used simple codes to enable later retrieval. I was sure that these data would form important evidentiary support for the propositions and assertions arising from my study. I viewed them as important because they could serve as illustrative examples in this thesis.

The pre-coding process was remarkable, as some of the quotes appeared so provocative that they threatened to become part of the title, organizational framework and even the thought-line or main idea of my report. For example, one of the teachers responded during a focus group discussion and said "Tine dzedu physics dzaishandiswa kare nevakuru vedu uye dzimwe dzacho tichiri kudzishandisa.

Tinogona kudzidzisana idzodzo tichishandisa maindigenous artefacts acho". He said "*We have our own indigenous physics. We can teach indigenous physics using our indigenous artefacts*." This response was so powerful that it nearly shifted the focus of my study to look at indigenous physics.

4.7 THE SECOND PHASE OF WORKING WITH DATA

The second phase of data analysis involved working with data in text form from the first phase of data analysis. This included printed text data that had been transcribed from audio and video recordings as well as collated written data from questionnaires, analytical insights, and observation notes. I could now analyze the data manually. I found the manual manipulation of data instilling in me a sense of ownership and control over my work and my data, in particular.

The layout of the data was in the double spaced format on the left half of the page. I kept a wide right hand margin for writing codes and notes. I separated the text into short paragraph-length units with blank lines between them (like poetic verses or stanzas) whenever the topic or subtopic appear to change. I remembered that formatting choices are a part of the data analysis and may reveal or conceal aspects of meaning and intent, as argued by Gee et al. (1992). I read and re-read the text to get an initial sense of data. I drew that insight from Patton (2000), who argues that the qualitative researcher should go over the data over and over again to see if the data constructs, categories, explanations and interpretations make sense. I gave a summary of responses on each of the research questions. I identified gaps, or areas that needed follow-up where questions had not been adequately answered.

I remember at one time, I could not continue with data analysis without going back to one of the elders for more data collection and clarification. This was not a challenge because I had cultivated cordial relationships with the participants as required by *unhu/ubuntu* during the process of data collection and also my exit from the field was proper. When I was in the field, I also remembered that even during analysis and writing stage, gaps, and ambiguities may emerge and may require collection of more data and may require reconvening of interviewees so that they could clarify or deepen responses or make new observations made to add depth to descriptions. I drew this wisdom from Patton (2002a), who asserts that data collection and analysis for a qualitative inquiry should be integrative, iterative, and synergistic processes.

At another time I had to go and re-do the interview with one of the elders when my video camera data storage crashed before I could make back-up copies. I had developed a habit of making back-up copies of all my data and putting one master copy away for safe keeping, because I knew that the data collected was unique and precious and could never be captured in precisely the same way even if the new observations are undertaken and new interviews are conducted. Protecting the data was thus also in line with the ethical obligation of respecting confidentiality. Nevertheless, disasters sometimes happen. My going back into the field extended my stay there and my contact with the research participants. It was heartening to know that according to Creswell and Miller (2000), prolonged engagement in the field increases the credibility of the data collected and the research in general.

This process of collating responses enabled me to produce data summaries for each research question. After developing the data summaries for each research question, I then developed coding schemes based on the research questions and research objectives. I also used my tacit and intuitive knowledge to determine which data looked alike and felt alike when coding (Cohen et al., 2011; Denzin & Lincoln, 2011a; Lincoln & Guba, 1985a).

Coding is a data analysis process in which data, in either qualitative or quantitative form, is categorized to facilitate analysis. Coding is the process of analyzing qualitative text data by taking them apart to see what they yield before putting the data back together in a meaningful way (Creswell, 2015, p.156). (Creswell, 2015, p. 160) regards coding as an act of "winnowing" while (Miles, Huberman, & Saldaña, 2014, p. 73) consider it as "data condensation".

Codes are labels that assign symbolic meaning to the descriptive or inferential information compiled during a study (Miles et al., 2014, p. 71). Strauss (1987) defines a code as a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and evocative attribute for a portion of language-based or visual data. It is a word or phrase that captures action. Generally, the word "code" is used to designate the label of any kind which is attached to a piece of data, and it is in this sense that the word code is used throughout the rest of this article.(Elliott, 2018). It can also be shorthand or an abbreviation for the more important category yet to be discovered. The coding process involved both decoding and encoding process.

Decoding involved reflecting on the sections of data in the summaries to decipher their core meaning. The coded information was interpreted and translated into a comprehensible form. Encoding involved the determination of appropriate code and label for the sections of data summaries. Information from the different sources was converted into symbols to facilitate analysis. There is no specific formula to follow when coding (Basit, 2003; Elliott, 2018). Many scholars suggest that the number of codes may be arbitrarily chosen (Elliott, 2018).

In this study I just settled on the number that enabled analysis to be done later in the data analysis process. I avoided too many code as advised by Elliott (2018). Saldaña (2016, p. 17) indicates that there are some researchers who feel that every recorded fieldwork detail is worthy of consideration while others suggest "only the most salient portions of the corpus related to the research questions merit examination" and that much else can be deleted. I did not delete the extra data but kept it in a safe folder on my computer.

I adopted some of the stages shown in the diagram below in Figure 4.9. I started with codes, then categories of data, which then produced other themes which led to findings and finally the design of a pedagogical teaching model. Categories "are broad units of information that consist of several codes aggregated to form a common idea (Creswell, 2015, p. 186).

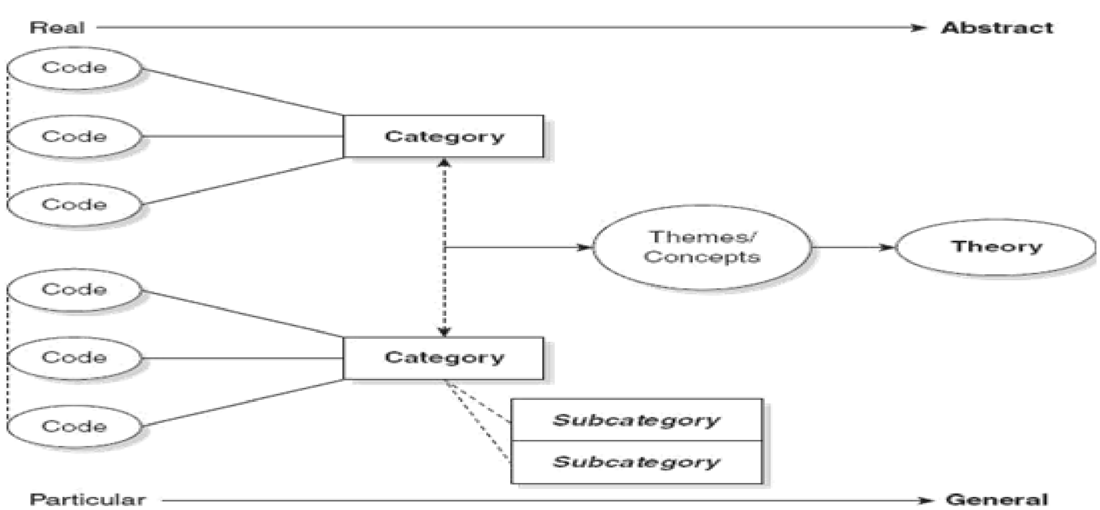

Figure 4.9: A streamlined code-to-theory model for qualitative inquiry [Adopted from Strauss (1987)]

Figure 4.9 indicates the adopted „descriptive coding technique" where summaries of the excerpts are given predetermined codes. For example, in the excerpt below one respondent said:

> "Tinoona maArtfact aya pamifananidzo iri mugomo reMazambara."
>
> (We see some of these IK artefacts on rock paintings in Mazambara Mountain).

The descriptive code was given as: SA and this was placed in category one which was "source of information" about IK artefacts. I had created a starting list of seven provisional codes (see Table 4.1) as recommended by (Cresswell, 2003). I tried to be as flexible and ethical as possible as required by the indigenous research paradigm that I had adopted.

I drew another lesson from Eisenhart and Jurow (2013) who pointed out that coding allows clearer clarification of the "bigger picture" portrayed by data. Miles and Huberman (1994) also confirm that data coding allows data to be brought together and make it easy for emerging trends to be identified. Coding allows easy identification of similarities and differences in the responses among participants and also easy identification of unusual data. Kelle (2007) argues that coding eliminates excessive data and summarizes data meaningfully. Coding also enabled me to gain new perspective on the collected data, as when I could easily segregate, group, regroup, and re-link data in order to consolidate their meaning and explanation (Grbich, 2012).

After coding the data, I then organized the data into categories. These were segments of related and explicit data that could be described by a word or a phrase. I organized and grouped similarly coded data into categories or „families" because they shared similar characteristics. The categories included those illustrated in Table 4.2, from which seven categories emerged.

Table 4.2: Categories of Coded Data

Category	Items included	Code
1	Sources of IK artefacts	SA
2	Identified IK artefacts	IA
3	Use of IK artefacts	UA
4	Structure of artefacts	STA
5	Mechanics concepts embedded in the artefacts	MA
6	Topics in Mechanics	TM
7	Views on integration	VI

Categories 1 and 2 were related to Research question 1. Categories 3, 4, 5, and 6 were related to Research Question 2 and Category 7 had codes related to Research question 3. Subcategories also clustered under the 7 major categories. For instance, the subcategories that emerged under the major category 7, „Views on integration", included implications for teaching approach, methods, strategy, media, lesson presentation and even the curriculum.

After categorizing the data and reflecting on the data analytically, I then identified emerging themes. In coding, categorizing and also when searching for the themes, I ensured that none of the important points of the data was lost. I kept a printed copy on hand of my research questions, objectives, theoretical framework, and purpose of my study to keep myself focused throughout these „metadata activities". Meta-data activities refer to the process and product of creating data about the data, in the form of codes, categories, analysis memos, and graphical summaries (MacQueen & Guest, 2008). I then generated findings by carefully weighing evidence through checking their recurrence across the emergent themes. After that, I then sought possible explanations and implications of these findings.

I then asked the participants some questions about the themes and categories that had emerged, to see if the categories were making sense and whether they were supported by evidence and also whether the overall findings and account of the study were realistic and accurate. I allowed the participants, my supervisor, colleagues, and other academics in the field to critique my research process and even the findings. This was to ensure the soundness and accuracy of findings and conclusions reached in the study (Long & Johnson, 2000). Creswell and Miller (2000) called such a process “member checking”.“ Member checking” consists of taking data and interpretations back to the participants in the study so that they can confirm the credibility of the information and narrative account (Creswell & Miller, 2000).

A colleague in science education also reviewed the data and the themes and acted as a sounding board for ideas. The research supervisor also requested explanations and evidence from interviews and observations, focus group discussions and even evidence of peer reviews. The supervisor also cross-checked the results. The colleague and the supervisor would question and challenge my assumptions, methods, and interpretations. I valued this peer interaction, which ensured that the themes derived are credible according to (Lincoln & Guba, 1985a). The verification and clarifications that emerged in the processes also provided me with further opportunities to make comments and relevant changes.

The degree of trustworthiness and rigor in the themes was also improved by the fact that the researcher was already conversant with some of the IK artefacts and IK practices that had been identified. In some cases the researcher could even take part in some activities involving IK artefacts, such as when he played a drum (*ngoma*). This participation also ensured the trustworthiness of the themes as the researcher could experience and feel the emotional response generated by the use of the artefacts (Johnson, 1997). In this regard, Dick, Chakravarti, and Biehal (1990) and Seidman (2006) confirm that when a researcher is conversant with the information and phenomenon under study, the data is of a high degree of trustworthiness and rigor.

The findings and themes that emerged are outlined, discussed, and explained in Chapter 5, and they lead to the pedagogical approach discussed in Chapter 6.

4.8 ETHICAL CONSIDERATIONS

One of the major issues in both qualitative and quantitative research is the importance of ethical considerations. This is important in the establishment of collaborative relationship of trust with the participants as well as gaining access to the schools and communities of the participants. Participants in the study were learners, teachers from three high schools, and Elders from Zimuto community.

The researcher got ethical clearance to conduct research from UKZN (Appendix K), written consent from the Ministry of Primary and Secondary Education (Appendix L-01), consent letter from Ministry of Primary and Secondary Education, Masvingo District (Appendix L-02) carry out the study in the high schools. The researcher also obtained consent from the District administrator to conduct the study in Zimuto community (Appendix L-03). The researcher also obtained informed consent from the participants in the research. Informed consent is a procedure in which individuals choose whether to participate in an investigation after being informed of the facts that would be likely to influence their decisions (Cohen et al., 2007, p. 52). All the participants were duly informed about the exact purpose and nature of the research study before participating. They were all informed that their participation in the research study was voluntary with an option to withdraw their participation any time without costs. Teachers and learners were requested not to write their names or names of schools on their questionnaires. The information gathered in the study, namely, questionnaires, interviews focus group discussions, and observations was stored safely as a measure to guarantee protection of confidentiality agreement entered into with the participants. Generally, the researcher sort informed consent from the participants ensured that there was no deception of subjects, violation of privacy, truth, rights, and inversion of participants' space.

Details of how ethical issues were considered in the study are also described in context in the description of the different parts of the research process.

4.9 RIGOR AND TRANSFERABILITY

In qualitative research, notions of reliability and validity have different meanings to those adopted in quantitative research. Quantitative research assumes the possibility of replication where, if the same methods are used again with the same sample, then the results should be the same. By contrast, in qualitative research reliability does not require such replication in generating, refining, comparing, and validating of constructs. Moreover, LeCompte and Preissle (1993) argue that such replication would be difficult, if not impossible, in qualitative research since it would require the researcher to repeat his status position, choice of respondents, social situations and conditions along with methods of data collection and analysis.

Some qualitative researchers have argued that the concepts of validity and reliability are not applicable to qualitative research,, but rather they are terms used in the quantitative paradigm (Altheide & Johnson, 1994; Golafshani, 2003; Leininger, 1994). The quality, rigor and trustworthiness have been suggested by Lincoln and Guba (1985b) and Stenbacka (2001) as being more suitable for (Golafshani, 2003). The idea of trustworthiness or rigor contains aspects of authenticity or credibility, transferability, dependability, and confirmability. Without rigor the research is worthless; it becomes fiction, and loses its utility (Golafshani, 2003).

The concepts of authenticity and transferability set the standards by which I tried to ensure that the research was of high quality. I promoted authenticity by building a rapport with the participants and making the climate for the interviews and focus group discussions as natural as possible. This made the study authentic, naturalistic, and ethnographic. Holloway and Wheeler (2002a, p. 255) note that transferability means that findings of a research project could be applicable to similar situations or participants. This implies that the knowledge that was acquired in one context would be applicable in another similar context and researchers in that other context would be able to apply findings that from the original research. To improve transferability or generalizability of findings, I tried to give detailed or thick descriptions of the discussions. Thick description refers to rich, thorough descriptions of the research setting and the transactions and processes observed during the study (Polit, Beck, & Hungler, 2001, p. 316). Data was collected in different forms to ensure trustworthiness of the data and the study in general. The use of multiple sources of data or information (data triangulation method) enhanced the rigor and trustworthiness of a qualitative research (Johnson, 1997, p. 289). Similarly, Jick (1979) asserts that a multiple research approach is one way of ensuring trustworthiness of qualitative research. Triangulation is a validity procedure where researchers search for convergence among multiple and different sources of information to form themes or categories in a study (Creswell & Miller, 2000, p. 126). Creswell and Miller (2000) posit that triangulation is used to increase credibility and check dependability by sourcing information from different sources to form themes of the study.

4.10 SUMMARY

Chapter 4 discussed the research design and methodology. A transformative participatory research methodology was formed by combining relevant aspects of transformative research and participatory research methodologies. Details of the methodology were outlined with indications of how it guided the research, together with the research analytical framework and the theoretical framework that had been introduced in Chapter 3. Chapter 5 examines the research findings.

Chapter 5

RESEARCH FINDINGS

5.1 INTRODUCTION

The data and analysis of responses to the research questions below constituted the major categories, themes, and findings of the research study. In this chapter, findings for Research Questions 1, 2 are discussed.

1. What are the indigenous artefacts that can be associated with Advanced level mechanics found in Masvingo District, Zimbabwe as perceived by Elders, teachers and learners?

2. What are the Advanced level mechanics concepts that can be associated with these indigenous artefacts identified in Masvingo District, Zimbabwe?

Generally, the research design and methodology allowed the researcher to reveal the themes and findings that served as answers to the research questions and the answers served were central to the findings, which are discussed in descriptive and diagrammatic forms supported by excerpts from participants.

5.2 BACKGROUNDS OF PARTICIPANTS

It was necessary to revisit and examine closely the background of the participants in order to ascertain that the information I got did indeed originate among the indigenous people themselves. This generally improved the generalizability of the responses, in the categories of data and themes that emerged from these responses. This agrees with the view of Patton (1990) who argues that when researchers get information from experts and knowledgeable people in the field, the quality of answers and the trustworthiness of the qualitative process is improved. According to Denzin and Lincoln (2011a), internal validity refers to the rigor with which the study is designed and the extent to which alternative explanations for expected correlational or causal relationships have been adequately examined within the research process. It thus measures the ability of the research to show relationships clearly and unambiguously (SCORE, 2008).

5.2.1 Elders

Most of the elders had been in the area for more than 40 years and their average age was 45 years. All of them grew up in the area with their parents who were mainly peasant farmers living in a traditional manner and depended mainly on local resources for their livelihood.

The focus group consisting of elders represented a broad spectrum of artefact specialists. There were basket weavers, potters, wood carvers, farmers, hunters, and fishermen, to mention a few.

The choice of elders as IK artefacts specialists for the interviews was based on recommendations from the members within the focus group discussion. This reduced researcher bias and improved the generalizability and transferability of the research process and findings.

5.2.2 Teachers

The eight teachers from the three high schools who were interviewed together with the other teachers who formed the focus group (a total of eighteen) had a variety of teaching experiences, ranging from 6 years to 25 years, with an average of 8 years. They were all trained and qualified to teach physics. All of them had teaching degrees from state universities in Zimbabwe.The average age of the teachers was 37 years. Fifiteen of the eighteen teachers came from Masvingo Province; nine from the Masvingo district; four came from Gutu and two from Chivi districts, and one came from Matabeleland Province and two from Manicaland province. The teachers in the focus group were all Zimbabweans.

Generally all the teachers had some knowledge of life in the rural areas. There was evidence that they had interacted with indigenous artefacts for a long time and also they had been teaching physics for quite a long time. There seemed to be a preponderance of male physics teachers in the schools as there was only one female physics teacher at the three high schools in my sample.

5.2.3 Learners

The classes had both boys and girls, although the boys dominated in the classes in the three high schools. All the learners were above 16 years of age. Almost all of the learners (98%) had a rural background. Slightly more than half (56%) of the learners were day boarders who came from the surrounding communities. Learners from urban areas used to interact with learners from rural schools through sports, music, and drama competitions. Learners also used to participate in community events like agricultural shows.

Learners had experiences of cultural events like the installation of chiefs, rain-making ceremonies and had also attended some funerals in the communities. The teachers used to accompany learners to these communities events, when learners would also assist with some work related to the activity. This enabled the majority of the learners to interact with elders in the communities and their associated indigenous artefacts. The learners displayed a rich indigenous cultural background and knowledge.

The backgrounds of the teachers and learners also indicate that they value the artefacts and their use, which implies that they would be eager to learn more about these IK artefacts and the physics embedded in them. This acceptance to learn from artefacts would also improve the validity and relevance of the study

The background of the elders indicated that if the artefacts were to be integrated into the teaching of physics, they would be available physically so that they could be brought into the physics classes and integrated in the instruction programs. The confirmation of their cultural background confirms that the elders held relevant ideas and information about the IK artefacts.

5.3 KNOWLEDGE THAT EMERGED FROM THE ELDERS, TEACHERS, AND LEARNERS

The responses to questionnaires, interviews and focus group discussions (Appendices B- I) with elders, teachers and learners together with the observations (Appendix J) made by the researcher, revealed several themes.

The themes that emerged from the findings from the exploratory study indicated that about 98 % of the participants in the three groups of respondents generally had:

- Indigenous artefacts in their homes,
- Knowledge about the artefacts,
- Skills on how to design, make and use the artefacts,
- Strong belief that artefacts are still useful and could be improved by learners and teachers in the schools.
- Artefacts can be used when teaching different indigenous concepts and skills.
- There are physics concepts embedded in IK artefacts.

- Strong belief that artefacts can be integrated in the teaching of school physics.
- Physics should be taught within learner‟s contexts and
- Made suggestions on how the integration of IK artefacts can be done in the teaching of Advanced Level Physics.

These emergent themes appeared to have a high level of dependability and trustworthness, since they became evident after considering information from multiple sources; that is, questionnaires, interviews, observations, and focus group discussions. The themes shown above also depended on rigorous theoretical triangulation to find out how well the findings addressed the research questions. Johnson (1997) defines theoretical triangulation as the process of reviewing interviewee responses to test the appropriateness for the theoretical explanations for the study. Triangulation involves a process whereby researchers search for convergence among multiple and different sources of information to form themes or categories in a study. It generally strengthens the findings from the study (Creswell & Miller, 2000).

The themes were described and excerpts from the individual interviews, focus group discussions, and questionnaires were inserted in with the descriptions to show how the themes had been arrived at. Excerpts were inserted in the descriptions of the themes to indicate how well the interviewees‟ view points; thoughts, feelings, intentions, and experiences were reflected in the analyzed data. An interviewee's personal interpretation was also included within the discussion process. Excerpts derived from data that had been recorded and transcribed (verbatim) were also included to ensure rigor and trustworthiness in the report. In the following section, the themes will be discussed.

5.3.1 Knowledge about the IK artefacts

Elders, teachers, and learners displayed an understanding of their indigenous artefacts and their origins. This is evident in a number of their responses as exemplified in the extract below

Extract from one of the elders:

Isu nevana vedu tine ruzivo chose pamusoro pemidziyo yedu yatinoshandisa (All the elders in the community together with our children have deep knowledge about all our artefacts). Ungatadza kuzviziva ugoita munhu here mwanangu. Wese abvazera anototi azive (Without this knowledge *you will not be a respectable member of the community, all the grown-ups have to know the artefacts).*

One of the elders during a focus group discussion stated categorically that.
Unototi uzive midziyo iyi nekuti ndiyo inoshandiswa pakuita mabasa anoraramisa mumisha medu .Vakuru vedu vanotidzidzisa (You have to know these artefacts, because we use them in our work, our elders teach us a lot about them).

These extracts imply that, the artefacts are still respected and valued in communities, so having knowledge of the artefacts would earn the person someone respect in the community. This increased my confidence in the validity of my research since it assured me that at least every learner at the schools in question would come with some valuable knowledge of indigenous artefacts. This also confirmed that I was looking at something that people would appreciate, benefit from, and use in their daily lives which were in agreement with insights from the Transformative Participatory research design that was adopted for the study discussed in Chapter 4.

5.3.2 Sources of information about and skills with IK artefacts

The participants in this study identified a number of sources of information about the indigenous artefacts. I had a keen interest in knowing the sources of information about the artefacts because I wanted to check whether the artefacts identified were indeed indigenous. Furthermore I wished to know whether the sources were reliable and could provide more information about the artefacts, should schools teachers decide integrated the artefacts into the teaching of physics in schools.
The sources that were identified were similar across the three groups of participants (teachers, learners and elders). Focus group discussions and subsequent interviews were held separately for the elders and teachers‟ groups.

A summary of the sources of information about IK artefacts is indicated in Table 5.1. The sources were revealed in the participants‟ responses to the questionnaires, focus group discussions, individual interviews, and observations made by the researcher (from Appendices B to I).

Table 5.1: Identified sources of information about IK artefacts

Source	Description
Story telling	Narration of events.
Rock paintings	Pictures of objects, animals etc. drawn on rocks. Some rock paintings were at Mazambara mountain, Chivavarira mountain and Gokomere (Mangwandi) mountain near Gatoramuzondo.
Elders	People who are above the school going age including the elderly living in a traditional manner in the community.
Revelations	The process of disclosing something previously kept secret in a dramatic or surprising way.
Proverbs	Short saying containing some commonplace fact.
Traditional games/songs	These are songs and games belonging to a particular country, people, family, or institution over a long period. These were handed down from generation to generation.
Archaeological sources	Sources related to the scientific analysis of the material remains or ancient of IK artefacts. Some excavations were done at Gokomere mountain.
Initiation and cultural Ceremonies	Ceremonies that are often secret, initiating young members into adulthood. This is no longer popular among the tribes in the area.
Old photographs	Old photographs showing indigenous artefacts

One source of information about the IK artefacts identified was a traditional game that children play (Shona: *mahumbwe*). This is a game where youth are allowed to stay away from home, usually in the fields during harvest, where they mimic family life. In this game, boys learn to provide for the family by mimicking the roles of the men in the communities. This would mean they engaged in activities that included the making and use of some of the IK artefacts.

In *mahumbwe*, girls would learn to cook and care for the children, and also enact the making and use of some IK artefacts associated with women. In the game, children visualize their future and are reminded that one day they will be adults of the community. The game allowed children to learn about and interact with the IK artefacts. However, the game is no longer popular among the communities in Masvingo district as the dawn of modern technology and the industrialization has led to people moving towards mainstream modern and western culture, which has seen a decline in this traditional practice.

A common response among the elders and teachers indicated that some knowledge of artefacts had been passed down to them from their ancestors; revealed indirectly through dreams and visions. They claimed that they have translated such visions and dreams into the physical objects. Other artefacts came into being intuitively or serendipitously by accident. Intuitive knowledge is the knowledge that a person finds within himself in a moment of insight or intuition. There is often a sudden eruption into consciousness of an idea or conclusion that was preceded by a long process of unconscious work. The knowledge is proposed and accepted on the strength of imaginative and creative vision or individual experience of the person proposing it. The insight may be a revelation of truth in the form of physics concepts embedded in the artefacts themselves.

Some people indicated that they had seen some of the artefacts on rock paintings on mountains in the area and in old photographs. They had then tried to copy the designs from these images and make similar artefacts. Some of the photographs that I was shown include those of clay pots (Figure 5.2 a) and rock paintings (Figures 5.2 b and c).

Figure 5.1a: Photograph of clay pots (Source: Photograph of an old photograph taken during an interview with an Elder)

Figure 5.1b: Photographs of rock painting (Source: Photograph taken on one of the mountains)

Figure 5.1c: Photographs of rock painting (Source: Photograph taken on one of the mountains)

Initiation and cultural ceremonies also emerged as sources of indigenous knowledge. Although the initiation practice is no longer popular, some elders indicated that they had got information about some artefacts when they had been involved in initiation programs. Participants also displayed knowledge about the environment in which they lived in terms of sources of raw materials for making the artefacts, on their design, how to make and use the artefacts and even equipment to use to make the artefacts.

When I visited the elders in Zimuto communal area, I found some of them working on some pieces of artefacts. They were using simple raw materials from their local environment. Although I could see that they were using very simple tools, there was evidence of special skills employed in the process, as shown in Figure 5.3. I observed that the designs, structures and shapes of the artefacts were not arbitrary, as the practitioners could explain and justify them both theoretically and practically. I could see that some physics concepts and theories were unconsciously being employed. This is evident in the following excerpt recorded when an old man was working on a mortar. He said:

Duri rinofanira kuva ne kuzasi kwakafara kuti risa dona.Kana rikadona rinoramba richikunguruka kusvika ratozotsigirwa nedombo. Kusi kudaro rinoramba richingo kukuruka (The mortar should have a broad base to be stable. If it topples over, it will continue to roll down until you stop it by putting a stone in its way).

In this excerpt, the old man unconsciously indicated the concepts on stability, centre of mass and equilibrium. The second part of his response indicates a deep understanding of Newton"s first law of motion (i.e., A body will continue in its state of rest or uniform motion in a straight line unless it is acted upon by an external resultant force).

Figure 5.2a: Old man carving an IK artefact (Photograph taken during interviews with some of IK specialists in the community elders)

Figure 5.2b: A woman making clay pots (Photograph taken during interviews with some of IK specialists in the community elders).

The participants also had knowledge about the uses of the artefacts and how some of the uses had changed over time. They also had information about the way in which this knowledge had been passed down to them by their elders; they also indicated how they would ensure their own children would acquire this indigenous information and skills.

Knowledge about the design and structure of the artefacts, even those that had since disappeared, was also shared by the participants. They revealed rich presentational and performance knowledge, which was deeply entrenched in their culture. Turnbull (1997) defines representational knowledge as knowledge that includes concepts, metaphors and conceptual schemes and associated worldviews used to describe and explain the world. Turnbull (1997) also defines performative knowledge as knowledge of what people can do to get results. The people had their own unique vocabulary when explaining concepts associated with their artefacts and when describing the artefacts. This is revealed in the following excerpt from one of the elders.

Guyo rinofanira kuva neman'aran'azha kuti rigokuya zvakanaka (guyo must have a rough surface for it to work well). Here, the Shona word "man‟aran‟azha" was used to refer to a rough surface that promote friction.

Those who made the artefacts also had some technical jargon, which was not familiar even to their fellow community members. One of the elders reasoned that it was their way of guarding their secrets from being known to all the people.

5.3.3 Skills on how to make and use IK artefacts

Practitioners of production of IK artefacts confirmed that they were involved in this activity using heritage knowledge from their ancestors, which they had acquired through an informal education system. The learning process involved observing the elders working on and using the artefacts. Learning was also through informal educational platforms such as village court discussions (*dare* or *legothla*) and through working with the elders in the production of the artefacts. *Dare* (village court) refers to a group of man gathered at an enclosed space in the village yard or a courtyard or an uncovered area shut in by the walls of a building or by different building or surrounded by bushes, in which men could relax or discuss social and economic matters concerning their community. The elders even indicated the moral, mythical, and social values associated with the production of the artefacts. The analysis of information on the sources of IK artefacts revealed that this information is readily available in the community. As such it can be tapped into and brought into the physics class as an integral part in the teaching and the learning process.

5.3.4 Sources of IK artefacts

All the participants indicated that there were many indigenous artefacts in their homes (Appendix J); some of which I saw when I went to interview an old man at his home. When I arrived, a number of IK artefacts were scattered in the yard, as shown in Figure 5.3. The IK artefacts in the photograph are among those that had already been identified by the participants.

Figure 5.3 IK artefacts in the yard of one of the community elders.

The IK artefacts had different uses, sizes, shapes, and designs. The participants indicated sources of the artefacts, which are in Table 5.2.

Table 5.2: Sources of the indigenous artefacts

Source	Description
Inheritance	Receiving something from a predecessor
Buying	Those who could not make artefacts bought them from other community members.
Designingand Making	Most of the people could make artefacts for themselves using simple, locally available materials.
Archaeological Sources	Some people got the artefacts from ancient settlements and abandoned settlements.
Gifts	Some claimed that they had been given some pieces of artefacts by friends and relatives.
Souvenirs	Some got the artefacts from places that they had visited

It was clear from the responses of the participants that the knowledge and skills that they displayed and were acquired over a lengthy period of time, through experience, and had been tested in practical life situations.

5.4 SOME OF THE IDENTIFIED IK ARTEFACTS AND MECHANICS CONCEPTS EMBEDDED IN THEM

Participants identified IK artefacts and described their designs, structures, and use in a way that revealed mechanics concepts that were richly embedded in them. The participants also demonstrated how they teach each other about the structure and design of the artefacts. They suggested effective ways in which the artefacts could be used to teach the associated mechanics concepts.

Responses that suggested this came from one of the elders, when he said "Kana tichivadzisa tinovarega vachiitoita zvekutogadzira chinhu chacho, Kutaura kwega nekuvaratidza hazvina kukwana." This translates as "We teach them through making them make the artefacts,showing the learners artefacts and explanations only are not effective enough." This excerpt indicates that the elders also recommend some teaching methods and approaches which they have seen to be effective when teaching about the artefacts.

During the focus group discussion with the teachers, we managed to list some of the mechanics concepts embedded in some of the identified IK artefacts and these were revealed during the interviews and observations. The identified artefacts included: the round hut, mortar and pestle (*duri nemutswi*), bow and arrow (*uta nemuseve*), *Sengende*, grinding stone (*guyo*), yoke (*joko*), clay pot (*hari*). These are discussed in detail in the following sections.

5.4.1 The Round Hut

Figure 5.4(a) Traditional hut at an elder‟s homestead. (Source: Researcher‟s Photograph)

The round hut shown in Figure 5.4(a) is one of the IK artefacts in which numerous mechanics concepts are embedded, but these concepts needed to be made explicit. Almost every household in Zimuto communal area has a round hut. Some of the round huts are made of bricks and others of poles and mud (*daga*). Although people may take its construction, design and structure for granted, the design, nevertheless, ensures that the structure is in mechanical equilibrium all the time. The structure must not accelerate so it must have zero resultant force and zero torque acting on it always, otherwise the shearing effects of winds could damage the hut.

The shape of the roof should ensure that the wind load (the force on a structure arising from the impact of wind on it) and the weight of the roof materials cannot at any given time exceed the force that the building can withstand. Mechanics concepts such as equilibrium, wind load, weight, and geometry (shape) can be identified and discussed, as shown below.

5.4.1.1 The traditional pole and mud (daga) round hut

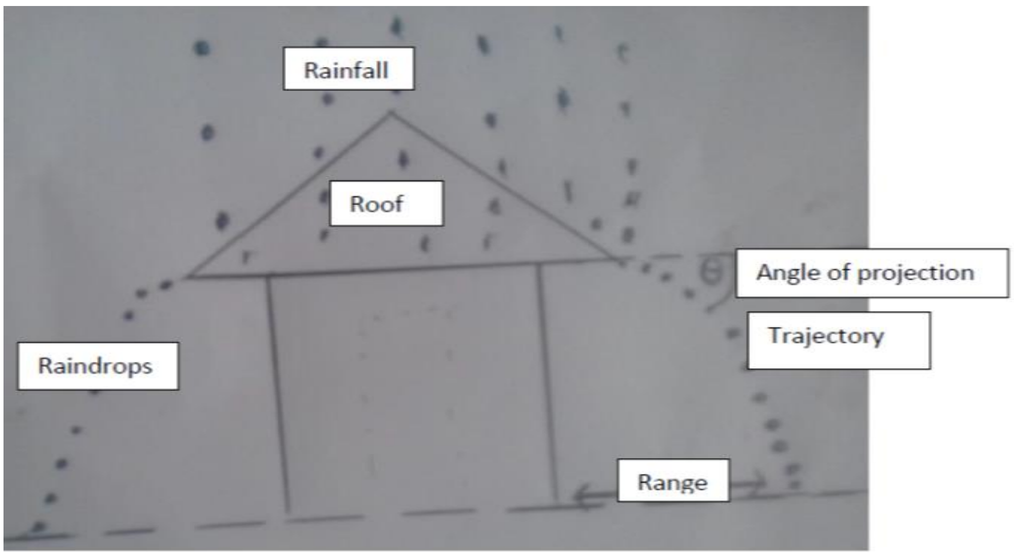

Figure 5.4(b). The traditional pole and daga round hut

The roof is designed in such a way that when it is raining, raindrops are projected from the edge of the roof and fall away from the walls of the hut as shown in Figure 5.4b. This is important, firstly, to prevent the rain from making the pole and *daga* wall wet and so collapsing. In addition the ground around the hut should stay dry; if it became wet it could result in mould growth and illnesses. Projectile motion and its features like the trajectory, angle of projection and the range can be demonstrated by the movement of raindrops from the roof to the ground as shown in Figure 5.4b. The concepts include projectile motion, fluid mechanics, stability, and instability. The design of the pole and daga round huts can be found to have some mechanics demonstrated below.

5.4.1.2 Fluid Mechanics

The other, more advanced, concepts that could be taught are related to fluid mechanics, such as the non-viscous fluid flow of the wind in Figure 5.4 (c), which is explained below.

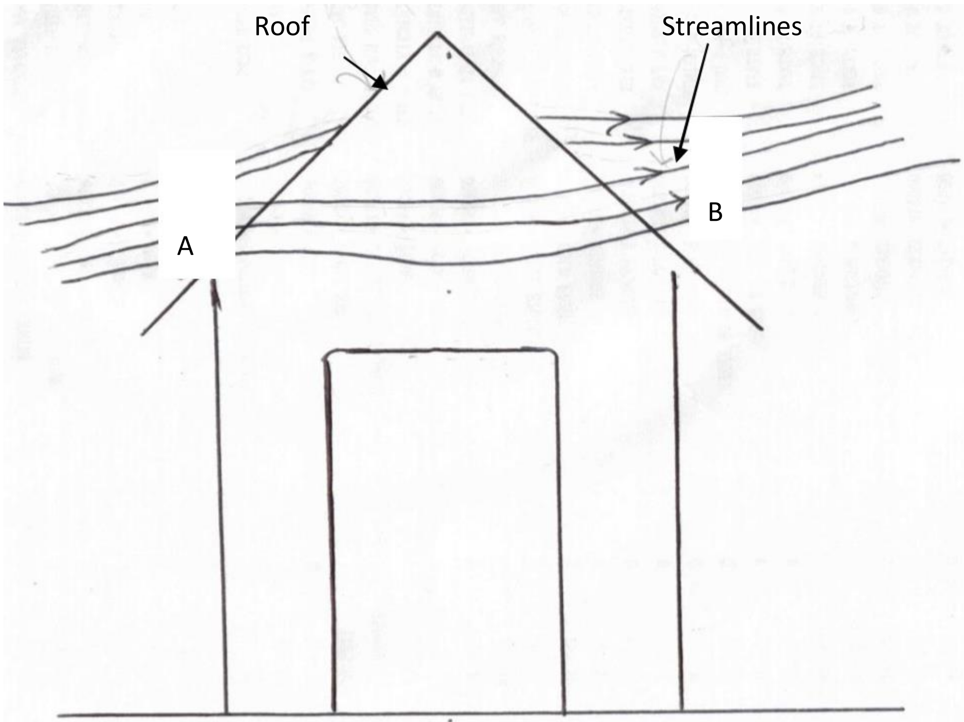

Figure 5.4(c): The flow of air round the roof of a round hut

It must be noted from Figure 5.4 (c) that each line of the air stream follows a smooth path and they do not cross. Therefore, there is laminar flow. There is no turbulence occurring at B, which could lead to the collapse or disturbance of the thatched structure. Hence, through this example, concepts such as fluid flow, laminar flow, viscous, and stream can be taught to physics learners. More advance fluid dynamics concepts could be obtained from observations of the stream of air flowing across the roof, which causes a reduction in pressure on the roof. This is because of the conical shape of the roof, which causes the air speed around the roof to be higher than that of the air in the surrounding area. According to Bernoulli"s principle, where there is high speed of a flowing fluid (wind), there is low pressure. When the roof is properly designed the pressure underneath the roof will be balancing the downward pressure on the roof.

Indigenous hut designers and builders in the area would make sure that the shape and angle of roof would be such that the strongest winds in the area would produce a pressure decrease on the roof that would allow for balancing of the pressure underneath the roof. If the roof is poorly designed, then the normal pressure underneath the roof would not balance the pressure on the roof, which could cause the roof to be lifted and hence be a danger.

5.4.1.3 Equilibrium and stability of the Hut

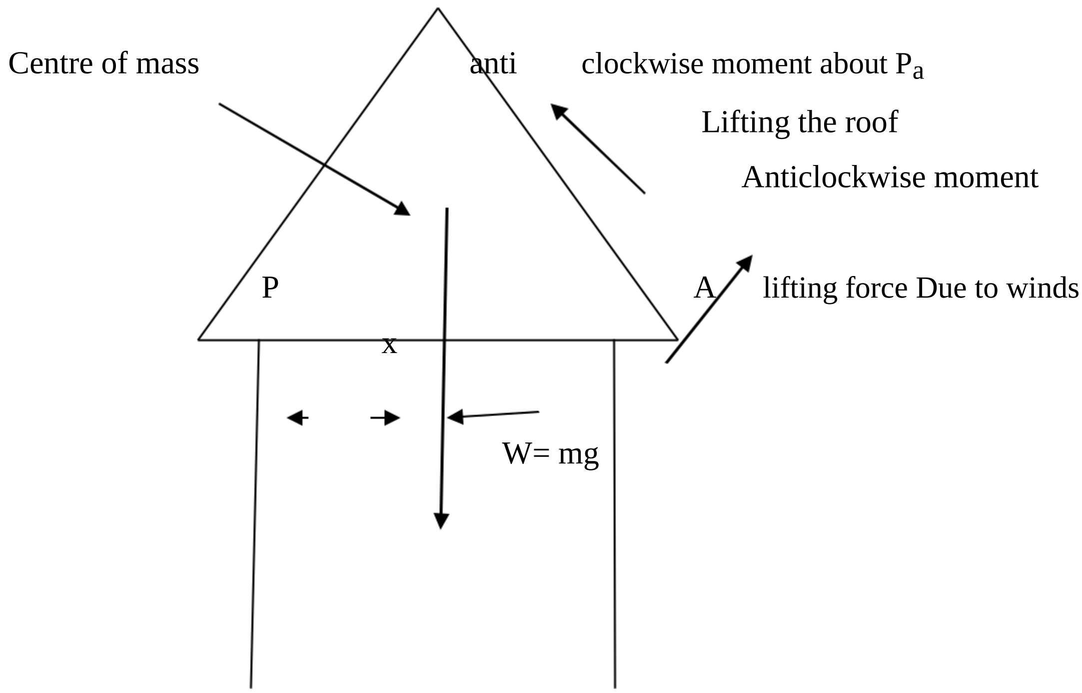

Figure 5.4 (d). Forces acting on a round pole and *daga* hut

In terms of statics and laws of moments and equilibrium, if the uplifting force acts on region A as shown, then P becomes the pivot or fulcrum. The anticlockwise moment (will then tend to rotate the roof, lifting it from end A using P as pivot.

Where the lift is force due to the wind and x is the perpendicular distance of the force from the pivot. However, the weight, $W = mg$, exerts a clockwise moment about P, tending to pull the roof downwards, as long as the centre of gravity remains above and not outside the base of the roof. The vertical line through the Centre of mass passes through a point within the bases of the roof

5.4.2 Mortar and Pestle

The mortar and pestle is an ancient and common tool used across cultures worldwide. In Zimbabwe it is used mainly for food preparation, in crushing or grinding ingredients.

The mortar (*duri*) is a strong vessel, commonly in form of an inverted bell, in which substances are pounded or rubbed with a pestle (*mutswi*), which is a heavy and blunt club shaped tool (see Figure 5.6 a). The Shona words, *mutwiwa* or *duure* refer to the meal ground in the duri.

Figure 5.5a: Mortar and Pestle (d*uri nemutswi*) (Source: Own field photograph)

Mechanics concepts illustrated by this IK artefact include those of centre of mass, stability, centre of gravity and torque. The structure of the mortar (*duri*) can be used in a demonstration to show the relationship between the position of the centre of mass and stability of an object (see Figure 5.5b). The lower part of the mortar (*duri*) is made heavier, which makes the centre of mass lower, which improves the stability of the mortar. A physics teacher could perform demonstrations and investigations with mortars of different sizes and shapes with centres of mass at different points or heights to demonstrate the concept of centre of mass or centre of gravity.

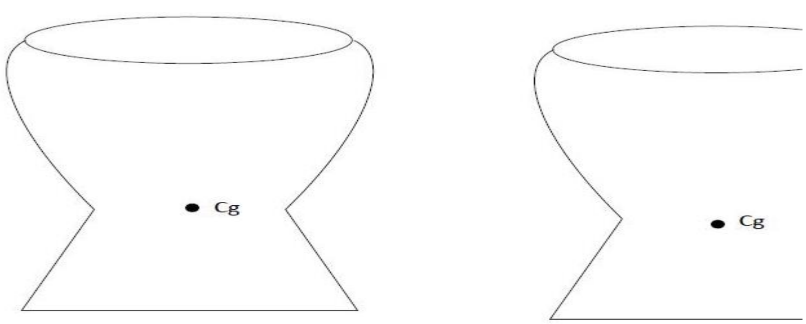

Figure 5.5 b: Mortar demonstrating position of Centre of Gravity

In physics, the position of the centre of mass (CoM) relates to the stability of on object or artefact. The effect of shift of CoM can be demonstrated using mortars, which are familiar to indigenous learners, instead of conventional laboratory apparatus. When the mortar is tilted so that the centre of gravity goes over its base, the mortar will topple. The conical shape improves stability since it ensures that the centre of mass lies within the base of the mortar.

The concept of torque can also be demonstrated using the mortar**.** The hollow part of the mortar has to be at the middle, and pounding should be done through the centreline, otherwise the mortar will topple over. This demonstration shows that force applied through the centre of gravity of a system or object does not produce a turning effect.

The relationship between pressure and area can also be demonstrated with this artefact. The tapered end of the mortar allows the tapered end of the pestle to act on a very small area, thereby increasing the pressure.

Applying the above formula, if area is reduced, this will make the pounding (force exerted on pestle) easier since less effort will be required for a certain value of pressure.

5.4.3 Clay pots

Clay pots are ancient containers and often shaped as oval pots, as shown in Figure 5.6 (a). They are made of clay which is usually found locally. The pots are hardened by baking them to red hot in a pit furnace using cow dung as fuel. Clay pots have domestic uses, such as fetching water, storing drinking water and traditional beer and also for cooking.

Figure 5.6 (a): Clay pots (*hari*) (Source: Own field photograph)

There are a number of scientific concepts that can be taught when making and using clay pots. Properties of clay pots and techniques employed when using them that are normally taken for granted in everyday experiences of the learners can be used to demonstrate and explain some concepts in mechanics like center of gravity (CG) and types of equilibrium.

5.4.3.1 Demonstration of unstable equilibrium

A system in unstable equilibrium accelerates away from the equilibrium position if displaced even with slight displacement. A clay pot resting on the floor is in unstable equilibrium (Figure 5.6 b). The net force acting on the clay pot is zero and the total toque about any point is zero. The center of gravity (CG) of the clay pot is directly above the pivot point and the base of support. A slight displacement can cause it to fall and move away from its position.

Figure 5,6b Clay pot in unstable equilibrium state (Source: Sketch diagrams from Focus group discussion with teachers)

However if the clay pot is slightly displaced (pushed out of equilibrium state), the CG will no longer be directly above the base of support (Figure 5.6c).

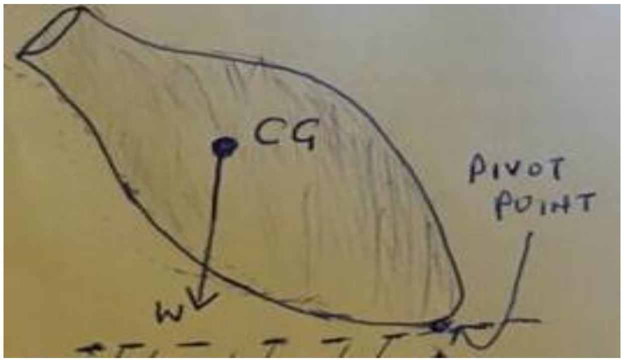

Figure 5.6c Displaced clay pot (Initially in unstable equilibrium state) (Source:Sketch diagrams from Focus group discussion with teachers)

A torque is created by its weight in the same direction as the displacement causing an increase in the displacement

5.4.3.2 Demonstration of Metastable equilibrium state

A system in metastable state can be pushed and pass a tipping point but remains in a stable state. The techniques employed when using the clay pot may also be used to explain and demonstrate metastable state (Figure5.6d).

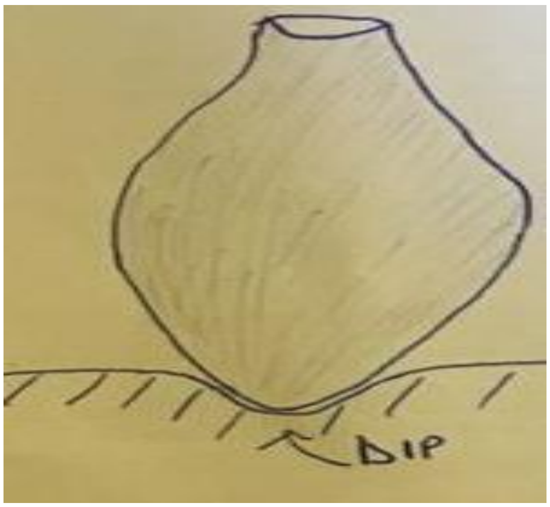

Figure 5.6d Clay pot in metastable equilibrium state (Source: Sketch diagrams from Focus group discussion with teachers)

The peak at the edge of the dip is analogous to the tipping point for the clay pot and if the clay pot is pushed beyond this point it will not be able to move back to the equilibrium position. This can also be explained and demonstrated using a situation where a kata/coil (hata in shona) is placed atop one‟s head when carrying a clay pot (Figure 5.6e) or when a clay pot with beer is placed in a dip especially during a village court (dare) or at a rain making ceremony.

Figure 5.6e Woman carrying a Clay pot with a kata (in metastable equilibrium state).

(Source: Photograph observed in the field)

A kata/coil (hata) is a small rolled up cloth placed atop the head by a person carrying an object like a clay pot to help provide comfort and balance, leading to a graceful walk.

5.4.3.2 Oval shape of clay pot

The oval shape allows the clay pot to have a large volume while the keeping the CG low.

Figure 5.6f Clay pot with oval shape

This also gives a lager base of support and greater the stability for the clay

5.4.4. Bow and Arrow (Uta neMuseve)

Bow and arrow is a weapon consisting of a stave made of wood bent and held in tension by a string. The arrow is a thin wooden shaft with a feathered tail. The arrow is fitted to the string by a notch in the end of the shaft and is drawn back until sufficient tension is produced in the bow so that when released it will propel the arrow. Arrowheads are made of shaped stone or metal and other hard materials. Archaeologists believe hunters used bows and arrows as early as 50,000 years ago (Paterson, 1984). Indigenous people used such weapons in every part of the world except Australia. In addition to hunting and warfare, bows and arrows were used for sport in ancient cultures.

Figure 5.7 (a): Indigenous Bows and Arrows

Figure 5.7 (b): A boy using an indigenous bow and arrow (Source: Own field photograph)

The artefacts, bow and arrows, as shown in Figures 5.7 (a) and 5.7 (b), have embedded physics concepts within projectile motion, for example, trajectory, maximum angle of projection for maximum range, and time of flight. These can be understood better by indigenous learners when this IK artefact is used as a teaching aid, than when foreign sports are used for examples baseball, basketball or tennis and are so often cited in the recommended imported textbooks.

Concepts like conversion from potential to kinetic energy are also embedded in this IK artefact. The bow has the Elastic potential, in its taught string. When released, the string Elastic potential energy is converted to Kinetic energy (the string moves) and then has an impulse force on the arrow, giving it kinetic energy.

This can be used as a familiar learning aid to explain physics concepts to indigenous learners. When the bow shoots an arrow, the string pushes the arrow forward and the arrow pushes the string backwards. Thus, Newton‟s third law and associated concepts can also be demonstrated successfully with the bow and arrow. The law states that action and reaction are always equal and in opposite directions. The law can also be stated as „if body A exerts a force on body B, body B will exert an equal but opposite force on A‟. In the situation of the bow and arrow, the string of the bow will exert a force on the arrow and the arrow will exert an equal and opposite force on the string.

Other concepts such as elasticity and elastic deformation can be demonstrated by stretching the string and releasing it. The string will return to its original shape and length when the stretching force is removed. The string of the bow will eventually break as a result of „fatigue‟ if it is used repeatedly for a long time. Fatigue is failure of a material when it is subjected to cyclic stress that, individually, is not sufficient to cause immediate failure.

This concept can be demonstrated in class as well.

5.4.5 Grinding Stone (Guyo)

A grinding stone or *Guyo* (Figure 5.8 a) is a large piece of rock on which dried maize grains are ground into mealie meal using a small top stone called the muller (huyo). It is also an ancient artefact, having been in use for over 30 000 years.

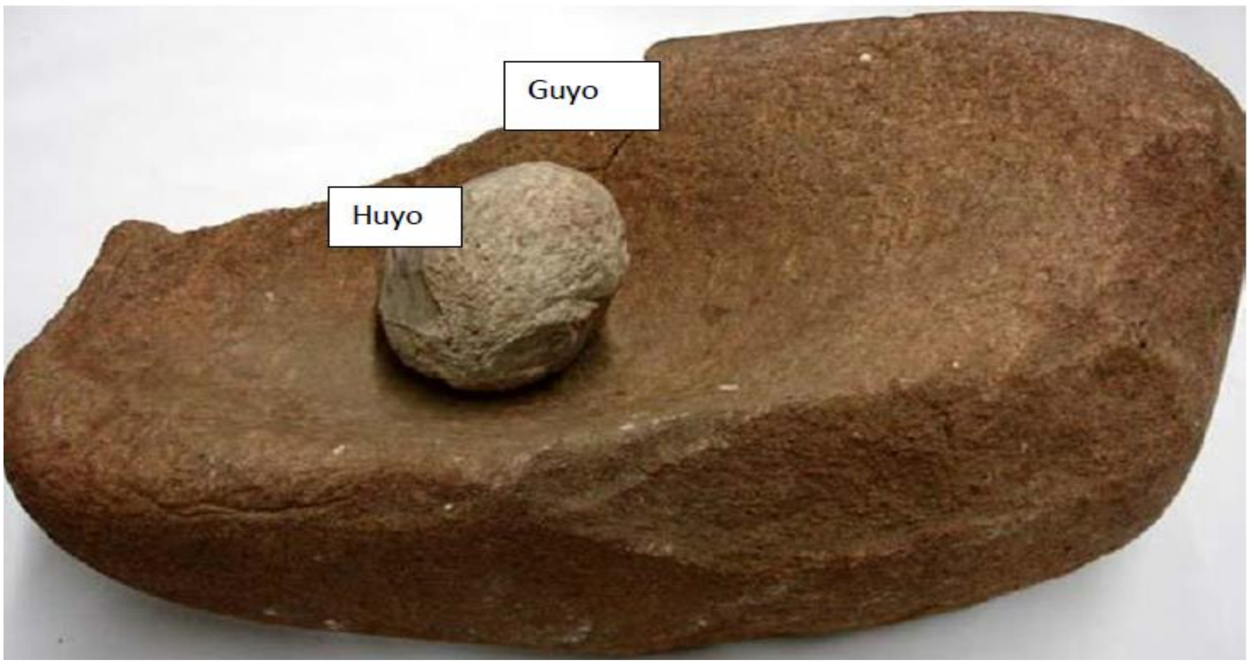

Figure 5.8 (a): Grinding Stone (*Guyo*) (Source: photograph observed in the field)

The muller or upper grinding stone is pressed down on the lower grinding stone, making it slide down, grinding the grains in the process.

Several topics areas and concepts that can be taught using this artefact as indicated in the following sections.

5.4.5.1 Static Friction

Limiting or static friction and its effect can be illustrated with a grinding stone, which is an artefact that is commonly available in learners" homes. Static friction is the resistive force that keeps an object at rest. This can be demonstrated by the letting the upper grinding stone rest on the grinding stone. Limiting friction is the force needed to overcome the frictional force when bodies are at rest.

Teachers could demonstrate the sources of friction. They could show that when two surfaces are placed together, they are not in contact over the whole surface area; instead they only touch at some parts of their actual surface. At the points of contact, the surfaces are actually chemically „welded‟ together and it requires energy to break the welds. In addition, at the points of contact there are electrostatic forces due to intermolecular attraction and repulsive forces. The motion of the top stone (*huyo*) over the grinding stone is a „stick-slip‟ movement: that is, the small projections of seeds or grinding material have to be broken as the upper grinding stone moves (Figure 5.8b). Due to continuous movement and abrasion, the grinding stones develop smooth surfaces, reducing further sliding and rolling friction. Rolling friction is resistance to motion by bodies that are in rolling contact to avoid slippage. Sliding friction is the friction between bodies which are in sliding contact.

Figure 5.8 (b): A person using *Guyo (Source: photograph observed in the field)*

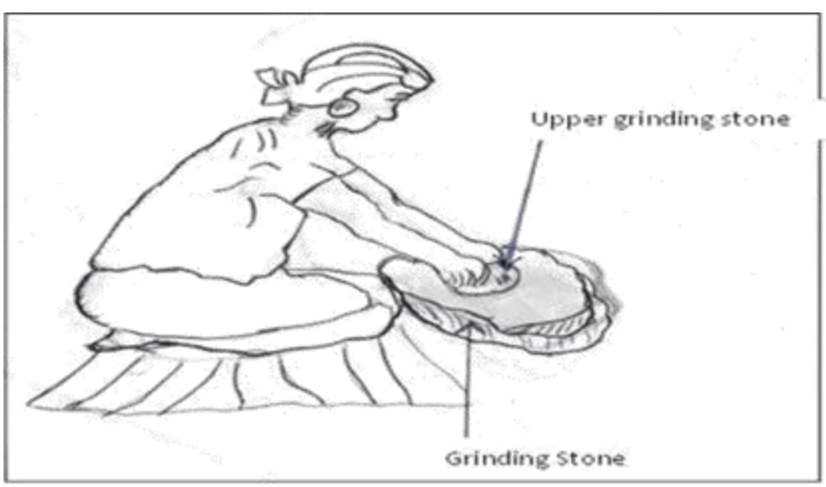

Figure 5.8 (c): A person using *Guyo(Source: questionnaire response sketch diagrams)*

The grinding process illustrates the useful application of frictional force. The negative effects of friction can also be seen in the smoothening of the grinding stone surface and the reduction in size of both lower and upper grinding stones over time with constant use. This observation indicates that friction leads to wearing away of objects. By observing that both the upper and lower grinding stones become warmer during use, can lead learners to conclude that friction can cause the objects in contact to heat up. This heating effect of friction can be demonstrated in class.

5.4.5.2 Forces acting on a body on an inclined plane

Forces on an inclined plane can also be demonstrated in class using the grinding stones as an incline (Figure 5.8 d), and taught using vectors mathematics. For example, a force is a vector quantity that has magnitude and direction. When the upper grinding stone is sliding or resting on the grinding stone, the free-body vector diagram would be as shown below in Figure 5.8(d)

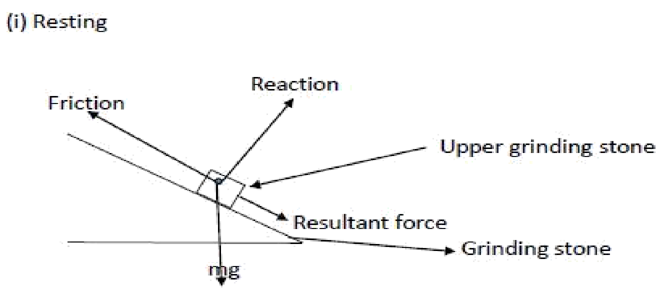

Figure 5.8 d: Forces acting when the upper stone is resting or sliding on the grinding stone

5.4.5.3 Work done by weight of a body moving down an inclined plane

Concepts such as mechanical work done can also be taught using the grinding stone. The lower grinding stone acts as the incline to demonstrate how to calculate the work done by the weight of the upper stone which is sliding down the plane.

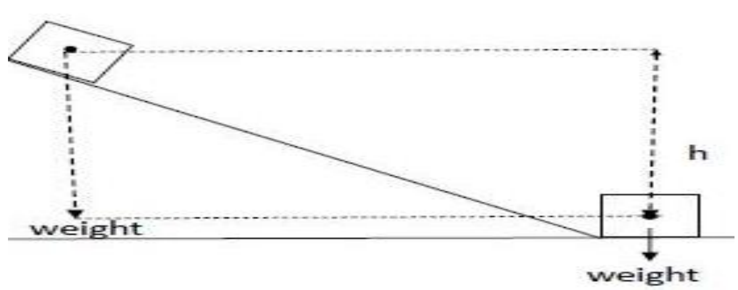

Figure 5.8 e: Work done by weight of a body moving down an inclined plane

As can be illustrated by the movement of the top grinding stone down the grinding stone in Figure 5.8(e), teachers can show how precise the definition of work is:

When a force moves its point of application, the work done by the force is given by the magnitude of the force multiplied by the distance moved in the direction of the force. In this case, the weight is the force that pulls the upper grinding stone *vertically downwards* a distance *h* (perpendicular distance) and this is the distance which is used to measure work.

Therefore *Work* (*W*) = *Force* X *displacement* = *Weight* X *h*

5.4.6 Swing (Dhaya)

A swing is a wooden seat hanging by two ropes from the branch of a tree. You can sit on the seat and move forwards and backwards through the air (Figure 5.10).

Figure 5.9: A Child on a swing (*dhaya*) [own picture-faces covered]

The discussion with teachers revealed that the topics and concepts that can be taught with the aid of the swing are pendulums and conservation of mechanical energy (Figure 5.10). To elaborate, in essence a pendulum is a point mass on a light, inelastic string. In such a case, aspects of the restoring force and the direction of the force, and angular displacement can be demonstrated. Aspects of simple harmonic motion (SHM) can also be demonstrated by changing the angle of initial displacement and making oscillations of small amplitude. Energy changes in SHM can also be demonstrated, such as the interchange between potential and kinetic energy (see Figure 5.10, swing at different positions).

The teachers added that properties of oscillations such as frequency, period, amplitude, variation of velocity and acceleration with displacement can also be demonstrated and discussed using a swing. Free and damped oscillations can also be demonstrated. On the one hand, free oscillations are to and fro movements in which the only external force acting on a particle is the restoring force; with no other forces to dissipate the energy the oscillations have constant amplitude. A person swinging passively can be taken as an example of free oscillation. On the other hand, damped oscillations have the total energy of the oscillator decreasing with time. The types of damped oscillations (heavy, light, and critical) can be also demonstrated. Other deeper concepts such as forced vibrations and resonance can also be demonstrated. If a person pulls or pushes the swing periodically there will be forced oscillations. Resonance occurs when the natural frequency of vibration of an object is equal to the driving frequency, giving maximum amplitude of vibration. Thus, if you push a child on a swing with the same frequency as the natural frequency of the swing, the amplitude of motion increases. Examples such as this, which are within the home experiences of the indigenous learners may bring the concept of resonance closer to them than would examples often found in recommended textbooks such as a soprano singer shattering a wine glass, and aircraft wing.

5.4.7 Winnowing basket (Rusero)

A basket used in wind winnowing which is an agricultural method developed by ancient indigenous cultures for separating rice or grain from chaff after threshing. The method can also be used to remove pests from stored grain in grain preparation. In its simplest form wind winnowing involves throwing the mixture into the air using the basket so that the wind blows away the lighter chaff, while the heavier grains fall back down for recovery.

Figure 5.10a: A winnowing basket (Source: Own field photograph)

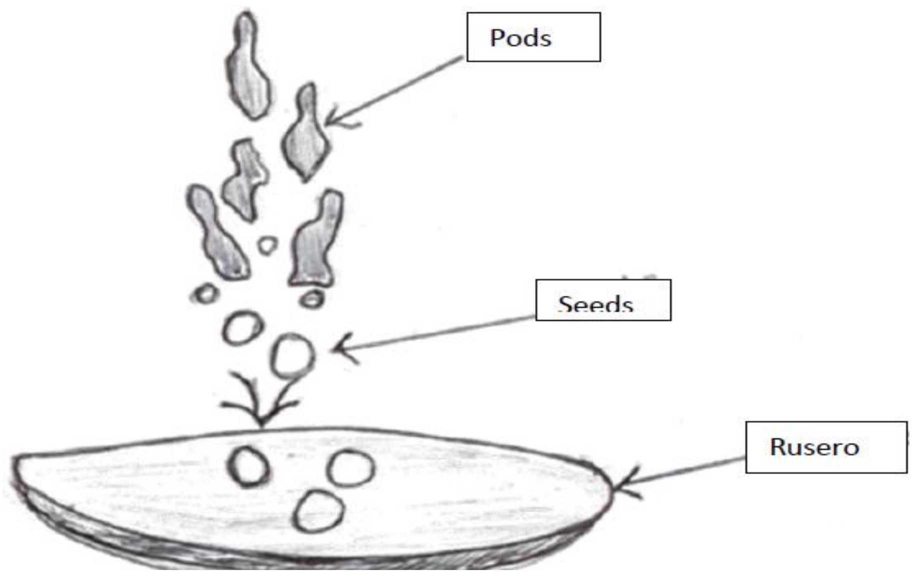

Figure 5.10b: A mixture of pods and seeds being separated using a winnowing basket

When a winnowing basket is used, a mixture of pods and seeds are thrown upwards into the air. Air is then blown across the falling mixture and pods are blown away while the seeds fall back into the basket. This happens because the seeds are heavier than the pods so their inertia is larger than that of the pods. This is illustrated in Figure…

Related topics include the following

1. Vectors

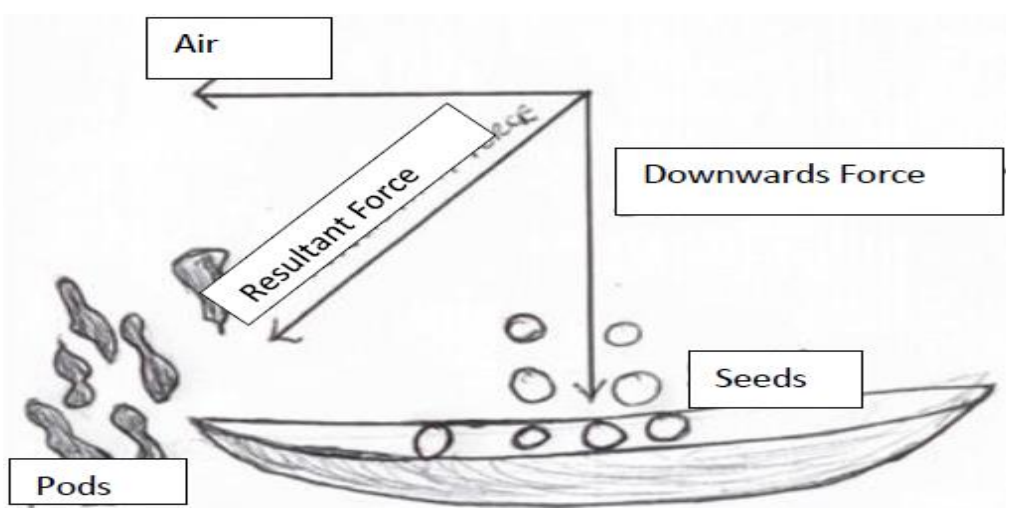

Figure 5.10 (c): Forces acting on pods and seeds and the resultant force

As shown in Figure 5.10 (c), the weight and the force of blown air are force vectors. The resultant vector indicates the direction and magnitude of the resultant force on the seeds and pods and can be determined in physics by the parallelogram method.

Terminal velocity

The seeds and the pods are separated due to their having different speeds downwards and different terminal velocities. Terminal velocity is the maximum constant velocity that a body can attain when falling through a fluid. Heavy objects have a higher terminal velocity than light objects because it takes a larger air resistance force to equal the weight of a heavier object. A larger air resistance force requires more speed. Therefore, heavier objects will fall faster in air than lighter objects. When using the winnowing basket, the pods reach their terminal velocity before the seeds because they are lighter and the seeds will have a higher terminal velocity as they are heavier.

Effective gravitational force is equal to weight minus Upthrust

Generally for a sphere of radius r and velocity v and ρ is the density of the liquid

$F = 6\pi r\eta v \qquad (\text{Stoke's law})$

$6\pi r\eta v = 4\pi r^3 \div 3\ (\rho - 5)g$

$v = 2gr^2(\rho - 5) \div 9\eta$

Where ρ is the density of the material pods/seeds

From the formula $v = 2gr^2(\rho - 5) \div 9\eta$, it is clear that viscous or frictional drag is smaller on material with a higher density (seeds) than on material with less density (pods).

5.4.8 Yoke (Joki)

A yoke (Joki) is a wooden beam normally used between a pair of oxen or other animals to enable them to pull together on a load when working in pairs (Figure 5.11a).

Figure 5.11 (a): Yoke (*Joki*) (Source: Own field photograph)

The yoke (*joki*) is an indigenous artefact, which incorporates the physics topics of moments of forces, couples, and torque.

Torque or moment is a twisting or turning force that tends to cause rotation or torsion about a centre of mass or a fixed point. The forces cause a system to turn in a circle or prevent it from turning. If there are two parallel forces acting in opposite directions which do not share a line of action they will produce a moment about a fixed point. This concept can be demonstrated or explained using Figure 5.13b.

Figure 5.11 b: Demonstration of Torque (Source: On field photograph)

The two forces produced by the oxen in the photo act in opposite direction and produce a turning effect moment about the middle point of the yoke.If the two parallel forces are equal they form a couple which can also be demonstrated using a yoke. A couple refers to two parallel forces that are equal in magnitude, opposite in direction which do not share a line of action. They produce or prevent a rotation without acceleration of the canter of mass of the system. This can be demonstrated or explained using the situation that is found when using oxen-drawn ploughs when ploughing the fields (Figure 5.11c)

Figure 5.11 c: Demonstration of couple, Torque and moment of a couple (Source: field photograph)

The two equal forces produced by the oxen pushing the yoke produce a couple that prevent the yoke from rotating about the centre of the yoke.

5.4.9 Catapult (Rekeni)

A catapult is a device for shooting small stones (Figure 5.12). It is made of a Y-shaped stick with a piece of elastic tied between the two top parts as shown in Figure 5.12a. It is used for hunting

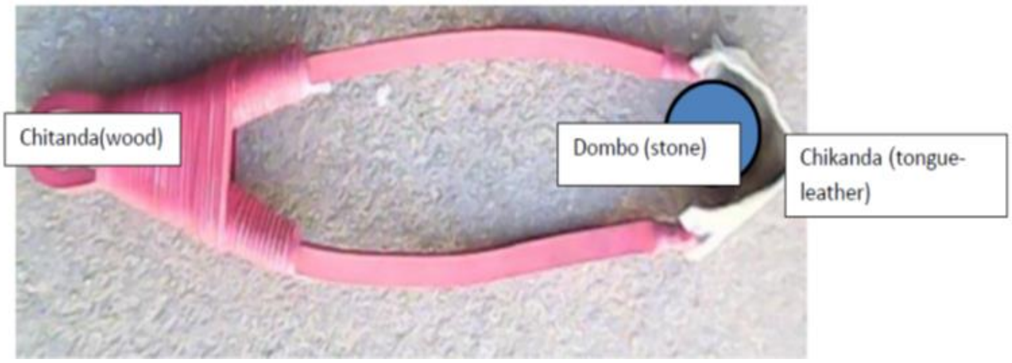

Figure 5.12a : Catapult (Source: Own field photograph)

The catapult also has number of concepts in physics embedded in its operation. Two identical strips of rubber are tied to a strong fork like piece of wood (*chitanda*). The two rubber strips are then tied to a piece of leather or tongue (*chikanda*) in which a round stone (*domb*), which will be used for shooting, will be loaded. When shooting, the loaded catapult is stretched and then released as shown on the diagram in Figure 5.12b. The following concepts can be covered in physics using a catapult.

1) Elasticity

A catapult can be used to demonstrate elastic deformation in the physics topic of elasticity. To demonstrate this, the catapult is stretched and released. Learners could investigate the effect different elastic materials on the propulsion of the stone placed in the tongue of the catapult.

2) Energy Changes

The catapult can also be used to demonstrate energy changes. For example, a stretched catapult has elastic potential energy. When released the elastic potential energy changes to kinetic energy and sound energy (Figure 5.12b).

Figure 5.12 b Demonstration of energy conversion using a catapult

The sequence of energy changes is:

Chemical (in your hand muscles) → kinetic (pulling the elastic back) → potential (holding elastic back) → kinetic (releasing the elastic)

3) Nature of materials

A catapult can also be used to demonstrate that a polymeric material can undergo a larger strain than can a crystalline material before failure. The explanation for this, being that the long polymeric molecules can become stretched so that they lie parallel to one another. The thinning of thick rubber strips when stretched can be used to demonstrate the effects of the new parallel arrangement of molecules.

4) Young‟s Modulus

A catapult can also be used to determine the characteristic curves (force versus extension graphs) for polymeric materials and so determine Young‟s modules for these materials.This can be an interesting experiment for learners as discussed below.

The catapult is stretched by loading it with stones of different masses. A force extension graph is plotted for both loading and unloading.

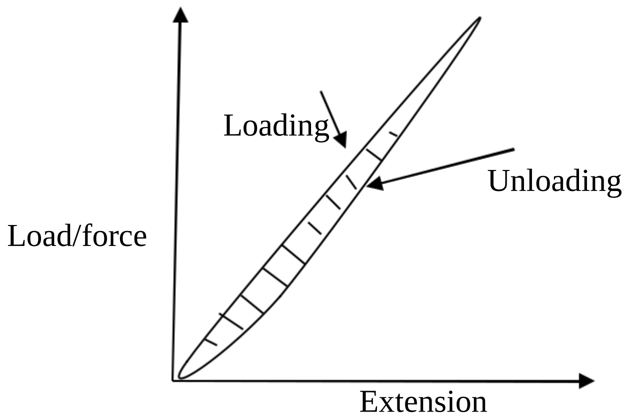

Figure 5.12.c: Force extension graphs for loading and unloading catapult

5) Elastic Hysteresis

Another concept that can be taught through a catapult is elastic hysteresis, as is demonstrated in the Figure 5.12 c. Elastic hysteresis is a feature observed when the unloading curve does not coincide with the loading curve. The graphs so drawn can be used to demonstrate how the work done in loading a rubber band can be determined. Generally, $W = F \text{ x } D$. Hence, it is the area under the curve in Figure 5.12 c. Elastic potential energy is equal to the area under the unloading curve. The difference in areas under the two curves; that is, the area between the curves is the increase in internal energy which explains the rise in temperature of stretched rubber.

6) Projectile Motion

Projectile motion can also be demonstrated as shown in the diagram below.

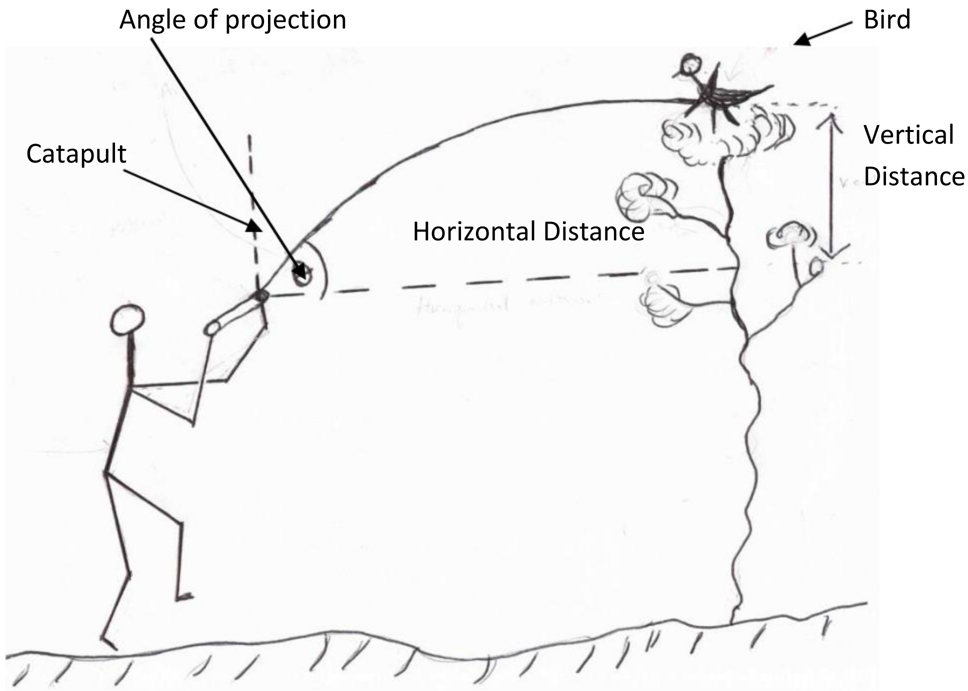

Figure 5.12d: Demonstration of projectile motion (Sketch diagram from questionnaire responses).

When shooting using catapult, the stone is normally released at an angle to the horizontal. The trajectory can be visualized clearly in Figure 5.12 d. Both vertical and horizontal motions can be seen. The effects of the angle of projection on the range can be demonstrated and explored by learners by shooting the stone from a variety of angles above the horizontal and noting the ranges reached by of the stones. Relative motion can also be explained using the idea of shooting a flying bird; although I do not recommend shooting birds, this would be thought experiement! The hunter has to release the stone with an appropriate velocity relative to that of the flying bird for him to hit it. The concepts taught or learnt in projectile motion include the two dimensional character of this type of motion, the range, velocity of projection and displacement.

5.4.10 Sharp tools (Knives)

Spears and knives are used to pierce and remove the skin of animals, respectively. The tips of the two tools have very small cross-sectional areas. The physics involved is pressure and surface area. The small cross-sectional area allows a small force to produces a large pressure such that during piercing or skinning, the skin of animals breaks away easily.

5.4.11 Children's Game of Stones (Nhodo)

Nhodo is a game similar to the western game of „jacks". In the game, small stones are snatched up before catching the large spherical piece in the same game (Figure 5.13a).

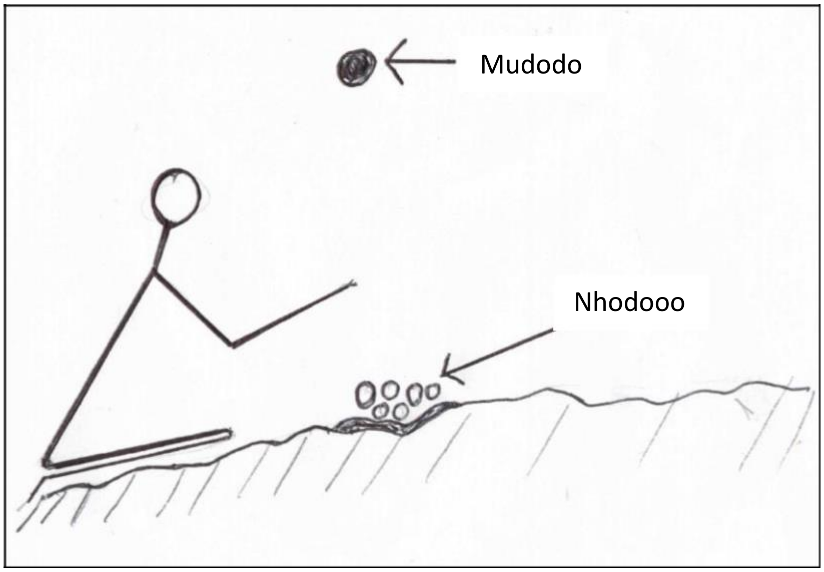

Figure 5.13 a: A person playing with stones (*nhodo*)(Source: sketch diagram from field notes)

The spherical piece or stone thrown upwards is called *mudodo* and the smaller stones being snatched are called *nhodo*.

Physics concepts which can be taught using nhodo include the following:

1) Kinematics and Dynamics

Motion of objects thrown upwards can be demonstrated using the large stone (*mudodo*).

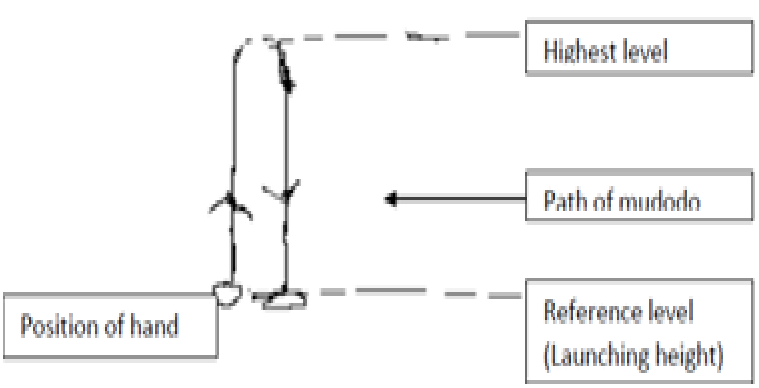

Figure 5.13 b: Path followed by stone (*mudodo*)

The changes in displacement, distance, speed, velocity, and acceleration can be demonstrated. The path followed can be used when sketching the graphs of the motion.

The interchanges of potential energy and kinetic energy can also be demonstrated. The *mudodo* has highest potential energy and zero speed at maximum height, with maximum kinetic energy and zero potential energy at lowest height. The motion of the *mudodo* can be used to demonstrate that in a gravitational field, which is conservative, the work done in taking a body round a closed path is zero. The work done by the *mudodo* when moving from the hand to its highest level is given by the formula $Wp = mgh$. The work done by the *mudodo* when moving from the highest level back to the hand is given by the formula $Wp = - mgh$. Hence the total or net work done is equal to zero.

A falling *mudodo* can be used to demonstrate forces acting on a falling object and Stoke"s law (Figure 5.13 c). This can help learners to understand concepts better than explaining falling billiard balls, which may not be familiar, even to the teacher. The diagram below shows the forces acting on a falling *mudodo*.

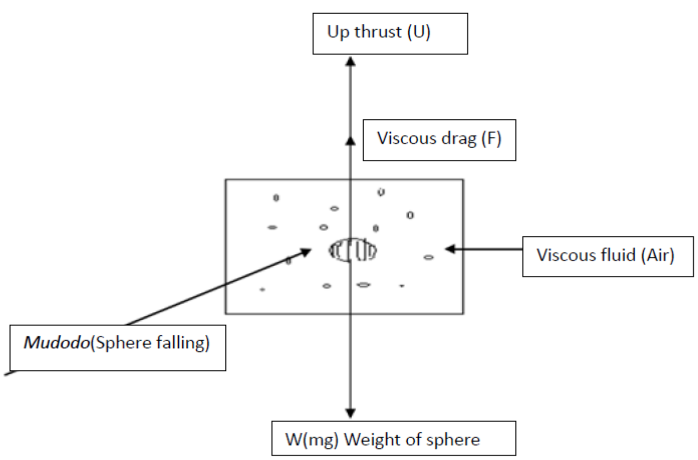

Figure 5.13 c: Forces acting on a falling *mudodo*

The resultant downward force is mg - U - F and causes the sphere to accelerate, and so the viscous drag reaches values such that W-U-F= 0. The *mudodo* (sphere) then continues to fall with a speed known as terminal velocity. A very light *mudodo* can be used to demonstrate terminal velocity since very small heights are involved. Besides being useful when learning physics concepts, playing *nhodo*, may enable learners to improve their reaction time and eye-hand coordination. This would greatly help them when carrying out practical on oscillations and simple harmonic motion.

5.4.12 Mice trap (Riva)

A mousetrap is a type of animal trap designed primarily to catch and, usually, kill mice.
A mice trap or *Riva* (Figure 5.14) has a flat stone, which is set in unstable static equilibrium with the aid of a thin strip of the inner fiber of green bark, known as *gavi*. Bait for example, a groundnut, is enticingly tied on to the supporting stick. When a mouse tries to remove the groundnut by pulling it from the small stick, the stone falls quickly, entrapping the mouse.

Figure 5.14 A Mice trap (*Riva*)

Riva can be given as an example of the useful application of instability. A flat stone is set in a very unstable state so that it falls as soon as the supporting bark is broken. The set *Riva* shows that the further away from the base the centre of gravity is, the greater the instability and the faster the stone falls when the bark is broken.

Energy conversion principles can also be discussed using the *Riva*. For example, when the trap is set it will be having potential energy, which will be converted to kinetic energy when the stone is falling. The kinetic energy will then be converted to heat and sound on hitting the ground. When the stone is flat on the ground the condition of stable equilibrium can be demonstrated

5.4.13 Fishing rod (Chiredzo) and hoe (Badza)

Figures 5.15a and Figure 5.15 b can be used to demonstrate third class levers. Third class levers are useful when you want to apply a small force to objects and move them easily. The effort is applied between the pivot and the load, as with a fishing rod and a traditional hoe (*badza*).

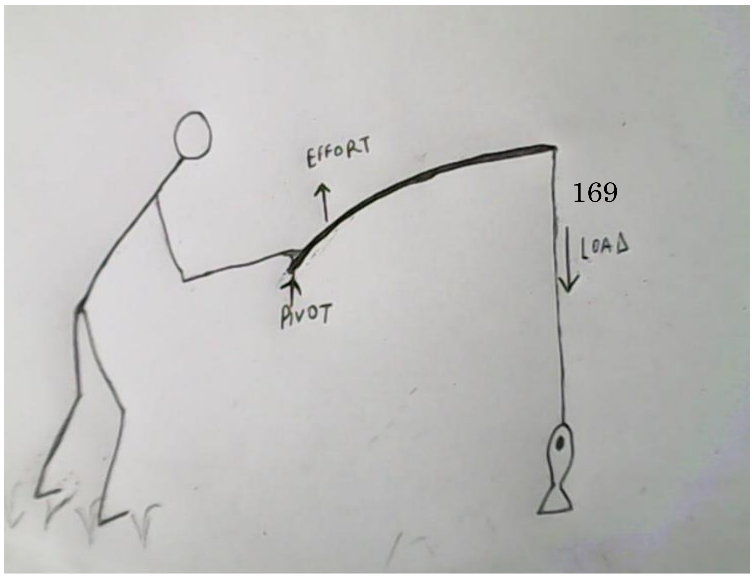

Figure 5.15 a: Fishing rod (*Chiredzo*) (Source: Sketch diagram from Focus group discussion with teachers)

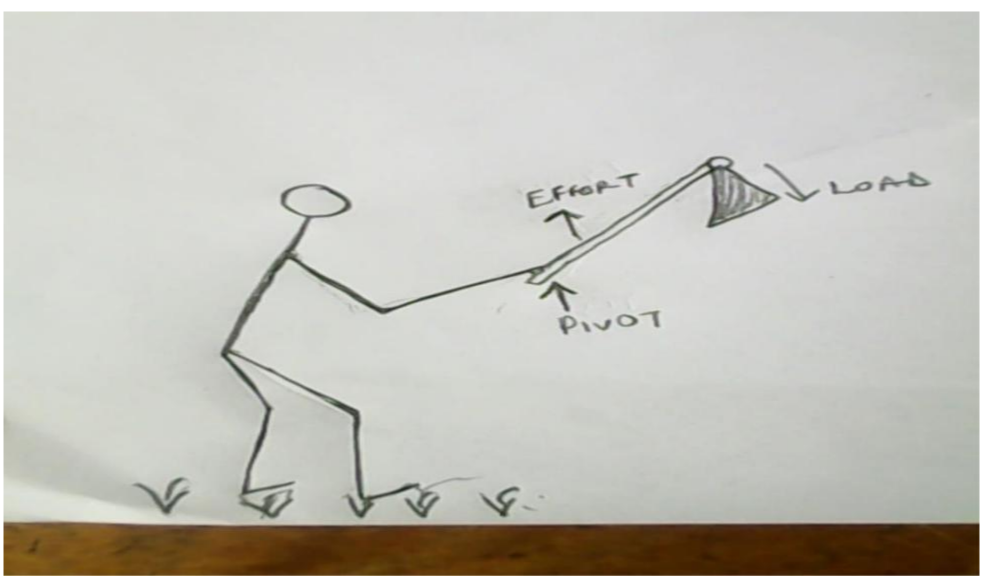

Figure 5.15 b: Hoe (*Badza*) (Source: Sketch diagram from Focus group discussion with teachers)

5.4.14 Cart (Sengende)

The cart (*Sengende*) is a strong vehicle with low runners or low wheels or even without wheels like a bullock cart (Figure 5.16). It is used for transporting goods, especially farm produce. In mechanics, the concepts of motion, friction can be discussed in relation to these carts.

Figure 5.16: *Sengende* (Source: Own field photographs)

Summary: The analysis of the several of the identified artefacts proved that there is significant number of concepts related to mechanics embedded in them. Teaching learners about these artefacts would inevitably include some explicit teaching of the embedded mechanics concepts. These artefacts can therefore be integrated successfully in the teaching of the mechanics concepts that are associated with them.

5.5 ELDERS', TEACHERS', AND LEARNERS' BELIEFS ABOUT INTEGRATION OF IK ARTEFACTS IN THE TEACHING OF PHYSICS AND SCIENCE

In this section, the beliefs of elders, teachers, and learners about the integration of IK artefa perceptions have a significant connection with classroom practice and influence the way learners would be taught to make connections between what they would be learning and their own lives. cts are discussed, together with interview excerpts supporting their viewpoints. These views and

These beliefs were revealed in the focus group discussions that were organized separately for elders, teachers and learners, and also in the individual interviews with some selected individual community elders, teachers, and learners.

The data revealed that the elders believed that the indigenous artefacts were of value and still very useful in their community. This is captured in a response during the focus group discussion below.

Interviewer: *Midziyo iyi ichakakukosherai here mukurarama kwenyu? (Are your indigenous artefacts still of value in your livelihood?).*

Elder: *Eee, Ko ndizvo zvatinoshandisa zvichitiraramisa zve.Munhu ane midziyo iyi pamusha pake ndiye "munhu". Vechidiki vanenge vachizvisvora asi zvinoshanda chose kana zvakanyatso gadzirwa.Dai vana ava vadzidziswa nezve midziyo iyi isa parara, tingafa nenzara, uye nezvirwere. (Yes, this is what we use for our livelihoods. A person with these artefacts is among the respected in our community. We wish to see our children being taught about these artefacts so that they do not go extinct. If these artefacts disappear we would die of hunger and diseases).*

The elders bemoaned the way in which some young people shunning using some of the artefacts. They see this as a contributing factor in the disappearance of some useful artefacts, as well as the prevalence of food shortages and associated diseases and general poverty amongst both the young and elderly in the communities. This resonates well with views of Quigley (2009) that many youths or learners from indigenous communities are becoming cynical about the indigenous practices or culture of their communities and this has contributed to the loss of these valuable practices. Quigley (2009) adds that this cynicism is due to the low value accorded to the indigenous practices by western systems.

A direct quote from one of the teachers giving his view on the integration of IK artefacts in teaching of physics was as follows:

Our learners come from rural communities were the indigenous artefacts are used for their livelihoods and development, therefore failure to include IK in our lessons shows that western artefacts are superior but they do not help in the community developments.

This response indicates that the learners have knowledge about the existence and use of IK artefacts in their communities, and their social and economic importance in the developments in their communities. The response implies that leaving IK out from the lessons would only serve to perpetuate the dominance of western artefacts over indigenous artefacts and also domination of local culture and people by western society.

Learners indicated that when they came to school they would already have acquired some of both western science and indigenous culture, and also revealed that embracing the integration of IK and western science would not be a problem for them. The excerpt below shows this.

Learner: *We have no problems in embracing this idea because we also have some of the western science and culture that we have already acquired from teachings from our homes due to modernization.*

This confirms the observation by Ogunniyi (2007) that learners from an indigenous background often hold dualistic science and IK worldviews from their communities. This resonates well with the views of Keil, Greif, and Kerner (2007b) that most children learn from birth using things that are created by the people who live around them and by people who come before them. In this regard, Aikenhead (1997b) working among aboriginal learners in Canada found that they already had some IK, which they had been taught at home and which showed important scientific conceptualization, but that knowledge had not been valued and acknowledged at school.

While the artefacts were valuable assets, the teachers argued that people could not afford to buy them because they are expensive. Another teacher in the focus group discussions said,

We need to include IK and IK artefacts when teaching to strengthen and improve livelihoods in indigenous communities.

This observation concurs with observations made by Breidlid (2013) and Duit (2016) that integration of IKS promotes development of local solutions and a healthy, sustainable lifestyle, and protects the environment. This response from the teacher also agrees with Shizha (2007), who asserts that learners in Zimbabwe and in Africa require locally applicable knowledge that reflects their social and cultural activities. Shizha (2007) further adds that learners need to be empowered through knowledge that is relevant to their social and cultural contexts; knowledge that they can identify with and can use to improve their livelihoods and communities. This perspective has the effect of instilling in the learners a sense of stewardship, entrepreneurship, and moral obligation to improve livelihood opportunities in their respective communities. Odora-Hoppers (2005) also suggests that use of IK and related artefacts bestows cultural identity to a group of people. Likewise, some elders and teachers indicated that something must be done to re-ignite the interest among people by going back to the use of IK artefacts. They agreed that IK artefacts can be improved and refined to be of current value and that learners and teachers should assist in this regard.

In one of the interviews with the elders, they revealed that they do not see their artefacts as out-dated, as indicated in the following excerpt:

Interviewer: *Your artefacts are out-dated; don't you think it is high time that you buy modern tools from shops?*

Elder: *Our IK artefacts are not out-dated because they are still helping use to solve some of our current problems and even increase our production in the fields. We expect that our children will continue to improve the efficiency, design and outlook /appearance of the artefacts like our generation has done. The hoe (badza) that you are now seeing does not have the original form; it was improved over the years.*

This implies that it is possible to improve or change some aspects of IK artefacts and, moreover, the elders want to see their children play a role in this regard. This concurs with ideas in Flavier et al. (1995), which allude to the idea that IK and its associated IK artefacts are dynamic in nature and can be modified or changed to suit or adapt to changing circumstances.

Mr Moyo (not real name), one of the teachers in the focus group discussion, said:

I think it is important to integrate IK artefacts in the teaching of physics because it helps learners to relate what they know to what they do not know. This helps them to understand better.

He added that "*it gives parents opportunity to assist their children in the subject*".

Some elders agreed that integrating IK artefacts when teaching physics would help them to transfer their traditional knowledge into the science curriculum and create rich and relevant learning experiences for their children. The elders indicated that they should also be included in the teaching programmes in the schools to assist teachers in teaching of physics in a more contextualised way. Physics should be taught in the context that relates to the learners" lived experiences (Niaz, 2008).An excerpt from one of the elders supports such integration of artefacts.

Zvigadzirwa zvedu ngazvishandiswe mukudzidziswa kwevana vedu tiwane kuudzavo vana vedu nezve midziyo yedu. Kana pavanoda rubatsiro tinovabatsira. (Artefacts should be integrated in the teaching of science because we will have an opportunity to teach our learners about them. If teachers need help we will assist.)

Learners also indicated that integration would help them to appreciate the value, technologies, and practices in IK, which are creations of their grandparents‟ minds and hands. One of the learners said:

The integration of our IK and IK artefacts by our teachers when teaching us physics is a sign of respect for our grandparents' creative minds and hard work which they did in the designing and making of the artefacts. People need to continue to attach value to this and make effort to preserve or improve these ideas and technology.

This endorses the view that incorporation of IK into the school science curricula could boost the learners‟ interest in the subject while valuing and keeping alive the indigenous knowledge of the parents (Kasanda et al., 2005; Ng'asike, 2011; Perin, 2011).

Learners also revealed that integration of IK artefacts in the teaching of physics is important in providing familiar contexts and tools that enable them to understand science concepts. This is captured in the excerpt below.

Learner*: If teachers use examples, illustrations and demonstration from our everyday home experiences the concepts will be easy to understand and the subject will not appear and sound exotic to us. It is also our right to be exposed to education in our familiar cultural contexts.*

This resonates well with the views of Baquete, Grayson, and Mutimucuio (2016), who argue that IK integrated into school science curricula provides familiar contexts within which learners learn scientific concepts as well as helping them to recognize the value inherent in IK and its related artefacts. Familiar contexts help reduce the feeling of foreignness that non-western learners may experience in science classrooms (Mashoko, 2014). The rights of children to education in contexts culturally familiar to them are enshrined in the United Nations conventions on the Rights of Indigenous People and the Preservation of Indigenous Knowledge (Oldham & Frank, 2008).

Teachers agreed that integration of IK and associated IK artefacts would prevent diversion of learners from their culture while also stimulating interest and understanding of the concepts used in physics.

Elders also expressed concern on how the modern science and extravagant living were damaging the environment, as illustrated in the excerpt below.

Elder: *School physics is damaging our environment. There is need for our children to come up with another way of knowing. Learners need to be exposed to our old learning ways which were meaningful and safe to the environment.*

The views of elders resonated well with those of (Ogunniyi & Ogawa, 2008), who assert that alternative ways of restoring our natural environment need to be sought. This view also agrees with that expressed much earlier by Scott and Meyer (1992), that the integration of IK artefacts is a way of educating learners that provokes them into discovering environmentally friendly solutions to the current environmental problems. This is supported by Le Grange (2004), who asserts that neglecting IK in the teaching of science will worsen the destruction of natural environments and the denigration of the culture of African people.

The three groups of participants, elders, teachers and learners, all saw the integration of the artefacts into the teaching of physics as a way of widening knowledge boundaries to include the formerly excluded IK systems and artefacts. This was also evident in one of the elders" response during the focus group discussion captured in the excerpt below. Excerpt 2 from one of the elders:

Aaa, zvakanaka chose nokuti ruzivo rwevana vedu nerwedu runowandavo patinosanganisa pfungwa dzeva"chena" idzi nedzedu dzechivanhu chedu (Aaa, this is very good, because our knowledge base and that of our children would be widened when we integrate our ideas with those of whites).

This resonates well with argument expressed by Aikenhead and Elliott (2010, p. 326) that there are several options in the world to know or to do the same thing in different ways, which they call "two eyed seeing". This indicates that the integration of IK and its associated artefacts would equip learners with more ways of explaining what they see in their environments and more ways and techniques of solving problems.

Other elders also shared the same views as indicated in the next excerpt.

Elder: *Kungoonavo nemamwe maonero.Zvakaipei? Ndiko kuwanda kweruzivo.(This is another way of seeing things and here is no problem with that. This would actually broaden our horizons).*

Participants revealed that learners could investigate, explore, and manipulate objects to bring life to the subject, which could enhance both IK and physics. Teachers viewed this integration of IK as a valuable pedagogical strategy that could also inspire learners to enroll in physics and hence follow physics and science careers, which are usually better paid than careers in the social sciences.

Learners also argued that because western artefacts have been incorporated into the teaching of science, they believe that IK artefacts could be similarly integrated in teaching of physics. They gave the example of a guitar, which is an exotic musical instrument, being used to demonstrate stationary waves to indigenous learners when an indigenous musical instrument like *Chipendani* (stick-zither chordophone), which is familiar to the learners, can be used more effectively.

The learners revealed that their knowledge about the designs, shapes, and use of some IK artefacts was derived from systematic observation, and experimentation, just as for western artefacts that are used in the explanations and demonstration of physics concepts. The excerpt below indicates this:

Learner*: Our IK artefacts are similar in designs, shapes, and structure to some western artefacts which are used in our science textbooks and also used by our teachers to explain and demonstrate some physics concept in the classroom. Therefore we can also use them instead of using the western artefacts which are not familiar to us.*

The teachers indicated their belief that the language of instruction plays an important role in the understanding of concepts by learners. Teachers spoke about many problems in physics learning that are associated with a weak command of the English language used in instruction. They indicated that the integration of IK artefacts would allow the use of local or indigenous languages, to the benefit of the learners. They thus endorsed the ideas from Shizha (2005b), who also revealed that language of instruction is an important tool in in integration of IK artefacts in the teaching of school physics. This is revealed in the except below from one of the teachers.

Teacher: *Our learners struggle to make sense of the concepts explained in English. This usually frustrate them and demoralise them. The use of some terms from the IK languages especially in situations where IK artefacts are being integrated in the teaching process would actually motivate the learners to learn and enhance their understanding.*

The teacher expresses his concerns about non-mother tongue language being used in teaching. In this regard, Shizha (2005b) asserts that the language of instruction in schools is a major obstacle in learners‟ understanding of concepts, cognitive development, and learning outcomes. Kurwa (2016) also concurs, and observed that language used in science classrooms is an additional challenge to science learners as it consists of foreign words, which have specific meanings according to their context, irrespective of whether they are technical or non-technical words. This difficulty experienced by learners is also evident in a study carried out by Bunyi (1999) who found that when English dominated the instruction, learners could not apply what they had learnt to practical situations at home and learners would not be motivated to learn. Studies on cultural beliefs and science in Africa have revealed that the teaching and learning of the sciences in schools is not successful because the subject is not linked to everyday life experiences of the learners and the language of instruction further alienates them(Dlodlo, 1999; Shumba, 1999).The view on the foreignness of English language was also echoed by another teacher as indicated in the excerpt below:

Teacher: *Learners find it difficult to understand concepts because the recommended terms to be used in explanations and demonstrations, whether technical or non-technical, present new and different language to learners*.

This shows that learners should understand the language first before understanding the scientific knowledge (Oyoo, 2007). The integration of IK artefacts would allow the use of familiar language in the explanations of concepts and would make it easier for learners to understand the concepts.The IK artefacts reduces the demand on language in understanding of physics.

Teachers and elders also indicated that the continued absence of IK in the teaching of science is a form of neo-colonialism. They argued that if people have achieved political independence, they must be free from using most of the former colonisers‟ artefacts and languages. The integration of IK artefacts in the teaching of physics would be one such sign of, not only political liberation of the people but also, the development of culturally connected science pedagogy.

This concern of colonization is revealed in the excerpt from one of the elders.

Elder: *Tikaramba tongoshandisa zvava chena mukudzidzisa muzvikoro medu tinenge tisati tasununguka.Kushandisa zvigadzirwa zvedu chiratidzo cherusununguko rwakazara (If we continue to use the IK and IK artefacts from the Whites, we would not be decolonised. Using our IK and IK artefacts shows that we are independent).*

The excerpt indicates that use of indigenous artefact in teaching and learning is part of the counter-hegemonic cultural efforts to that of colonisation. This agrees with Ntuli (1999), who posits that the use of IK overcomes intellectual colonisation as well as advancing an agenda of transformation and re-Africanisation.

Learners also viewed the integration of IK and IK artefacts as a way of demonstrating independence and empowerment in science pedagogy. Secondary school science in Zimbabwe is a legacy of the British colonial education system, which tends to ignore or not adequately respect and acknowledge the home experiences of the indigenous learners (Shizha, 2005a). The exclusion of the IKS including indigenous languages from schooling in Africa has been viewed as a form of cognitive imperialism (Battiste & Youngblood, 2000, p. 12) where European based knowledge is centered at the xpense of other forms of knowledge(Battiste, 2014).

Learners also indicated that Integration of IK and IK artefacts in the teaching of science offers excitement and satisfaction and learning of science would therefore become relevant and meaningful. One of the learners said:

Learner*: I am excited to see different IK and IK artefacts being used to explain some physics concepts. I derive satisfaction from the way the IK would be linked to the western IK and science concepts.*

This is in line with the observations by UNICEF (2007) that integration of IKS helps learners to develop their talents and abilities, to gain confidence, and improve self-esteem, to use their initiative and creativity, to gain life skills and make informed decisions and to understand and experience pluralism and democratic co-existence. This also agrees with the assertion that integration of IKS makes learning of science more meaningful to learners from indigenous communities, because their cultural backgrounds and values are included in the classrooms discourses (Aikenhead, 1996; Jegede & Okebukola, 1991; Ogunniyi, 2011) .

Some teachers opposed the use of IK artefacts in physics lessons. They indicated that assessment in tests and final examinations included very little about IK artefacts and therefore they saw no need for them to integrate the IK artefacts in their teaching. This is indicated in the response from one of the teachers.

Teacher: *We teach learners so that they pass examinations. We do not have to waste time teaching learners things that are not examined at the end of the course. We do not set IK and IK artefacts questions in the final examination.*

This view of teachers about assessment agrees with the observation made by Kawagley et al. (1998) and Barnhardt and Kawagley (2005) that worldwide, science curricula, teaching methodologies, and assessment strategies at school level are presented according to a western worldview. As assessment usually drives teaching and learning, teachers are consequently usually discouraged from attempting to integrate IK artefacts in physics lesson (Barnhardt & Kawagley, 2005). This contrasts with the argument by Ogunniyi (2011) that IKS is an integral part of any culture or society and cannot be ignored simply in the interests of creating a smoother assessment curriculum.

Some of the teachers who were interviewed indicated their fear that they may be teachingpseudo-physics when integrating IK artefacts into western physics in the normal classroomphysics sessions. Similar concerns have been expressed by De Beer and Whitlock (2009) andWellington (2002). They argue that IK and its related artefacts have not been scientifically proven and they have been produced by methods which have not been scientifically proved.Inan even stronger fashion, Silva (2003) asserts that anything related to IK is not science.Thisconflict is shown in the following excerpt from one of the teachers.

Teacher: *If we integrate IK artefacts in the teaching of physics, we will not be teaching proper physics to our learners, that's pseudo-physics. Hadzisi Science dzakaongororwa dzikaonekwa kushanda kwadzo (The applicability of the science in these IK artefacts has not been scientifically tested and proved).*

Another teacher echoed the same sentiments, indicating that the integration of IK artefacts in the teaching of physics would contaminate and dilute physics. This is captured in the excerpt below from one of the teachers.

Teacher*: The power and prestige associated with physics as a subject will be diluted. Concepts would lose their original detail and may lose their original meanings as they will be analysed and explained in contexts different from those in which they were originated*.

These arguments from some of the teachers that science would be diluted are counteracted by the views from Cobern and Loving (2001), who argue that good science explanations will always be universal regardless of the origins of the knowledge source. Òtúlàjà, Cameron, and Msimanga (2011) emphasize that "only some aspects of IK are spiritually rooted while perhaps the largest part, has to do with the science of day-to-day experience" (p. 698).

Teachers also revealed that if they are not well trained in the integration methods so they could become confused in the classrooms. Teachers lament the absence of relevant instructional materials for them to refer to, and of methods and pedagogical content knowledge. This deficit has also been noted by Mothwa (2011).The excerpt from one of the teachers confirms that confusion among may arise among teachers if they are not trained.

Teachers*: There is need for a clear policy on how the integration should be done. Teachers should be trained on the methods that they would use in the physics classrooms. If this is not done there will be confusion.*

With unspecified policy and curriculum requirement and a lack of training makes, iintegrating IK just for the sake of integration becomes a meaningless technical exercise, as Seehawer (2018) emphasizes.

Some learners were also against the idea of integration. They argue that IK is old fashioned, degenerated, demeaning, useless and not aligned to modern thinking and trends. This is captured in excerpt below.

Learner*: We now have computers and other modern technologies. The IK and IK artefacts are not compatible with these modern inventions and ideas.*

The other argument about this is that, there are many IK practices in Zimbabwe because of the different ethnic groups hosting different types of IK and IK artefacts. This makes it difficult for teachers to teach classes with learners from different cultures, as is captured in the following excerpt.

Learner: We have Shona, Ndebele, Tonga and Shangaani people in our science classes. These groups of people have different cultures and IK. When teachers want to integrate IK when teaching such classes they would have challenges on whose IK to integrate.

This challenge was also observed by Webb (2016), and Meier and Hartell (2009) who said that teachers who teach groups of learners from different cultures normally face problems.

The participants also indicated their views on assessment in situations where there is integration of IK artefacts in the teaching of physics. This is captured in the following excerpts.

Elder: *Vana vanofanira kunyora Zama, Ndiko kuti tizive kuti vari kugona zvavari kudzidziwsa here. Uye tinoda kuziva kana Tichibhadharira School fees chiripo. (Learners should be assessed This would allow us to check on their performances and to see if something is being secured for the money that we pay as school fees).*

This resonates well with views of Linn (2001) that assessment should be done for public accountability and also to monitor the quality and standards of education.

Teachers and elders also criticized the current assessment procedures and tools. Assessment has been criticized on the grounds of not being suitable for evaluating scientific processes and conceptual understanding in context, and should also be undertaken to measure what people can do with what they know; in other words, the problem solving abilities of the learners. This agrees with the criticism on tests, which are one of the current tools which are being used in physics assessments. Testing has been criticized on the grounds that it is:

(a) unsuitable for evaluating scientific processes,

(b) inadequate for measuring learners‟ reasoning ability (Fredicks, 1999),

(c) unable to measure what people can do with what they know (Lirenman & Wideen, 2016) ,

(d) unable to evaluate problem solving ability (Treagust, Duit, & Fraser, 1996).

Furthermore, it can be argued that teachers teach concepts because they are in the syllabus, but not in any way related to the experiences and day-to-day lives of the learners.

Summary: The beliefs about the integration of IK artefacts in the teaching of physics held by most teachers and elders indicate that they all support the integration of IK artefacts in the teaching of physics; even though a few teachers felt it will dilute the physics content.

They see it as a way of linking the home experiences of the learners with classroom physics, broadening perspectives and horizons of indigenous learners, motivating learners to enroll in physics courses, decolonizing the science curriculum and its pedagogy, reclaiming the IK artefacts pedagogical space in science teaching, and contextualizing the assessment. This gave the researcher assurance that the study was worth undertaking and was relevant.

5.6 VIEWS OF ELDERS, TEACHERS, AND LEARNERS ON HOW INTEGRATION CAN BE ACCOMPLISHED

The majority of the elders, teachers, and learners indicated in the focus group discussions and interviews that they see the integration of IK artefacts in the teaching of physics as a good practice. This was revealed and discussed in Section 5.5. However, the participants had different views on how the integration could be accomplished, as indicated by their responses to interview questions, in questionnaires and during focus group discussions. The varied sources of data provided an opportunity for gathering a wide range of worldviews about how the integration of IK and associated artefacts could be put into effect. In their suggestions, the participants unconsciously revealed different approaches to bringing IK artefacts into the physics learning situations. They consciously and unconsciously revealed possible areas of integration and possible integration approaches, methods and strategies. Possible implementation challenges were also consciously and unconsciously presented in the responses.

The approaches which they revealed fall into three general categories found in the IKS-Science literature. In particular, Naidoo and Vithal (2014) proposed three categories of approaches as being separationist (side by side), incorporationist (best fit) and integrationist (connections) approaches.The incorporationist approach involves fitting of IK and its related artefacts into science. It includes selecting those artefacts that would harmonize with the learners‟ beliefs or activities that attend to those beliefs or that include aspects of the beliefs of physics content. This view contradicts the philosophy of IK and its associated artefacts as being holistic in its practice, while physics and science are often compartmentalized into „silos‟ or that each way of knowing is like having ideas in different pockets. In the separatist category, IK artefacts can be used alongside other ways of knowing with distinct domains. These views of have resonated well with those of McGregor (2000), who claims that "because of hegemonic power relationships we should not integrate or bridge western science and IKS but we should actively support a postcolonial model called co-existence which allows both systems to function side by side" (p. 454). This referred to as an „add-on‟ or tokenism approach.

The integrationist approach allows for IK artefacts to be respected and valued like the western ideas. The approach allows learners to learn about their IK artefacts as they use them to learn and gain a deeper understand of concepts, including scientific and physics concepts.

Teachers highlighted that they have learnt about some western culture indirectly when they were trying to understand concepts explained using some of the western cultural objects. One of the teachers said that he learnt about „pudding and plums‟ which are part of the western diet when he was learning about the early model atomic structure described as the „plum pudding model‟. The issue of the integrationist approach was also evident in the following excerpt from one of the teachers:

Teacher: *We can demonstrate concepts on projectiles using catapults. In the process learners will be learning about the aspects of projectiles like …Trajectory, time of flight, range but at the same time he /she will be learning about the artefacts and its effective use.*

This shows that the physics concepts can also be taught effectively, even if teachers integrate IK artefacts in their teaching process.

The teacher's response was echoed by one of the elders during the focus group discussion, as was captured in the excerpt below from one of the elders:

Elder: *Pamunodzidzisa paya pfekeraivo ruzivo hwedu kuti vana pavanonzwisisa physics dzacho vanenge vachitodzidzavo nezvedu. (When teaching physics, just infuse our artefacts in the process so that your learners, while understanding the physics concepts, will also be learning and understanding our artefacts).*

This elder proposes that teachers should integrate and its related artefacts into the other knowledge systems as they try to teach physics concepts.

The need to use local language and its rich metaphors, idioms etc. in the teaching process was also revealed as one of the strategies that could be used for effective integration. This is indicated in the excerpt below from one of the elders.

Elder*: Mutauro wedu wakafuma chose. Unogona kushandiswa pakudzidzisa. Tsumo, madimikira , Nyaudzosingwi, nefananidzo, zvirahwe, Ngazvishandiswe pakutsanangura. Inga patinovadzidzisa kugadzira midziyo yedu tinozvishandisa wani vachitonzwa. (Our language is very rich. It can also be used. We all use proverbs, metaphors, ideophone, similes, puzzles, paradoxes, and apparent contradictions when teaching them to make our indigenous artefacts. They are very effective in enabling them to understand.*

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This agrees with the view of one of the teachers who jokingly argued that Newton's 3rd law which states that, "For every action, there is an equal but opposite reaction" can be explained using a shona proverb "*Chindiro chinopfumba kunobva chimwe*."

Learners indicated that teachers should be allowed to use indigenous languages when presenting lessons. Code-switching should also be allowed. They believed that this would enhance their understanding of concepts. Excerpt 1 from one of the learners shows this.

Learner*: We have problems in understanding the English language which our teachers use when teaching us. This is making the subject difficult for us. We would appreciate a situation where teachers use our indigenous languages as medium of instruction or mix indigenous terms and English terms. This would also give us opportunity to express our cultural views of the world and our existence.*

The sentiments of the learners confirms that indigenous language incorporated in the science curriculum could assist learners to understand science principles and link western science to indigenous ways of knowing, as was also observed by McKinley, Stewart, and Richards (2005). Shizha (2005a) also argues that the language of instruction is a major obstacle in learners" cognitive development and learning outcomes. In a study in Kenya (Cleghorn, 1992) discovered that, among the Grade 5 learners, when code-switching into home language was allowed during science lessons it fostered understanding of science concepts.

Elders indicated the need to create a school environment that resembles the indigenous culture of the learners. They proposed that the infrastructure should have space for a fair mixture of indigenous and non-indigenous features in the school environment and in classrooms.

They indicated that this would make learners value IK and related artefacts, motivate learners to take up science subjects and grasp science concept easily. Elders also revealed how the integration could be facilitated through the creation of space for IK and IK artefacts. They argued that there should be heavy presence of IK and IK artefacts embedded in the school environment. They reasoned that this would decolonise the school environment, which is currently dominated by western artefacts. As indicated in the excerpt below from one of the elders.

Elder: *Tichisvika pachikoro ngaparatidze kuti ndepedu ndepevanhu vatema kwete pavachena.Nharaunda inofanira kutaura yega,Zvivakwa uye midziyo inoshandiswa pachikoro ipapo.Zvinofanira kunge zvakasangana nezvatinogadzira isu.Zvikadaro vana vangaona kukosha kwemidziyo yedu zvese nedzidzo yacho.Vanopedzisira vofarira kudzidza "science" uye vanotanga kudzidza vachinzwisisa. (When we get into the schoolyard, the environment should indicate that we are at an African school not school for the whites. The infrastructure, and the artefacts found at the school should include our IK artefacts. Learners could see their value. They would be motivated to learn science and they could understand concepts taught easily.)*

This view from an elder also indicates that they advocate having a decolonised environment for the effective implementation of a decolonised pedagogy. They revealed the need to make the formal school environment and the classroom, which generally have a western set up and culture, the right place for the use of IK and its related artefacts.

The teachers also identified manipulating the classroom environment as another strategy for effective integration of IK artefacts in the process of teaching physics. This is captured in the excerpt below from one of the Teachers.

Teacher: *The classroom environment should also have space for indigenous knowledge and artefacts. The displays, charts, hangings etc. should all have a fair mixture of indigenous aspects and western aspects.*

Learners advocated for learning environment that resembled features of their home environments. This is indicated in the excerpt below from one of the learners.

Learner: Learning environments enable us to be psychologically, physically, and emotionally used to the conditions found in our communities where we would be expected to apply the knowledge that we would have learnt from our physics classes. The environments should bear imprints, connotations, and footprints of IK and associated IK artefacts. Such an environment would allow us to be creative and innovative.

This statement shows that an environment that enables learners to adapt their mental, physical, and emotional state to the demands that they find in their communities would also enable the learners to generate ideas or knowledge whose expression is mediated by the realities found
in one‟s environment and sociocultural experiences. Learners see the environment as a useful pedagogical resource. This agrees with the argument that there is a relationship between the learning environment and learning outcomes in terms of learners‟ achievement, satisfaction, comfort levels, or success (Puteh, Che Ahmad, Mohamed Noh, Adnan, & Ibrahim, 2015). Physical learning environment influence learners‟ psychological and social behaviors (Puteh et al., 2015).

Learning can only occur successfully when there is an interplay between thinking faculties or cognitive structures and the environment; thus an environment that triggers off the process of adaptive behavior is necessary (Ogunniyi, 2000). In this regard they advocated that the environment should include a variety of materials and initiatives that include IK and IK artefacts. They revealed initiatives such as using indigenous artefacts in the design of furniture, buildings, shapes of charts and posters, indigenous names for school buildings like laboratories and classrooms. This is revealed in excerpt below from one of the learners.

Learner: *We have seen buildings in some schools with architectural designs and shapes that resemble western artefacts. We have some laboratories and building in some schools with western names. These remains of colonial legacies do not help us in any way. We can make can have designs and names that resembles some aspects from our own culture and show that we are independent.*

These would constantly remind the learners of the need to respect, use, conduct research on, and improve their respective IK and IK artefacts.

Misconceptions may arise and can be obstacles to successful learning of science concepts (Ausubel, Novak, & Hanesian, 1968).

However the misconceptions may be a blessing in disguise when they are properly handled by both teachers and learners.Clement, Brown, and Zietsman (1989) argue that misconceptions can be used as building blocks for facilitating the construction of scientific understanding of concepts.

The teachers complained about the use of textbooks. They argued that the textbooks frustrate their efforts when they want to integrate IK artefacts in their teaching of physics, as is indicated in the following excerpt from one of the Teachers.

Teacher: *The recommended textbooks have examples, illustrations and demonstrations that are not connected with the IK and the IK artefacts of the learners, making it very difficult for learners to understand concepts. Some of the textbooks have some misconceptions that also mislead the learners about both IK and physics.*

This shows that teachers are of the view that textbooks may not be relied upon when they want to ensure successful integration of IK and artefacts. Tshuma and Sanders (2015) also note that textbooks may be sources of misconceptions which can hinder the understanding of science concepts by learners.The learners also indicated that the use of textbooks as sources of information should be reduced since they do not have relevant IK and IK artefacts. Integration of IK would alleviate learning from classroom and textbook based science which leaves them illiterate in issues relevant to their own lives and communities (Chinn, 2007). Textbooks do not consider IK and IK artefacts; instead IK is vilified and considered to be of less value (Milne, 2011, p. 20). Learners also indicated that for examples of physical phenomena, teachers should draw on IK and IK artefacts that are familiar to the learners‟ ways knowing, so as to complement textbook information and provide a valuable link between the school science and everyday life. The excerpt below from one of the learners indicates this.

Learner*: I think teachers should use examples from our IK when teaching us and try to link the science concepts well with these aspects from IK. In my view this would enable us to understand concepts better than when they base their instructions on textbook material which is not related to our context but to that of authors, editors and sponsors who are usually foreigners.*

This agrees with observations made by Ogunniyi and Ogawa (2008) and Mapara (2009) that understanding of concepts can be enhanced if teachers would complement what are in the science textbooks with traditional or indigenous knowledge.
Elders also indicated what should be included in the assessment, as indicated in their views on assessment. This is evident in the excerpt below.

Elder: *Nepamibvunzo yacho,ngazvisanganiswe,zvedu nezvavachena zvacho,Kana kungovhunza zvinoenderana nemagariro,midzdiyo,nemashandiro udu amazuva ose.(In the assessments, there should be a mixture of items related to our IKS and IK artefacts or something related to our day-to-day life experiences and IKS and related IK artefacts).*

This implies that the elders advocate that assessment tools and procedures should be contextual and related to the everyday experiences of the community.
Some teachers raised problems associated with moblising IK artifacts for use in lessons and in laboratories. These include lack of funding to take learners into communities to see the IKartefacts in use and prohibitive cultural protocols to be followed when organizing such trips.

The responses on how the challenges may be overcome were captured in the excerpts from one of the teachers and an Elder.
Teacher: *In situations where schools lack a budget to establish the physical integrated laboratories, "Virtual laboratories" may be established equipped with latest technological advancements that provide 3D virtual learning environments that support simulations and observation of IK and IK artefacts in laboratory investigations.Learners may engage in virtual simulations depicting out of school activities and projects.*

Elder: *Vamwe vana vonopedza nguva huru vari kuchikoro saka ngavaratidzwe mabhaisikopo* *ane mifananidzino yemagarire edu nemidziyo yedu.(Some learners spent most of their time at boarding schools with no time to interact with the IK artifacts in the communities, those learners should be shown vedios or films of our culture and associated artefacts.*

This implies that the teachers and elders advocate for establishment of Virtual laboratories as the answer to the problems faced by educational institutions struggling to offer Science learners the actual experimental learning experiences involving IK and IK strategies.

These views from the participants had a great influence on the main features of the emergent pedagogical model that is discussed in Chapter 6.

5.7 SUMMARY

The findings indicate that there are commonalities in both science and IK artefacts that can be used for culturally relevant teaching in school physics. The participants revealed that they use IK artefacts at their homes, displayed deep knowledge about the production and use of these IK artefacts. They also revealed the physics concepts embedded in the design and use of some of these indigenous artefacts. A number of IK artefacts were identified and the concepts related to mechanics embedded in them were highlighted to confirm this. The participants confirmed the close relationship between the mechanics taught in the physics laboratories and mechanics concepts embedded in the artefacts.The findings justified the need for, and shown the feasibility and desirability of creating, an IK integrated pedagogical approach to enhance concepts attainment by Advanced Level physics learners. The next chapter will give a detail description of the pedagogical model implied by the findings.

CHAPTER 6

DISCUSSION OF FINDINGS FOR AN INTEGRATED PHYSICS-PEDAGOGICAL MODEL

6.1 Introduction

Chapters 4 and 5 presented answers to the first two research questions, which are:

1.What are the indigenous artefacts that can be associated with Advanced level mechanics found in Masvingo District, Zimbabwe as perceived by Elders, teachers and learners?

2.What are the Advanced level mechanics concepts that can be associated with these indigenous artefacts identified in Masvingo District, Zimbabwe?

It was revealed in Chapter 5 that many indigenous artefacts suited to teaching physics were identified in Masvingo District. There were 20 discussed in this depth. It had also been revealed in the literature review (Chapter 2) and in the interviews and focus group discussions that the IK artefacts have mechanics concepts associated with them. The sources of information about the IK artefacts confirmed that the artefacts were indeed indigenous because there was evidence that they had been developed by the indigenous people in the area, using local resources and indigenous skills. The skills for making the artefacts had been passed down from generation to generation through traditional means. The finding agrees with that of Vhurumuku and Mokeleche (2009), who indicate that IK includes shared experiences passed from one generation to another through oral transmission, writings, paintings, or artefacts.

Generally, the three groups of participants in the study agreed that IK artefacts can be integrated into the teaching of Advanced Level physics to facilitate understanding of concepts by the learners. This was discussed at length in Chapter 5. In this chapter, Research Questions 3 and 4 are answered. The research questions are:

3. How can indigenous artefacts be integrated in the teaching of Advanced Level physics mechanics as perceived from the elders, learners, and teachers?

4. What feasible pedagogic model of teaching and learning can be proposed regarding the integration of IK into physics, considering the views of elders, teachers, and learners in the Advanced Level physics in Zimbabwe?

The answer to Research Question 3 is presented as a physics-IKS integrated content model (P-IKS-ICM) summarised in Figure 6.1. Data and results in support of the answer to Research Question 4 are presented as the physics concepts attainment – IK – integrated pedagogical model (PCA-IK-IPM) as the model for this emergent integrated pedagogy. The characteristics of the two models are drawn from the findings for the first three research questions, as the direct responses given by the community elders, teachers, and learners recorded in the questionnaires, individual interviews, and focus group discussions. Other views were also derived from the analysis of the field observations.

The models thus represent a translation of the research findings and insights into a practical guide for the physics teachers regarding the integration of IK artefacts into the teaching of physics and in the physics laboratory discourse. This will assist physics teachers when teaching physics to indigenous learners.

6.2 Physics-IKS-Integrated Content model (P-IKS-ICM)

The Physics-IKS Integrated Content model (P-IKS-ICM) proposed in the study is summarised in Figure 6.1 and is a macro-model depicting the link between physics content and IK artefacts as implied by insights from community elders, physics teachers, and learners discussed in chapter 5.

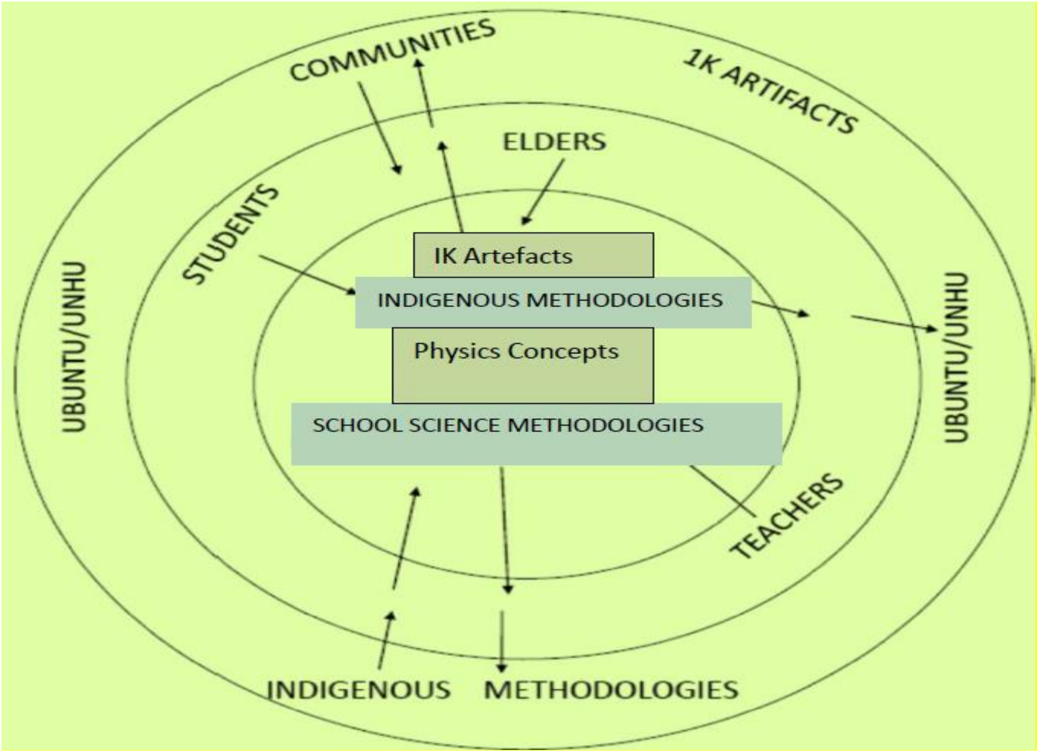

Figure 6.1: Physics-IKS Integrated Content Model (P-IKS-ICM) (Source: Own design)

The arrows in the Figure 6.1 indicate the sources and direction of flow of ideas about IK and IK artefacts as well as the interactions involved. The physics-IKS integrated content model (P-IKS-ICM) shows that teaching of physics should be a collaborative effort among physics teachers, members of the community and the learners themselves.

Figure 6.1 shows that the IK and the associated IK artefacts together with associated indigenous methodologies to be integrated in the teaching of physics are derived from the communities together with aspects of *Ubuntu/Unhu*. These are brought to the school and physics class by learners, teachers, and elders, as indicated by the arrows. At school and also in physics classes, which is represented by the central part of Figure 6.1, IK artefacts and the associated indigenous methodologies are artfully blended with the western ideas, content, methodologies and strategies that are already perceived to be embedded and dominant in the school and classroom physics, as revealed in the literature and the research findings. This integration is done to enable understanding of physics concepts taught to the indigenous learners. The IK and associated artefacts together with associated indigenous methodologies brought into the physics learning situation act as meditational tools that facilitate understanding of concepts by the learners. This is found at the central part of Figure 6.1 like the „bull‟s eye‟, to use the western analogy of a dartboard. I decided to call it the bull‟s eye because it is the main focus of the physics-IKS integrated content model (P-IKS-ICM) that ensures the understanding of concepts or concepts attainment by learners. The IK artefacts and associated indigenous teaching methodologies would be integrated in all components of the teaching process including the teacher and learner activities during the physics lesson. The integration would be informed by the views, wishes, thoughts, practice, and context of the teachers, learners and the community. Accordingly, the learners maintain their links with their culture (including *Unhu/Ubuntu*), community, and home experiences as they learn the school physics culture and content. There is contextual approach to teaching of physics. Ng and Nguyen (2006) posits that contextual approach to teaching places learning of physics in real-life contexts where phenomena familier to learners' personal experiences are used as contexts for learning or otherwise incorporated as much as possible into the teacher' teaching.

This model (Figure 6.1) can be extended to show the way this could be done in the school environment and in the classroom. This is described and explained in Section 6.3 and summarized as the physics concepts attainment-IK-integrated pedagogical model (PCA-IK-IPM) shown in Figure 6.2 page 200.

The school environment is also considered to be a teaching resource, and would be conducive to effective teaching and learning of physics concepts, if IK and IK artefacts are embedded in it. This can be done by providing supporting infrastructure and facilities that provide out-door science settings like libraries of indigenous artefacts, a model indigenous homestead, indigenous names for the laboratories building and rooms, and posters of IK artefacts in the school, as will be shown in Figure 6.2. Section 6.3. These supporting infrastructure and facilities would create a psychological and physical space for IKS and its associated artefacts, not only in the school but in the whole physics learning environment. The embedded IK, indigenous methodologies and IK artefacts would act as teaching meditation tools, whichalso stimulate and sustain the idea of integrating them among other effects in the teachers, learners and the elders. The action of integrating IK and its associated artefacts would also serve to destroy, dilute, or at least re-evaluate the oppressive physical and psychological images as well as attitudes of power that had been established during the colonial era. This decolonization process involves mental reorientation or repositioning and diluting or doing away with legacies of colonization that are still visible in classrooms and school environments. Decolonization is an intellectual process that painstakingly and persistently empowers the formally colonized people to become aware of and how to counteract hegemonic practices (Wane, 2006). A decolonized environment of this nature adds relevance to school physics. It does so by being culturally appropriate (Linkson, 1999), including multiple worldviews and the social and political aspects of science (Fleer, 1997) and becasue it links classroom knowledge to the learners‟ everyday life experiences (Peacock, 1997; Terwel, 2005).

The decolonized environment also accommodates multiple intelligences and learning styles. Goodenough (2001) and Stears and Malcolm (2005) posit that the relevance of knowledge and skills taught and the participation in learning are inseparable aspects of the learning process. Relevance of the subject matter encourages learners to participate actively and deeply in classroom processes and activities; learners learn in their own ways and bring together their own ideas, interests, and experiences. Such a decolonized environment also allows for the teaching and learning process to follow the natural pedagogic way; that is, of learners observing, raising questions, designing activities, attempting to test hypothesis, doing, reflecting, and adjusting their ideas until observations can be explained. Learners are exposed to a culturally aligned, visual, kinesthetic, auditory, and tactile learning process.

In this regard, the school in general, and the physics classroom in particular, serve as social units where the teacher and the community elders interact with learners as mantors, facilitators or guides. In such an environment, the teaching and learning processes would proceed naturally as implied by the sociocultural theory that forms part of the theoretical framework for this study.

After understanding the science concepts at school and in the physics laboratories, the learners would take the newly acquired and refined knowledge, skills, perceptions, facts, principles, school science pedagogical ideas etc. back to their respective communities to assist in socioeconomic development, including solving problems and improving the efficiency and physical appearance of their IK artefacts and other aspects of the community knowledge. In Figure 6.1, this is indicated by arrows pointing *outwards* from the centre. Informal teaching and learning would continue in the communities as the learners continue to integrate the school science methodologies acquired from their schools with their IK, IK artefacts, and strategies as they try to broaden their understanding of the world. Learning would continue even when the learners engage in their every day social and economic activities. Traditional learning sites like mountaints and traditional learning platforms like dare/ remain centres of learning and teaching. Indigenous learning tools like games packaged with wisdom, knowledge and values are also integrated with werstern games in the communities.

Community members would do informal evaluations, consciously or unconsciously, as they witnessed improvements in the efficiency and physical appearance of their IK artefacts, and also engage in the socio-economic changes. This allows the intrinsic efficiency and efficacy of IK and its associated artefacts as tools for economic, personal, societal, and global development to be identified, validated, and accredited. The feedback from the communities would be through interactions with the teachers and the learners. The feedback may lead to adjustments, where and when necessary, of both content and pedagogical approaches to the curriculum. This process thereby encourages a dialogue between school and community in facilitating the integration of IK and associated IK artefacts into school science. Such a school-community link has already been suggested in the literature (Aikenhead (2001).

What actually happens at the micro-level in the central part in Figure 6.1 as implied by insights from community elders, physics teachers, and learners is described next in Section 6.3 and illustrated in Figure 6.2 on page 180.

6.3 The Physics Concepts Attainment-IK-Integrated Pedagogical Model (PCA-IK-IPM)

This section provides an expansion and clarification at a micro-level of what the proposed macro physics concepts attainment-IKS-integrated content model (PCA-IKS-ICM) infers should happen in its innermost part of Figure 6.1 (i.e., the bull‟s eye). Here I show in particular how the main components of the teaching process are perceived, according to the research findings discussed in Chapter 5.

The expanded part of the PCA-IKS-ICM shown in Figure 6.1 is now termed the physics concepts attainment indigenous knowledge (IK) integrated pedagogical model (PCA-IK-IPM). It is illustrated in Figure 6.2 below. Figure 6.2 shows details of the expected interactions among the teachers, learners, community, and the environment, as implied by the research findings.

6.3.1 Complexity of Pedagogy

This core or bull‟s eye of the model from Figure 6.1 is, in my opinion, the „black box‟ of the model. I call it the „black box‟ of the model because the interactions that occur there are complex and some actions and situations cannot be captured or described fully. The other reason is that the teaching processes, including classroom practice and activities, do not follow a neat sequential order or specific approach. Strategies, techniques, and methods used during the teaching process are often situational; that is they depend on the situation and context. Activities in the teaching process cannot be executed linearly; stages are not sequential or standardized, so they cannot be serially carried out. I drew this insight from (Ogunniyi, 1986), who revealed that in some situations scientists do not follow the rules of logic and instead deploy practical or experimental reasoning, intuition and sometimes serendipity. Diwu (2010, p. 64) calls this intuition "happy coincidence". The dynamics of science are, in some cases, non-linear and emergent and this aligns with what actually happens in practice with a good teacher in the real teaching process.

6.3.2 Explanation of the terms used in the Physics Concepts Attainment – Indigenous Knowledge – Integrated Pedagogical Model (PCA-IK-IPM)

A concept is defined by Mayor (2009b) as an idea of how something is, or how something should be done. Huddleston and Pullum (2005) define a concept as being a principle or idea. The term „concepts‟ in the name of the pedagogical model represents the ideas, notions, conceptions, abstractions, principles, theories, laws, equations, formula, skills etc. of physics.

The word „attainment" means the state of having successfully obtained, reached, achieved, accomplished, gained, or done something difficult that one has intentionally worked for. Mayor (2009b) defines attainment as achieving something or reaching a particular level of achievement. In the context of this study it means attainment of physics concepts. The name of the model „The Physics Concepts Attainment-Indigenous Knowledge-Integrated Pedagogical model (PCA-IK-IPM)" therefore implies the integration of IK in teaching of physics in a way that enables learners to understand the ideas, notions, conceptions, abstractions, principles, theories, laws, equations, formula and master scientific skills that are the heart of this study.

6.3.3 PCA-IK-IPM framework as an integrated pedagogical approach

The model enshrines an integrated pedagogical approach that allows physics teachers and learners to explore, gather, process, refine, and present information about the physics concepts encountered in the physics class with the aid of their IK artefacts and associated IK strategies. It is informed by responses from participants to the research questions in this study. The model reduces the constrains imposed by current conventional physics pedagogical materials, environments, approaches and strategies, which have little connection with the context, culture or home experiences of the indigenous physics learners and even the physics teachers.

The physics concepts attainment – indigenous knowledge – integrated pedagogical model (PCA-IK-IPM) model exploits the interconnectedness and interrelationship between classroom physics and the IK artefacts that were revealed and discussed in Chapter 5. The learning and teaching processes implied in the model revolve around themes and IK artefacts and associated IK strategies that were revealed in the research findings, and which are relevant to the learners. IK artefacts are connected and unified with the Advanced Level mechanics and sound concepts in ways that were directly revealed or implied by the exploratory research findings. Connections among specific IK artefacts, physics concepts, and community needs were established in these findings.

The model allows teaching and learning of physics concepts by using IK artefacts as meditational tools for the important components of the teaching process. IK strategies and IK artefacts are used as a mechanism for meaningful conceptual attainment and to enhance effective learning. The model presents a pedagogical intervention approach in which IK and associated IK artefacts are used in the creation and transfer of meanings of physics concepts to indigenous learners. The PCA-IK-IPM adopts as its cornerstone both IK artefacts (that is their properties or structure, shape, design, and the skills of making and using them) and the indigenous teaching strategies, methods, approaches and techniques employed by the indigenous people when transferring skills between people. Both aspects emerged from the study. In the model, integration of IK artefacts acts as a way of bringing the school closer to home, and the experiences of the learners closer to school, to facilitate understanding of school science concepts by learners. IK and IK artefacts are also employed to work as lenses through which learners make sense of events and concepts taught in the physics lesson. The IK and IK artefacts are used to facilitate the learners" access to real classroom physics without departing from the demands of the curriculum and the fundamental physics principles, laws and theories.

The model indirectly reinforces and extends the learning and teaching of physics to incorporate relevant IK artefacts. The model will allow teachers to artfully fuse information about artefacts and even the physical properties of the artefacts into regular physics lessons in order to facilitate understanding of the concepts by the learners. This emergent model is an IK artefact-based convergent integration approach, in which effective knowledge is hybridized and infused from both western and indigenous knowledge systems and used in the laboratories as teachers teach and also as learners learn physics principles, concepts, laws, and theories. The findings indicate that the teachers, elders, and learners can provide theoretical or instructional frameworks, patterns, or examples for some physics topics and concepts.

A model of teaching is seen by Joyce and Weil (1980) as a plan or pattern that can be used to shape curricula, to design instruction materials and to guide instruction in the classroom and other learning settings. The findings informs the theoretical or instructional frameworks, patterns, and provide examples of some ways of integrating IK artefacts into the pedagogical components such as teaching techniques, teaching methods, teaching approach, classroom climate management, selection, and development of instructional support materials including instructional technology and activities when teaching Advanced Level physics.

6.3.4 Interactions and their characteristics in the Physics Concepts Attainment-Indigenous Knowledge-Integrated Pedagogical Model (PCA-IK-IPM)

The interactions featured in the Physics Concepts Attainment-Indigenous Knowledge-Integrated Pedagogical Model (PCA-IK-IPM) are insights derived from the emergent themes and findings that answered the fourth and the fifth research questions. These implied important characteristics for the main components of the teaching process shown in Figure 6.2 and classroom practices that reinforce effective integration of IK artefacts in the PCA-IK-IPM. Classroom practice refers to any strategic intention, act, or activity that teachers and learners experience within the context of the classroom, which ideally have a formative effect on the mind, character, or physical abilities of learners.

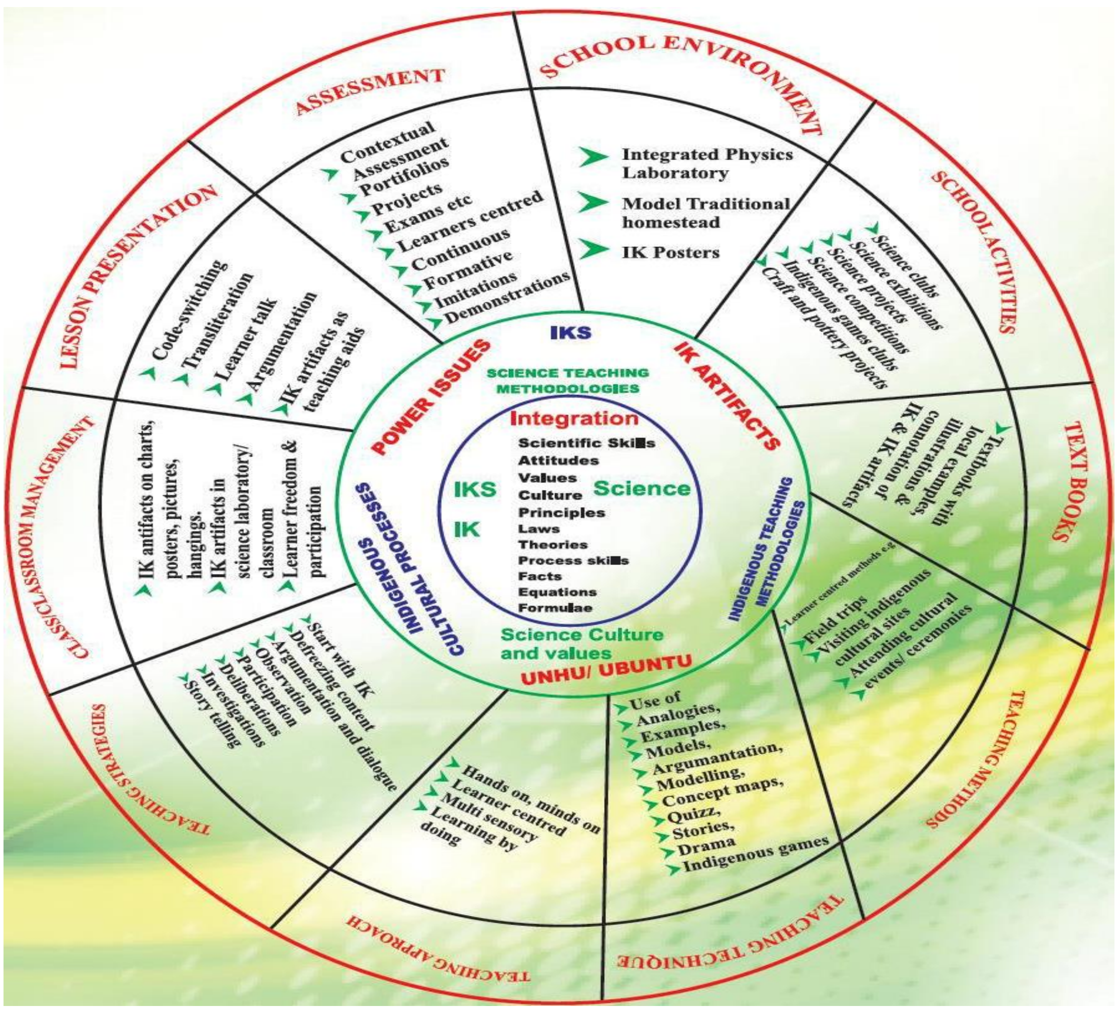

Figure 6.2: The Physics Concepts Attainment-Indigenous Knowledge-Integrated Pedagogical Model (PCA-IK-IPM)

The main components of the teaching process shown in Figure 6.2 include teaching methods, teaching strategies or approaches, teaching techniques, instructional technology and media, assessment, and classroom and class management and the school environment and activities. The findings discussed in Chapter 5 show that the main components of the teaching process, as indicated in Figure 6.2 which forms part of the "black box" of the model, should have special features some of which are indicated in the figure. These features of the teaching process components derived from the findings would allow effective integration of IK and IK artefacts in the teaching of physics and acquisition of physics content (including principles, laws, and theories), scientific attitudes, values, and scientific process skills by learners. Examples of these special features are also indicated in Figure 6.2 and they will be discussed in Section 6.3.5.

Scientific skills are skills developed during science processes. Scientific process skills are a set of skills used in conducting scientific activities, producing, and using scientific information and problem solving. (Chiappetta & Koballa, 2004). The skills are some of the tools that are necessary for the production and use of scientific information, to perform scientific tasks, to conduct research and to solve problems. Mutasa and Wills (1994, p. 7) divide the skills into four categories, as shown in Table 6.1.

Table 6.1 Scientific Process Skills

Scientific skills	**Description**
Thinking skills	Making hypothesis. Devising experiments to test hypothesis. Explaining phenomena. Solving problems. Planning etc.
Practical skills	Careful and systematic observations confidently, accurately and safely. Taking measurements. Carrying out experiments etc.
Communication skills	Orally or in written form-presenting insights, observations, solutions. Comprehending instructions from others. • Using appropriate language, symbols and signs to communicate scientific information
Social skills	• Working as a team, cooperating • Cooperating • Honestly in reporting results • Relating science to everyday experience etc.

Scientific values should also be inculcated in the learners. Abrusscato (1998) argues that there are many values of science, which learners can develop at school as they experience the processes of science and learn the content of science. Values (a part of culture) have always been taught in science, whether explicitly or implicitly (Hildebrand, 2007). The values taught explicitly are those from government policy and curriculum planners that are reflected in the syllabus documents. Examples of values of science include those indicated in Table 6.2.

Table 6.2 Values of Science

Values	**Explanation**
Truth	Discover, record and report the truth
Freedom	Operating in an environment that provides freedom to follow paths wherever they lead
Skepticism	The unwillingness to accept at face value that which is presented to us by the natural world
Originality	Develops from creative thinking or thinking inductively which allows development from specific observations to more general interpretation of what we observe
Order	Gather information and organize it
Communication	Communication of results to their scientists, beyond the scientific community and to the public

Scientific attitudes include persistence, curiosity, objectivity, cooperation, creativity, humility, self-discipline, and commitment.

6.3.5 IKS- Knowledge, Skills, and Values

The features of components of the teaching process derived from the research findings should also facilitate acquisition of knowledge about IK artefacts and IKS, *Ubuntu/Unhu* and appreciation of respective indigenous cultures, as indicated in Figure 6.2. These were derived from the research data that had been gathered and then analyzed and discussed in Chapter 5. These features allow contexts and pedagogy to be selected in view of the indigenous learners" indigenous home experiences and learning styles.

6. 3.6 Detailed Description of components in the PCA-IK-IPM

6.3.6.1 Teaching Methods

Teaching is a process of conveying an instructional message to learners using an identifiable method. A teaching method is the *modus operandi* of teaching, or the way in which information is transmitted to the learners (Egunza, 2014). A teaching method includes the principles and methods used by teachers to enable child"s learning. Teaching methods describe the instructional process; not only of how information gets from the teacher to the learners but also how the learners use it, interact with it, receive guidance and are given feedback (Egunza, 2014). Mnkandla (1996) defines a teaching method as a way of doing things, which is accompanied by procedures and activities. Teaching method, therefore, refers to the general principles, pedagogy and management strategies used for classroom instruction. A teaching method describes conceptually the whole teaching process, starting from where the teacher begins to present the instructions in class, through to the teaching strategies or approaches and teaching techniques. These are the sub-sections of teaching methods.

The research findings from this study indicate that IK artefacts can be integrated into the teaching processes and give insight into how the integration can be done based on the views of the elders, teachers, and learners. For example, the use of mortar and pestle can be used to teach concepts on stability of objects and center of mass.

6.3.6.2 Teaching Strategy or Approach

A teaching strategy or approach is defined by Knott and Mutunga (1995) as the overall way to which the process of instruction is organized and executed. They further argue that a strategy can either be expository or discovery. Whichever strategy is used, IK artefacts can be made available to enable learners to understand the concepts. For example, teachers may allow learners to interact with IK artefacts that show aspects related to physics concepts during and after the lesson to enable them to consolidate the concepts taught.

6.3.6.3 Teaching Technique

A teaching technique is a detailed learning activity, according to Knott and Mutunga (1995), which is usually of short duration, and used during an instructional process for a specific purpose. Examples of such techniques are video playback, buzz groups, poster design, and quizzes.

The teaching methods, teaching strategies or approaches and teaching techniques should, as indicated in Figure 6.2, ensure that the physics or science content being taught or knowledge to be imparted and the IK artefacts to be employed as meditational tools should be derived from the knowledge of indigenous people and not necessarily scientists, that is community elders, teachers and learners. The Ministry of primary and secondary education should re-conceptualize their idea of a „school" and consider the whole school as a community of learners, teachers, and community members with similar goals and experiences.

6.3.6.4 Instructional media and instructional technology

The PCA-IK-IPM in Figure 6.2 included instructional technology and instructional media to be critical and necessary aspects in the teaching process. Shumbayawonda and Maringe (2000) define instructional technology as a systematic way of designing, carrying out and evaluating, by means of a combination of human and non-human resources, the total process of learning and teaching in terms of specific objectives, based upon research in human learning, communication, with the intention of bringing about more effective instruction. Instructional technology thus involves the planning and designing of instructional media, as well as the process of building, constructing and evaluating such media and their functions. Mawere, Shava, Mapolisa, Ndamba, and Makura (2006) argue that while instructional media are resources, instructional technology is a process that is meant to improve learning. In the context of this study, instructional technology would involve the acquisition, use and production of the relevant IK artefacts, together with their use as integral part of the teaching and learning of physics concepts.

Instructional media can be understood to be audio-visual or related materials that serve instructional functions for education and training (Kemp & Dayton, 1985). These include whatever material is selected or designed for instructional purpose. Their role is to send out some information and make knowledge accessible to the learner.

In the PCA-IK-IPM, IK and the indigenous artefacts are considered to be part of the cultural tools that can serve the purpose of sending information to learners and make knowledge accessible to the learner. This idea resonates well with that of Kota (2006) who posits that teachers must use all the available resources from the learner"s community to broaden the curriculum and to provide better learning. When IK artefacts are used as instructional aids, teachers and learners should remember to focus on the "big idea" being looked at.

The research described here among the elders indicated that IK artefacts exist in the community and the elders would use pre-existing IK artefacts as instructional media to teach other people about the artefact or other artefacts. They would use these as examples or as apparatus in experiments or as models for demonstration of some skills. The PCA-IK-IPM requires that the teacher, in consultation with the learners and the community members, should help in the selection of relevant instructional technology and media. Teachers should explore different IK artefacts linked to the topics in the syllabus to use as instructional media. Shumbayawonda and Maringe (2000) argue that the selection of media for teaching process cannot be haphazard. The instructional media should be carefully selected from a collection of IK artefacts. The selection of instructional media should be guided by a specific curriculum policy that takes into account learners needs, budget, physical space, personal requirements and the guiding philosophy of education. In terms of philosophy, decolonization, and indigenous knowledge systems, the PCA-IK-IPM requires that the prior knowledge and culture of the learners to be respected and incorporated in the teaching and learning process.

The teacher must recognize that to adopt an IK artefact for specific lesson objectives and concepts they must have some experience of its manufacture, use and local relevance to be able to link the related physics concepts connected to it and decide on the level of understanding of the artefact by the learners. Generally, before bringing them into the lesson, teachers should familiarize themselves with the artefacts, by asking community members for samples and to describe their function and use in everyday contexts. They must also ensure that the particular

artefact would also fit the learners‟ capabilities. Initially, such lessons may be trial and error, but with peer involvement, the selection and effective use of the artefacts can be consolidated.
Teachers should also check whether learners would learn accurately and effectively when the IK artefacts are used. The PCA-IK-IPM requires that teachers use the IK artefacts expertly, not only as visual meditational tools in the process of assisting learners to expand their ZPD, but also to move the learners to higher cognitive reasoning levels, which would enable them to make sense of the new concepts and go even beyond them. Sarwadi and Shahrill (2014) caution that misconceptions may result when IK artefacts are integrated in the teaching process. Misconceptions are scientifically incorrect ways of reasoning adopted by people when trying to understand their surroundings, which Duit and Treagust (2003) argue may be due to their observations and questions being answered by family members, friends or schoolteachers, before coming into contact with physics teaching in schools.

With regards to misconceptions, Ball, Thames, and Phelps (2008) argue that one of the tasks of teachers is to identify and interpret learners' errors, misconceptions, and alternative algorithms. Teachers can detect misconceptions through student centred activities, using argumentations, frequent dialogues and written reports, and should correct them, to avoid the propagation of students' physics misunderstandings (Duit & Treagust, 2003). Duit and Treagust (2003) add that, if unnoticed, uncorrected, misconceptions can grow stronger with further experiences, further misunderstandings of school teaching, and the development of cognitive competences with age. However, there can be a situation of “the blind leading the blind” when teachers also have misconceptions. South African researches has revealed that teachers, who are the very people entrusted with addressing learners‟ misconceptions, often have misconceptions themselves (Molefe, 2013; Ngxola, 2013).

According to the PCA-IK-IPM, teachers should consider the communities as rich sources of instructional media, which is available for teaching and learning purposes. Teachers and learners, with the help of elders, can gather samples of relevant IK artefacts from communities, thereby also creating an entrepreneurial partnership where schools or sponsored companies can pay for the supplies of artefacts. The samples of the IK artefacts can be preserved for future use in the school foyer by creating a museum or display panel. Teachers should also design files or portfolios to record and store relevant instructional media together with their indigenous classification systems and their descriptions of the physics concepts perceived in the artefacts and propose ways of integration these in preparation for instructional teaching. The PCA-IK-IPM incorporates the community, teachers and learners as co-participants in the production, gathering and preservation of IK artefacts to use as instructional aids. In this way IKS can have currency and benefits for future generations. Folios or portfolios are a record of classified aids, articles, research papers, presentation papers or various hand-outs about IK artefacts. They can also include samples of real IK artefacts or their models. Egunza (2014) argues that these records are important because no one has a photographic memory to remember everything about the artefacts.

6.3.6.5 Sequence in Lesson Presentation

Drawing from the findings on how IK and knowledge about the IK artefacts were taught in the community, the PCA-IK-IPM proposes strategies that teachers can use to present these in lessons, which allow learners to understand concepts presented through their IK and related IK artefacts. Before introducing a concept, teachers should start by identifying any relevant misconceptions that exist among the learners, so that they can make informed decisions on how to proceed. Learners often have conceptions about science concepts and phenomena that differ from established scientific understanding; commonly referred to as alternative conceptions (Caleon & Subramaniam, 2010). Teachers may explain a physics concept by first casting it in indigenous terms to which the learners can relate, and then continue by explaining the indigenous way of understanding, and by looking at the IK artefacts. After learners have understood the concepts presented in the indigenous way, they can then be explained in western terms to show how the conventional and indigenous physics complement each other.

When teaching, the teacher may also employ a technique of starting by identifying the physics concepts observable in the artefacts, and in the process elaborate some physics concepts. He or she may resort to using parts or the whole of artefacts to bring out meaning or to simplify concepts. Such a teaching style should encourage active observations, interpretations, and explanations by the learners. This is as was observed in the field interviews with elders as was valuable to understand complex content or artefacts (Appendix M). This may stimulate learners to learn physics in a smart and enjoyable way and also to construct school physics content and pedagogy from their own experiential ideas. This process will help science teaching where learners would have to construct and modify knowledge from parts of artefacts and code it in their mental schemes to allow understanding of concepts. The teaching behavior of teachers should adopt various features of constructivist-oriented science classrooms. In these classrooms, teachers provide, for instance, cognitive activity by addressing thought-provoking questions as well as incorporating conditions that support conceptual change such as dealing with everyday phenomena familiar to learners (Widodo, 2004). Elicitation of students pre-instructional knowledge and dealing with students‟ conceptions during instruction, are some of the key phases of conceptual change approaches promoted by constructivist-oriented teaching sequences (Driver, 1989). The teachers have to guide learners step-by-step from the learners‟ own ideas to the scientific views using IK and IK artefacts. The PCA-IK-IPM acknowledges that the community or societal knowledge manifest in different indigenous artefacts can be used to enhance the construction of new and modification of old knowledge.

The PCA-IK-IPM also requires that the curriculum support materials and teaching instruments of teachers show evidence of integration of IK artefacts in his or her teaching process. E. Chiappetta, Koballa, and Collette (1998) assert that teaching instruments are documents that teachers use to organize, guide, and track the progress of instructional activities. Teaching instruments include schemes of work, lesson plans, records of work and students‟ continuous assessment (Chiappetta et al., 1998).

6.3.6.6 Analogies

The PCA-IK-IPM requires that teachers regularly refer to some IK artefacts or their characteristics in their lesson presentations in order to build bridges between the known and the unknown. In some situations, pointing out analogies, metaphors, proverbs, similies, songs, poetry, and relationships that have connotations with IK and IK artefacts are a way of bringing IK, IK artefacts and associated indigenous pedagogical techniques into physics teaching. This may involve incorporating IK artefacts in conjunction with appropriate analogies in class. The use of analogies is a teaching technique that was revealed in the focus group discussion with the elders.

This strategy is supported by many science educators (Duit, 1991; Duit & Treagust, 2003; Mintzes et al., 2005; Treagust, Harrison, & Venville, 1998). Leach and Scott (2003) see analogies as simplified models established on familiar concepts and intended to elucidate abstract concepts. The PCA-IK-IPM recommends adoption of familiar IK artefacts blended with analogies as potential learning resources for improving learners" sense-making of new physics concepts.

The model requires that teachers use repertoire of well thought out and well prepared teaching analogies, providing contexts that would enable learners to understand concepts and to construct their own knowledge, rather than being passive recipients of information from the teacher. Analogies may promote the cognitive development of physics conceptions based on the familiar experiences and contexts. The PCA-IK-IPM values the intermingling of experience, culture, and practical activity in acquiring the physics content.

Misconceptions may arise from the use of analogies, especially when links between the analogy and the concepts are based on misunderstood preconceptions, they must be addressed. Sarwadi and Shahrill (2014) posit that if the misconceptions are not addressed they may lead to rote learning, which does not promote sense-making of the new concepts. Misconceptions are difficult to address and this can only be done by employing a different meditational tool (Sarwadi & Shahrill, 2014). Different IK and IK artefacts can provide a fresh approach for addressing the misconception because they are mediation tool that is familiar and within the learners" experiences. Despite the negative effect of using analogies, Sinatra, Kienhues, and Hofer (2014) maintain that misconceptions serve as pointers to the content gap between physics knowledge and the real world application. This indicates the potential of this way of integrating IK artefacts into the teaching of physics concepts.

The PCA-IK-IPM explicitly acknowledges misconceptions and see them as catalysts in the learning process because they are viewed as a natural stage of conceptual development, as suggested by Sinatra et al. (2014). They provide an opportunity for teachers to discover learners" current knowledge and how they construct new knowledge. Teachers may select critical tasks and activities that embody known misconceptions; this may help learners to test their thinking and see how and why various ideas might need to change.

6.3.6.7 Games and Drama

The PCA-IK-IPM holds the suggestion that teachers may also employ indigenous games like stones (*Nhodo*) and drama as methods of teaching. This was implied in some of the indigenous teaching methodologies incorporating child play (*Mahumbwe*) discussed in Chapter 5.Corbi, Santos, and Burgos (2019) argues that games provide a novel way of visualizing ideas when performing the predefined motions needed to master the associated techniques. Games are packaged with a lot of wisdom, knowledge and values (Kuyimba, 2016).

Drama is recommended as one of the methods in the sociocultural, sociolinguistic tradition contributing to constructive learning in science (Abrahams & Braund, 2012). Odegaard (2003) observed that drama assists learners in understanding and learning about the nature of science, about relationship between science and society and even about learning science concepts. Lemke (2001) argues that meaningful learning occurs by engaging in social activities. Drama events or episodes offer learners new insights into the reality of the processes of scientific practice.

Aikenhead (1996) argues that drama can improve the learners‟‟ empathy and identification in socio-political situations of science and may challenge learners‟‟ worldviews. Abrahams and Braund (2012) argue that use of drama in teaching science increases learners' interest and engagement in science. The history and politics of science and physics development integrated with IKS can be developed through drama and play. There is over 20 years of research into the use of cross-curricular drama in secondary science, which has indicated that this medium enables learning of affective, cognitive and procedural knowledge (Widodo, 2004). Widodo (2004) posits that to-date, academic research has tended to frame successful drama pedagogy as resulting from a Drama-in-Education approach, incorporating extended role plays and simulations of social events. Some sports-related activities that may be involved in drama episodes can foster intuitive knowledge about Physics (Corbi et al., 2019).

Pedagogical episodes in the drama may include good management of class and classroom space, continuous monitoring of group planning and role play preparation and the ability to link the played actions to science and physics in particular. Learners share ideas, practice skills, and apply concepts when performing drama episodes where IK and IK artefacts are involved.

Science teachers should allow learners to work in groups, make IK presentations, make drawings of IK artefacts, use real life IK scenarios, use argumentation and co-operation in groups, work on inquiry-based activities, and draw from the resources of learners‟ own experiences. The PCA-IK-IPM requires that the teacher select activities associated with indigenous artefacts that illustrate some physics principles in a range of different contexts, so that the learners can practice the ability to recognize and apply the abstract principle being learnt in unfamiliar contexts. An abstract principle learnt in a single context leaves learners understanding the concepts only in that context and with little insight into the abstract principle itself. The PCA-IK-IPM requires that teachers constantly look for opportunities to direct learners‟ attention to the wider social, environmental and cultural issues associated with the learners‟ work.

6.3.6.8 Argumentation

Part of the PCA-IK-IPM requires that the teacher encourage learners to put forward their own ideas, to explore and debate points of view. Learners should have freedom to express themselves where their contributions are considered as tentative suggestions. They should be able to ask questions and engage in discourse that promotes critical thinking. As learners argue and justify their views they develop good habits of the mind of questioning and relating ideas to society or current events. This implies that PCA-IK-IPM requires teachers to employ an argumentation instructional method.

Considering perspectives from the socio-cultural theory adopted for this study, interactive classrooms, argumentations, and conversations may help learners clear their doubts, improve current knowledge, acquire new attitudes and reasoning skills, gain new insights, make informed decisions, and even change their perceptions (Stears, Malcolm, & Kowlas, 2003). This is in line with the observation made by Fakudze (2015) that science education research endorsed the concept of argumentation as a possible teaching and learning strategy. Argumentation instruction is a method of teaching and learning, in the course of which the teacher creates opportunities in class for learners to argue about and discuss freely a particular topic in a situation where learners can possess varied view points and worldviews (Ogunniyi, 2007; Treagust & Duit, 2008). Different perspectives of a subject are expressed by opposing groups or individuals with the hope of reaching a consensus. (Ogunniyi & gawa,2008) see many advantages to argumentation instruction. For instance, learners learn to articulate their reasons for supporting a particular claim while striving to persuade or convince others about the truthfulness of such a claim. This provides a critical environment for learners to externalize their doubts, clear up misconceptions, and reflect on their ideas and those of their peers, in order to arrive at clearer and more robust understanding of a given topic than would otherwise have been the case (Ogunniyi & Ogawa, 2008). These interactive classroom, argumentations and conversations may help learners to clear up their doubts, improve current knowledge, acquire new attitudes and reasoning skills, gain new insights, make informed decisions and even change their perceptions (Stears et al., 2003). The teacher interacts with learners in a way that brings the cultural and physics content to life.

The PCA-IK-IPM requires the argumentation process to follow the traditional African, approach as was revealed by the findings. Nafukho (2006) is of the view that the African approach of argumentation and debate is not confrontational and violently rejects the idea of establishing who is right or wrong. He adds that it focuses more on building of consensus through overlapping and carefully dovetailed interventions than on oppositional jostling.

This kind of learning approach is implied in the teaching approach adopted by elders when teaching their children about artefacts and other topics at the village court (*Dare*), as was discussed in Chapter 5. Activities during the lesson should involve listening, receiving feedback, encouraging, and handling conflicts. The teacher should have the skills required to guide learners, deal with issues of power, identity, and connectedness. The teacher should address power issues by giving up his or her monopoly on knowledge and rather assume the role of facilitator of classroom discussions. Odora-Hoppers (2002a), a widely respected IKS scholar, suggest that integration of IKS should be through critical engagement that also addresses power imbalances between not only epistemologies but between teachers, communities, and learners.

The PCA-IK-IPM requires the teacher to invite and welcome learners ideas in a way that allows dialogic teaching approach which Calcagni and Lago (2018) view as a teaching approach characterized by the acknowledgement and emphasis on the learners's views and voices. This is in line with the ideas from the theoretical framework on which the study is based, that of

Vygotsky‟s social constructivism.

This emphasizes the importance of social factors in the acquisition of knowledge (Matthews, 1994). The PCA-IK-IPM enshrines the argument that learners construct concepts as a result of social interactions, and the help of instruments or meditational tools and persons are necessary for understanding of concepts and performance of activities. This agrees with the ideas of Freire (2009) that teaching is a social practice, a cultural action, because it is concretized in the interaction between the teacher and the learner, and through the use of the method of dialogue it reflects the culture and social context in which it belongs. The teacher may give direct instructions and questions to learners during the lesson as part of his or her strategies.

The PCA-IK-IPM expects teachers to not rely heavily on textbooks for information, although they should regard them as repositories of consensual physics concepts. Textbooks do not offer sufficient help for teachers on how to integrate the community‟s IK when teaching physics concepts to indigenous learners. In Shizha's (2007) view, textbooks document „fact‟ and „truth‟; they are written in such a way that gives access to physics content. Nevertheless, the multiple presentations, examples, demonstrations, and discussions through which the content is mediated are all based on the authors‟ worldviews and culture. The PCA-IK-IPM expects the teacher to be able to adjust textbook subject matter content and his or her subject matter knowledge in order to communicate with the learners.

Standard A level textbooks are invariably imported. Consequently, they lack approaches related to IKS. School science curriculum materials such as textbooks use examples and principles remote from the majority of learners‟ lived experiences (Gwekwerere et al., 2013). So according to the PCA-IK-IPM they will be of little assistance, and maybe even a hindrance, in the effective integration of IK artefacts in the teaching of physics. Clark and Ramahlape (1999) found out that learners‟ under-achievement in science was due to the subject being presented in textbooks as a fixed body of knowledge and as absolute truth. This added to the problem of science teaching being dominated by textbooks in English and English as a medium of instruction. Milne (2011, p. 20) adds that school curricula and science core textbooks do not consider IK, which is considered to of lesser value importance. Teachers should therefore find unique ways of presenting the textbook content that is relevant to the class they are teaching, by using additional visual media like IK artefacts. This is the recommendation arising from this exploratory research, in the models presented in Figures 6.1 and 6.2. If textbooks are to be used, these two models indicate that they should include local IK and related IK artefacts to indicate some standardization to teachers about which IK and IK artefacts to include in teaching and assessment, particularly for examinations. Examples and illustrations in textbooks should also refer to intellectual property rights of IK, to avoid perpetuation and plunder of IK and its related artefacts. The PCA-IK-IPM requires that an appropriate analytical tool should be designed to analyze textual materials and used to reduce misconceptions and errors in the materials as textbooks.

6.3.6.9 Indigenous Languages

The PCA-IK-IPM respects that learners‟ indigenous or home language and indigenous terms may be retained and then used as basis for learning the language and terms that are conventionally scientific. Language is an important tool for incorporating IK into school science (Shizha, 2005b). The model in Figure 6.2 includes indigenous languages as they can be used when explaining concepts. Code switching, transliteration, and classroom talk by learners should be allowed to ensure effective communication of ideas (Quiroz, 1999). This would allow learners to ask questions in their own language for better understanding of the concepts and the teacher could then serve as the translator from the indigenous language and codes to the scientific language. Learner talk would highlight the extent to which learning process has taken place as learners construct new conceptions.

In the PCA-IK-IPM, learning is considered to be a social process, in which language plays an important role. This is indicated in the sociocultural theory that forms part of the theoretical framework for the study. The teacher needs to find ways of scaffolding the language of the learners, so that it will measure up to the language requirements in the physics community in order to close the gap between IK science ideas and the classroom physics. The language used in science teaching is a challenge for learners because it contains foreign words, which have specific meanings according to the context of use (Kurwa, 2016; Oyoo, 2007). The PCA-IK-IPM indicates that learners are encouraged to show their scientific knowledge through both the use of

scientific words and non-scientific or non-academic or everyday language.
This allows a learning environment to be established where learners feel comfortable dialoging in science and no longer see the home and the school as being in opposition to each other. Learners express their ideas freely and unashamedly when teachers facilitate classroom communication and interactions that resemble family–like settings (Cronje et al., 2015; Rahman, 1999). Furthermore, as Shizha (2007) observed, learners taught in their home language perform significantly better than those taught in English. Cronje et al. (2015) argues that the use of indigenous language allows learners to assimilate information faster than when the language of learning and teaching is foreign. Nevertheless, terminology of the local language cannot encompass all the concepts in science (Dziva et al., 2011; Shizha, 2007). The PCA-IK-IPM directs teachers to work with the learners and knowledgeable people in their communities and the elders to create convenient or working vocabulary to name or describe concepts or scientific processes, laws and theories.

The PCA-IK-IPM allows teachers to sometimes borrow from European vocabulary and merely modify it pronunciation so that it sounds like some convenient indigenous terms. This creates a sense of ownership of the knowledge by the learners. Kibirige and Van Rooyen (2006) maintain that owning a type of knowledge brings joy and satisfaction to the learners and it is highly likely that in that situation the learners would increase their retention of the new concepts taught. The model also allows teachers and learners to give meaning to accessible words needed to explain the concepts, rather than borrowing from western languages by phonetic transcription. This would result in the development of a mother tongue nomenclature for science and technology education with some IK and IK artefacts connotations. This necessitates the development of modern scientific vocabulary in African languages.

The PCA-IK-IPM encourages teachers and learners to respect cultural protocols, preventing the breaching of cultural taboos about use of some terms, respecting the principle of *Unhu/Ubuntu*. This would solve the common argument among the stake holders or detractors or opponents of IK to justify the absence of integration of IK artefacts in conventional texts, which is that there is lack of scientific terms in the indigenous languages like the Shona language of Zimbabwe. This argument was also noted and dismissed by Dlodlo (1999). He observed that when the indigenous

Africans were introduced to European technologies and tools, they created their own vocabulary to name and describe them. For instance, in Zimbabwe we created a word for cellphone in our respective indigenous languages, for example, in Shona we call it "*mbozharunhare"*. When learners engage in learning science, they construct meanings and develop understandings in a social context that includes the language with which they are familiar. The language is normally embedded in the learner"s society"s cultural practices, IK, and IK artefacts. In this regard, Duit and Treagust (1998) argue that much meaning making occurs through classroom discourse, which is teacher talk and learner interaction using familiar or common language. This dispels the myths of the need for a special language for school science, and that truly scientific knowledge can only be taught through the colonial scientific languages such as English, French, Portuguese, or Spanish (Corsiglia & Snively, 2001).

The PCA-IK-IPM indicates that teachers should incorporate examples and contexts that relate to the learners" culture and interests, which would assist them in extending and constructing their knowledge in ways that engage diversity and broaden their perspectives. When we introduce principles, theories and laws of physics, there should be a link with the indigenous knowledge of the learners.The lack of opportunities for learners to draw from their everyday experiences and ideas and to use their own voices had been linked to disengagement from learning and a decrease in motivation and academic performance (Aguiar, Mortimer, & Scott, 2010; Morales-Doyle, 2018). The PCA-IK-IPM requires that the teachers elaborate on the link between the IK artefacts and the conventional laboratory equipment when issues or opportunities arise.

Challenges may arise where learners pick up an unintended meaning from the artefacts, especially when the learners learn the artefact rather than the concept it is meant to illustrate, or when they lack the necessary imagery to grasp the meaning embedded in the artefacts. Some learners may also lack the skill of identifying the boundary between the artefacts and the reality that the artefact represents. To overcome these challenges the PCA-IK-IPM implies that teachers may introduce the concept that the artefact is intended to show and find out what ideas learners already have about the concept.

6.3.6.10 Class, classroom management, and indigenous spaces

The PCA-IK-IPM indicates class and classroom management to be important components of the teaching process. These are discussed next together with assessment.

a) Class and classroom management

Class management refers to how the teacher manages the class when teaching; how the teacher introduces the lesson, how he or she develops the lesson, and how the teacher makes the learners learn. This is done through management skills such as demonstrations, questioning technique, involving learners in meaningful learning activities (Figure 6.2). Class management also involves how the teacher motivates learners and reinforces concepts through a variety of techniques. In short, class management involves the actual teaching the teacher discharges with his or her class. Learners assist each other and learn from each other in order to achieve set goals.

Classroom management is the organization and arrangement of the classroom in order to enhance pupils‟ learning (Egunza, 2014). Egunza (2014) adds that classroom management involves planning activities, organizing how those activities will be carried out, the resources required and general arrangement of the areas in the classroom. Classroom management refers the classroom appearance; for example, display of charts, fliers, arrangement of furniture, creation of a nature corner and maintenance of discipline. The environment is the sum total of the physical and human qualities that combine to create the space in which learners and adults work and play together. The environment includes all the conditions that affect the learners‟ surroundings and the people in it.

The PCA-IK-IPM requires that classrooms be characterized by a supportive and interesting environment, which is in turn characterized by respect, care, and security. Teaching should involve the provision of an environment for effective learning (Egunza, 2014; Mukwambo, Ngcoza, & Chikunda, 2014). There must be deliberate, systematic control and manipulation of the classroom conditions were learning occurs (Webster, 1995). The PCA-IK-IPM indicates that teachers should respect the learners‟ beliefs, curiosity, abilities, and learning strategies; all of which are rooted in their respective indigenous communities. Layder (1998) advocates teaching that emphasizes respectful relationships achieved through engaging learners in conversations that elicit their experiences and stories. The PCA-IK-IPM shows that the learning environment should provide a restful, restorative place and offers a sense of security, as described by Vogel (2008).

The learning environment should thus be relaxed and physically, morally, and psychologically non-threatening. The learning environments associated with children‟s play (*Mahumbwe*) and the village court (*Dare*) observed during the data collection implied such environment, which proved to be effective in assisting children with understanding the concepts taught.

The teacher‟s effort to inculcate *Unhu/Ubuntu* in learners should also be evident in the classroom environment and all activities associated with it. Accordingly, teaching should involve inculcating moral values, abilities, and skills by an experienced person in order to ensure positive changes in the behaviour and development of learners and subsequently society. This adheres to the main idea drawn from the theoretical framework for the study, which is that learning science occurs within social settings (Mortimer, Scott, & Leach, 1994), which is similar to the idea from Duran, Dugan, and Weffer (1998) that learning of science is a discursive and cultural process. The teacher should allow learners to form different constructions and give different emphasis on their outcomes in relation to physics and IK knowledge.

The PCA-IK-IPM requires that classroom displays and charts include a fair mixture of concepts from both IKS, with IK artefacts, and western or conventional physics apparatus, which may reduce the chances of stigmatization of the IK artefacts. This decolonizes the visual instructional media space in both the classroom and the minds of the learners by creating a physical indigenous space in the classroom and psychological indigenous space in the minds of the indigenous learners. Learners can begin to learn about physics concepts embedded in the displayed IK artefacts and everyday practices through observations, inference, and prediction and other learner centred techniques.

b) Assessment methods

The PCA-IK-IPM indicates assessment to be an important component of the teaching process. In the PCA-IK-IPM, assessment strategies and procedures should depart from the current situation where, as reported by Klassen (2006), factually based problem solving questions serve as summative, high-stakes assessment after the completion of the syllabus in the classroom. Klassen (2006) further notes that tests and examinations have strict time limits, which are consistent with short and specific responses or answers to the test items.

There little room for the reflective or creative thoughts of the learners, since tests and learning objectives are equivalent (Shepard, 1991). In the Advanced level Zimsec Physics syllabus 6032, Paper 1 involves many selected response tests like multiple choices which test. The free response questions in Paper 3 primarily focus on particular concepts, for example, definitions, short explanations, and exemplar type of problems in which the learner applies a law or principle to determine numerical or algebraic solutions, Tests are constructed from the curriculum sections in a uniform fashion. Results from tests are processed and analyzed using inferential standards and have validity only in terms of the probability that the constructs are adequately represented in the test. As (Gunzenhauser, 2003) notes, educational assessment involves little reflective, engaged dialogue among the various stakeholders. The PCA-IK-IPM suggests that curriculum design; that is the implementation, monitoring, pedagogy, assessment, and evaluation strategies and procedures, should be devolved to schools to allow effective contextual assessment, which is also authentic.

The PCA-IK-IPM advances the idea of contextual assessment, as appropriate to the constructivist theory of teaching and learning. Contextual assessment is an assessment approach in which the procedures and tools present information, questions and tasks in such a way that learners are able to construct meaning and give responses based on their own experiences. Contextual assessment emphasizes problem solving and recognizes that teaching and learning occur in multiple life contexts for learners and infers that assessment tools and procedures should accommodate these differences. In the PCA-IK-IPM such assessment is made possible and effective by the intended outcomes being specified narrowly enough to ensure common achievements, but broadly enough to allow local interpretation in different districts and cultures. This would allow the curriculum to promote learners‟ acquisition of concepts in their local context, while being sensitive to international or even global imperatives and contexts.

The PCA-IK-IPM allows assessment to be done in the context of everyday survival and should reflect real life (out of the classroom) tasks that require learners to use critical thinking skills (Crotty, 1994). The PCA-IK-IPM allows science assessment to satisfy the goals of the individual in the classroom and those demanded by society (Klassen, 2006). Findings from this research have indicated that indigenous communities are practical in their approach to knowledge acquisition, transmission, evaluation, and assessment.

According to the PCA-IK-IPM, by integrating IK artefacts in the assessment part of the teaching process, competency of learners should be tested in a real world context. The implication of the research findings as expressed in the PCA-IK-IPM is that contextual assessment methodologies that allow authentic assessment should be employed. Scientific inquiry assessment and evaluation tasks carried out by teachers and school-based learners currently do not reflect the core attributes of authentic scientific reasoning as observed by Chinn and Malhotra (2002). Authentic assessment is a form of assessment in which students are asked to perform real world tasks and projects that demonstrate meaningful application of essential knowledge and skills (Fakudze, 2015; Lemke, 2001). Stephen (2010b) defines authentic assessment as that which is construed to be more consistent with what people do in situations that occur naturally in real life outside the classroom.

Authentic assessment differs from performance assessment in that performance assessment is performance-based, but with no reference to the authentic nature of the tasks (Scott & Meyer, 1992; Stiggins, 1987). The PCA-IK-IPM requires that contextual and authentic factors such as usefulness and everyday applicability or the influence and advice of others are relevant to items taught and so should be included in design and application of assessment tools like tests and examinations. Contextual assessment methodologies include concept mapping, performance assessment, and portfolio assessment.

The PCA-IK-IPM advocates that learners should be assessed through projects or tasks, and produce portfolios that involve their IK artefacts, home experiences, and familiar indigenous contexts, in which they could prove that they have acquired and mastered the required skills and concepts. These insights were derived from the indigenous ways of assessment that were revealed in the responses of the participants and the observations made in the communities by the researcher. These projects and tasks could involve making, using, evaluating, and improving IK artefacts. Learners could also look at IK artefacts that have equivalent functions to some western artefacts as part of their projects and tasks. For example, Wolcott (1999) describes how learners of the Alaska First Nations can make snowshoes, which show the use of concepts in science such as pressure and surface area, and these can be compared to snow skis used by

Europeans. Such projects would involve consolidation, practice, and application of the learnt concepts and skills in the physics lessons. The other project approach proposed in the PCA-IK-IPM involves a situation where learners are assigned or choose a topic for in-depth study.
The learners produce a report that can be assessed or presented to the class or panel of examiners by the learner. This promotes independent learning and individualized teaching. It can also encourage initiative and creativity among learners.
The PCA-IK-IPM indicates that imitation and demonstrations may also be included as assessment tools. Learners may be given tasks and skills to imitate or demonstrate using IK artefacts. These can also be effective ways of checking whether learners have acquired the intended concepts, skills, values, and attitudes.

Portfolio assessment has emerged as a popular method for learners to exhibit their classroom work and demonstrate their understanding, progress, achievement and attitude in a particular subject area or across the curriculum (Berenson & Carter, 1995; Klassen, 2006). A portfolio is a systematic collection of a selected learners' work (Popham, 2002). Portfolios contain consciously selected examples of a learner's work that are intended to show the learner's growth toward important learning goals.The work is a reflection of the learner‟s abilities over a wider range of instances, as indicated in the PCA-IK-IPM. This provides a more realistic measure of the performance of the learners.

The PCA-IK-IPM indicates that assessment of practical performance should also be adopted. This would release pressure on educators from accountability based on multiple-choice and norm-referenced testing (Khattri, Reeve, & Kane, 1998). This is a form of performance assessment would involve learners demonstrating science process skills and knowledge they should have acquired, in a practical hands-on activity. In this activity learners are provided with laboratory equipment and requested to use the equipment to solve a given problem. This approach is similar to that proposed by Ruiz-Primo and Shavelson (1996b). Such an approach contrasts with the traditional practical work in science education that all too often involves learners following a highly structured, step-by-step approach, explain, or justify their work to themselves or even to others. This has led Hodson (1991) to conclude that school practical work is ill-conceived, confused and unproductive for in which teachers dominate and control the

sequence of activities, while learners play a passive role (Wellington, 2002; Zion & Sadeh, 2007). The step-by-step procedure is laid down by the teacher or the recommended textbooks. This kind of approach does not give learners any chance of higher level engagement or reasoning, such as questioning procedures, generating their own testable hypothesis or proposing reasons for anomalous results (Preethlall, 2015). The nature of such practical tasks does not
require learners to learners. According to the PCA-IK-IPM learners are expected to use context sensitive strategies, critically analyze the results, and link these with their indigenous home experiences, IK, and IK artefacts. The model requires that tasks involved in practical activities present new situations to learners the answers are not derived from factual and procedural recall, which would affect the validity learners‟ practical results , and summative evaluation.

In this regard, the PCA-IK-IPM indicates that a physics learner is a learner who has learned, modelled, and thoroughly assimilated the physics concepts and habits through the relevant indigenous habits, IK, IK artefacts, and technologies of indigenous communities. The PCA-IK-IPM allows learners to be judged by demonstrating explicitly the concepts learnt using IK and IK artefacts, for example, concepts on stability of objects and centre of mass in classroom physics in his or her own indigenous context. This perspective concurs with those of Odora-Hoppers (2001) and Seepe (2001), who emphasize that efforts in curriculum transformation or change require that learning and achievements for African learners be not pegged onto an elitist culture that centralizes European values and marginalizes all that is African.

The research findings are generally in support of continuous and formative assessment that is learner-centred assessment; that is, assessment in which learners are given maximal opportunities to show what they know and can do in their own context with the classroom physics, integrating their own culture and learning styles. According to the PCA-IK-IPM, although assessment should largely be carried out by teachers, it can also include contributions form peers and the community elders. Teachers should always give learners activities to which they can relate and which they can approach from the viewpoint of what they already know. The PCA-IK-IPM requires that the teacher to always look for opportunities to direct learner‟s attention, as they study physics to also consider the wider social, cultural, and environmental issues associated with their work, in order for them to be able to interpret their own environment. Both the out of school experiential contexts and school science contexts should be integral parts of the assessment programs and assessment items. This insight is from Gunstone, Gray, and Searle (1992) and Villani (1992), who maintain that scientific concepts exist in both there outside-school experiential form and in their school–science form. Considering various contexts in assessment enables a clear picture to be produced of whether the conceptions the learner acquired are correct and relevant and can be applied effectively.

The PCA-IK-IPM also requires that aesthetic aspects be included in assessment tools like examinations and tests questions, for example, "How would you improve the design and efficiency of two indigenous artefacts of your choice?" Teachers should give assignments to learners that require them to inquire about specific indigenous knowledge and IK artefacts or practices in their families and communities and then to discuss the knowledge in class (Keane, 2006). This enables learners to enjoy the beauty of IKS and associated IK artefacts. It would also continuously remind the learners about the link between classroom physics and IK artefacts.

c) <u>Activities of the School</u>

The PCA-IK-IPM shows that schools that offer physics should organize activities for all learners, not only the science learners that foster learners‟ interaction with indigenous artefacts to promote their effective integration in the teaching of science in the school. This should increase the learners‟ understanding and appreciation of the IK artefacts‟ design, structure, shape, use, and associated ideas, together with the physics concepts embedded in them. This may also enable learners to appreciate the role of indigenous technology and its link with the IK artefacts. These activities may include establishment of science clubs, which can then organize activities that promote learners‟ interaction with IK artefacts. These activities may include visiting indigenous communities to see and use IK artefacts, visiting museums or even carrying out archeological excavations. This resonates well with views from Cocks, Alexander, and Dold (2012) who propose the idea of taking learners to places (e.g., nature, museum) where they can learn about indigenous knowledge.Science exhibitions and competitions can be held annually at a school. Initiatives could also include an exhibition room, which one may call an „indigenous laboratory‟, where relevant IK artefacts that with some physics concepts perceived in them are kept or displayed. Competitions that involve IK artefacts and physics may be organized to stimulate research on IK artefacts and the teaching of physics. Competitions may lead learners and teachers to think more deeply about IK and associated IK artefacts. This may also add humor and invoke interest in the subject.

Integrated Physics Laboratories

The PCA-IK-IPM recognizes the value of locally developed and owned pedagogical innovations and initiatives such as integrated physics laboratories and model traditional homesteads among others, in schools that offer physics to indigenous learners. The PCA-IK-IPM requires that schools be encouraged to establish what I call „integrated physics laboratories". These are laboratories in which relevant IK artefacts (or their models) and conventional apparatus are kept together. Models are representations of the real IK artefacts. These could be produced by elders in the community, by teachers or by the learners themselves. Models have features that are similar to those of the real objects and can be equally effective in putting across physics concepts. The relevant IK artefacts (or their models) and conventional apparatus kept in the integrated laboratories are given same status and value. Establishing separate equivalent laboratories, one with IK artefacts and another with conventional apparatus would create unnecessary comparison, competition, and stigmatization by teachers, learners, community members and other stakeholders. The laboratory technicians in charge of these laboratories should have knowledge of both IK artefacts and conventional apparatus.

During focus group discussions, the elders bemoaned the disappearance and even extinction of some of their useful IK artefacts, so the creation of these laboratories may enhance preservation and conservation of IKS together with their associated IK artefacts for use by future generations. The laboratories stimulate the learners and teachers to be curious, creative, and critical, to think about, and to discuss how to solve problems. Elders can help in building these integrated laboratories as well. In situations where schools lack a budget to establish the physical integrated laboratories "Virtual integrated laboratories" may be established as also advised by Bogusevschi, Muntean, and Muntean (2020). These may have latest technological advancements that provide 3D virtual learning environments that support simulations and observation of IK and IK artefacts in laboratory investigations and experiments. Lynch and Ghergulescu (2018) posits that Virtual laboratories are based on inquiry-based and self-directed learning which places the learner at the center of the learning process. Virtual laboratories are the answer to the problems faced by educational institutions struggling to offer Science students the experimental learning experiences they need (Lynch & Ghergulescu, 2017).

d) Model Traditional Homestead

Indigenous technology must be integrated with indigenous science, for example having a model traditional homestead with indigenous settings, traditional huts, and indigenous artefacts should be established in the schools' premises as a way of creating indigenous space in the school environment. The PCA-IK-IPM shows that this would serve as a permanent symbol of remembrance and reminder of the need to integrate IKS and its associated artefacts in science lessons, particularly in physics. The model traditional homestead would also serve as learning centre for both teachers and learners since some IK practices could be done there and an assortment of IK artefacts be kept there. This would give an authentic environment in which the learnt knowledge could be applied. If there was a model indigenous homestead, the facility would be a constant reminder for learners of the relevance of their classroom physics to their communities.

The number of outdoor activities at the school should be increased and should include IKS and related artefacts. Outdoor activities may include visiting cultural sites (e.g. Great Zimbabwe ruins) and taking part in indigenous cultural events like rainmaking ceremonies (*mukwerere*) and chiefs‟ installation ceremonies. Teachers could take the learners to places (e.g., nature, museum) where they can learn about indigenous knowledge (Aikenhead & Jegede, 1999; Khupe, 2014b). Among other benefits, this would increase the interaction of learners and teachers with the various indigenous artefacts. This concurs with the views of Millar (2010), who asserts that science teaching should involve showing learners certain things, or putting them into situations where they would see things for themselves and not merely telling them. The latter is unlikely to lead to understanding.

f) SimVillages

The establishment of what I called "SimVillages" also emerged as one of the strategies for creating IK space in the physical learning environments. This is a concept which I believe the participants borrowed from the idea of SimCity which is a simulation of the real- world city and not the city itself. They advocated for the creation of simulations of real-traditional villages where the learners and teachers would observe local traditions, songs, stories, games, dances, and creative-expressive indigenous artifacts and cultural activities like indigenous people making fire from friction, using clay pots for cooking, traditional shelters, craft like weaving, cooking, sewing, and pottery. SimVillages provide a powerful alternative means of experiencing a society that is relevant to the learners‟ lived experiences. Lived experiences describes the first-hand accounts and impressions of living (Doshi, Kumar, & Whitmer, 2014). This would give learners a chance to develop intimate relationship with the environment and promote innovation and advancement. This agrees with Ezeanya-Esiobu (2019) who argues that at the foundation of innovation and invention is the intimate knowledge of the environment within which the end product will be utilized. He also adds that researchers, inventors, and innovators who have an intimate relationship or understanding of the environment are often successful in developing technology or other products, tangible and intangible which impact the environment in deep and meaningful ways, often bringing about transformation and noticeable progress. Innovation involves doing new things (process of renewing, changing, transforming and creating more efficient and effective means, products, processes or ways of doing things (Ezeanya-Esiobu, 2019).

The science activities, integrated physics laboratories, the model traditional homestead and SimVillages should arouse and sustain the IK integration ideological and transformation commitment among the teachers, learners and the community. In the model, these symbols of remembrance are not designed to be merely distractions that could prevent learners from their real goals. Instead, they should also allow learners to apply and practice some indigenous and science process skills like observation, predicting and inferring (Govender, 2009). Lirenman and Wideen (2016) define observation as the determination of properties of an object or event by using different senses. Predicting is anticipating consequences of a new or changed situation using past experiences and observation(Chiappetta & Koballa, 2004). It therefore involves forecasting future events or behavior. Inferring is drawing a conclusion about a specific event based on observations and data (Lincoln & Denzin, 1994a). Inference normally involves giving reasonable, but tentative, conclusions or explanations about events or causes based on one‟s prior knowledge.

The PCA-IK-IPM facilitates awareness of the learners‟ learning needs and indicates how the teachers can assist learners to learn using their IK artefacts. It provides guidelines for the teacher to design IK integrated teaching strategies, techniques, activities and learning environments that would allow him or her to effectively reach more learners, by creating a richer and more diverse learning environment. The model provides a cross-cultural pedagogical paradigm for teaching Advanced Level physics that allows both physical and epistemological access to the subject by indigenous learners to Advanced Level physics.

The findings discussed in Chapter 5 and the PCA-IK-IPM presented here inspires a conceptual eco-cultural paradigm. An eco-cultural paradigm is a state in which the growth and development of an individual‟s perception of knowledge is drawn from the social and cultural environment in which the individual lives and operates (Jegede, 1995). The model proposes how new knowledge that learners encounter in physics class can be made easier to understand and more relevant by re-introducing IK artefacts together with learners‟ every day prior knowledge about these indigenous artefacts.

The PCA-IK-IPM reconnects indigenous artefacts and school physics in a way that was indicated by the study findings. The model enables IK and IK artefacts to reclaim and re-inhabit their traditional pedagogical space in the teaching of science, technology, technological skills, and related concepts. The important role of artefacts, together with their explanations, as objects of scientific inquiry was highlighted in the literature in Chapter 2 and through the findings of this study in Chapter 5. The PCA-IK-IPM thus redeems the African indigenous languages, philosophies, IKS, IK artefacts, and ways of knowing from the onslaught of neo-colonialism and globalization.

The PCA-IK-IPM radically modifies or redesigns existing methods of teaching and instructional delivery, so that the resultant instructional technique provides opportunities for personally meaningful, experiential, inquiry-based learning that is important in conceptual development for indigenous physics learners. The model also shows how the role of indigenous knowledge in general, and IK artefacts in particular, can be brought from the margins of physics education to its centre, thereby enriching
and improving the learning of physics and scientific enculturation by native learners. The models demonstrates how concepts from one knowledge domain (i.e., IKS) can be used to facilitate the learning of concepts from another knowledge domain (physics), which Jegede and Aikenhead (1999) called simultaneous collateral learning.

The PCA-IK-IPM shows how learning environments and instructional experiences can be manipulated, constructed, sequenced or delivered in a way that make indigenous artefacts and their properties an integral part of the whole teaching process. The model evokes a pedagogical perspective that emphasizes a hybrid of western science and IK together with its related IK artefacts in its associated approach, methods, strategies, and styles. The model attempts to instill changes in the learners and influence their thinking, feelings, attitudes, and values, and social interactions in ways that encourage them to transfer the new attributes to other real life situations and experiences and also to push back the frontiers in physics knowledge and in IKS. The new frontiers may involve designing and sending indigenous experiments in deep space probes into unknown galaxies, or the production of goods that conform to modern standards or to standards which are yet to be established and also into markets which are yet to be discovered. This agrees with ideas of Stephen (2010a), who asserts that the application of physics principles in the development of IK technologies will help in the production of goods that conform to modern standards which can be marketed beyond traditional communities. This may sound far-fetched but if one imagines what people thought the day when John F. Kennedy first talked about Neil Armstrong planning to go to the moon; one would not doubt this dream.

This stance is commensurate with the transformative agenda explained in the theoretical framework of the research study in Chapter 3. This dream is also enshrined in the 2012 Zimbabwe science and technology education policy where it indicates that research on relevant

IKS for current and future needs would help complement existing and emerging technologies(Hove & Zinyama, 2012; Republic of Zimbabwe, 2013). The model offers an alternative idea that can be implemented and also move research in science pedagogy towards unanticipated results.The PCA-IK-IPM portrays physics as a human enterprise and not as an esoteric subject to be encountered only in the school environment. The model would allow the provision of a worthwhile educational experience in physics for learners who wish to take up the subject as a career and would nevertheless benefit even those who might not wish to do so.

The PCA-IK-IPM advocates for community collaboration in the design, trial, use, management and maintenance of IK artefacts and infrastructure and both symbolic and materials tools relevant to physics curriculum and pedagogy. There should be dialogue between the school and the communities and principles of *Ubuntu/Unhu* should be cherished in the learning and teaching process. The model implies a minds-on and hands-on approach to teaching of Advanced Level physics. It is a transformation model of teaching and learning, which allows learners to be actively involved in the teaching and learning process, shifting from traditional teacher–centred education. In this regard, Yost, Senter, and Fonteza-Bally (2000) argue that a transformation model ensures active involvement of learners through doing research work, through inquiry and investigations, and by embarking on problem solving and adopting collaborative techniques. In such a model, learners are to be pro-active and engage in problem solving in the classroom and in their respective communities with the assistance of the teachers and the community elders.

Therefore the model strengthens physics pedagogy by making it less homogenous in terms of western values and intrests.The model has features of The Whole Brain Teaching strategy (WBT) as it pays close attaintion to the learners' four brain areas.Torio and Cabrillas-Torio (2016) define WBT as a brain based teaching strategy that targets the four learning areas of the brain (namely lecture,individual work, group work and practical displays) for holistic development.

The PCA-IK-IPM allows effective civic engagement and service learning where learners are connected with their community and can conduct science related studies in areas similar to those they have been taught in the classroom. Application of the PCA-IK-IPM therefore improves the relevance to and usefulness of school physics in the future careers and lives of the learners. As informed citizens they can solve community related problems using science and IKS knowledge in an integrated manner. Generally the PCA-IK-IPM offers ways of viewing, analyzing, handling, presenting, and teaching physics concepts that are an alternative to the abstract and sometimes alien western based approaches. It facilitates indigenous learner engagement and access to concepts in a more meaningful way. It shifts physics instruction towards meaningful culture-based learning though

teaching that is based on the components of the model. The model is intended to produce a perceptual shift from construing western artefacts and IKS and its associated artefacts as polar opposites in the physics classroom, to regarding the two domains as compatible and complementary. As Kapoor and Shizha (2010) asserts, IK and western science complement each other and are not necessarily oppositional binaries.

The approach advocated by the PCA-IK-IPM allows both indigenous and western philosophies, beliefs, spirituality, and technology to be used and also to be taught not in opposition or in isolation. The model requires that in all the customary instructional components, western artefacts and strategies may also be included so that they complement the IK artefacts in offering a broader appreciation of contexts beyond the local level and even beyond those contexts yet to be discovered. This allows the model to produce learners who are competent in making decisions about everyday life and in solving both local and global problems.

6.4 THE PCA-IK-IPM AND GLOBALISATION

African nations have been reduced to a state of absolute poverty and marginalization for many reasons; these include post-effects of colonization, tyrannical leadership, corruption and the effect of globalization on the world economy (Okoli & Atelhe, 2014). Globalization has a significant and often negative effect on African culture due to the ever-changing technological advancement, improvements in communication, changes in knowledge and skills. Odora-Hoppers (1999, p. 237) declared that, “Whether we like it or not, we are of two worlds, both western and African” and “the success of our renaissance will depend on how we position ourselves and reconcile the worldviews we have inherited”. The PCA-IK-IPM respects this view and also clarifies the two worlds indicated by Odora-Hoppers (1999, p. 237); but it adds a third world that represents IKS and IK artefacts of other regions which are not western (Figure 6.3), with which indigenous people also need to be reconciled.

The model respects that no country lives in isolation, and acknowledges that the indigenous knowledge and associated IK artefacts originating from indigenous people worldwide have made significant contributions to global knowledge. The model respects the need to teach IK, culture, values and worldviews of other non-indigenous people like those from the west. These must not come at the expense of the indigenous people"s values, worldviews, cultures, and knowledge systems. Every country is part of an international community and the global world. The PCA-IK-IPM enshrines the view that the physical universe can be understood by rational means in the IKS, western science, and science from the other regions. The model intends to produce learners who can accept membership in the international community with all the obligations and responsibilities, rights and benefits that this membership entails. These views indicate the need to spell out the position of the PCA-IK-IPM in the global context so that the graduates from a system in which it has been applied remain competitive in both local and global arenas. Figure 6.3 shows how the PCA-IK-IPM describes the intersecting relationship among the different IK and IK artefacts from different regions of the global arena and the proposed interactions among them in the teaching process. The intersecting perspective presents the most useful perspective to ensure that IK and IK artefacts of a particular region are not lost into other knowledge systems.

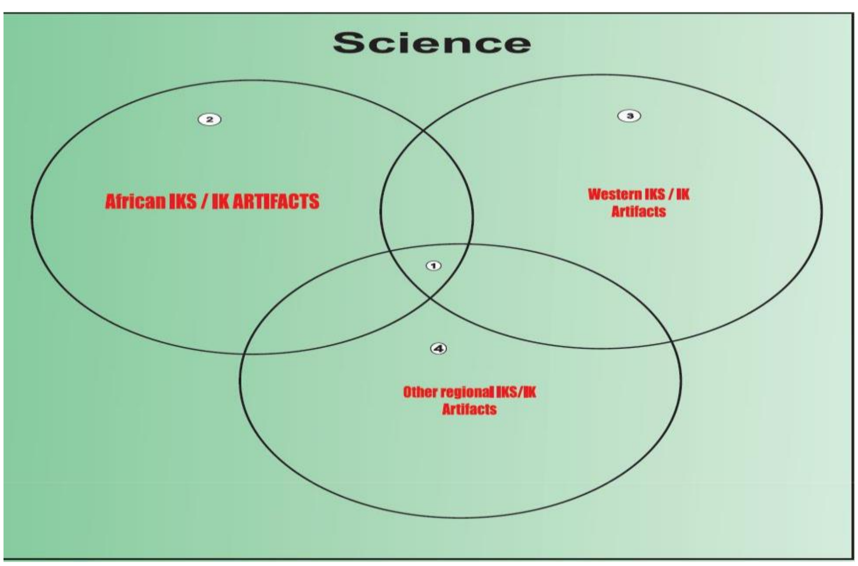

Figure 6.3: The PCA-IK-IPM and Globalization

African indigenous knowledge and its associated artefacts has its own space together with western and other regions represented by spaces labelled 2, 3, and 4, respectively. The space labelled 1 in Figure 6.3 indicates an area of overlap, where ideas from the different regions‟ IKSs and their associated artefacts complement each other in meaningful positive ways, to solve some real life problems like production of affordable agricultural emplements, scientific and science pedagogical problems of both local and global nature. It shows an area of integration and overlap, where the different knowledge systems and their artefacts combine in mutually supportive and inclusive ways that enable each to make a meaningful contribution to the solving of problems or issues of concern. In the space marked 1, one would also find „inter-epistemological dialogue‟, which Beck, Lash, and Wynne (1992) define as a type of reflexive learning that harmonizes different forms of knowledge in the learning process for the benefit of the learners. The dialogue can also move indigenous learners towards negotiating a new research order that would ethically engage different knowledge systems. In the context of the PCA-IK-IPM, this dialogue would allow for active engagement of IK and IK artefacts associated with the different knowledge forms.

The space labeled 1 also indicates that the model respects a peaceful co-existence or intermingling between scientific knowledge and different indigenous knowledge systems and associated IK artefacts with blurred boundaries among them. This insight was derived from Ogunsola-Bandele (2009), who asserts that science and IKS should be allowed to co-exist. This mutual space indicated 1 is where relationships among IKSs are established through construction, reorganization, and validation of knowledge, shared experiences and meanings as well as their symbols. It shows the epicentre of multi-scale interactions that may result in adoption, modification, adaption, and critique of epistemologies, values, and culture from other regions.

The space marked 1 also represents the philosophy of the multiplicity and diversity of knowledge enshrined in the core values of the PCA-IK-IPM. The space indicates that the PCA-IK-IPM rejects the idea of one form of knowledge dominating another. The model respects that there are different knowledge systems, including IK, which are empirically testable, and which are all concerned with understanding the same world. The model supports redistributive justice that is required by the current complexities of globalization. The PCA-IK-IPM requires that there is equitable and fair distribution of political space, physical space, pedagogical space, psychological space, and attention among the different knowledge systems and their respective IK artefacts in the physics education discourse. This would ensure that no knowledge system and its associated artefacts would be at some kind of unfair disadvantage, or not receive a fair and equitable share of attention and support. This is unlike the situation that afflicts most IKSs in Africa, as was revealed in the literature. In this regard, IK and IK artefacts should rather be used as instruments for attaining nationally and internationally recognizable standard of science education.

The PCA-IK-IPM is not a call to throw away ideas or ignore other knowledge systems, but it is a call to seek a constructive integration of the IK artefacts with other global knowledge systems, without disturbing the delicate power balances among them. It is anticipated in the model that all forms of knowledge, ways of knowing, and worldviews be acknowledged as equally valid, adaptable, and complementary to one another in equally valuable ways. Knowledge systems should complement each other, as noted by Muchenje and Goronga (2013). This agrees with insight from McCallum (2012) and Msila and Gumbo (2016) that indigenous and western philosophies, beliefs and spirituality cannot be used or taught in opposition or in isolation. This idea of integrating western and African knowledge systems was also stressed by Wiredu (2004). This allows learners to interrogate meaningfully different ways of knowing and choose what they see as being suitable for their situations. It promotes international consciousness and fosters positive attitudes towards other nations and their respective IKS.

The PCA-IK-IPM ensures globalization but maintain an intensive IK and IK artefacts presence in its approaches, strategies, and techniques. The model accepts that while the use of IK artefacts is important and effective, there are some new concepts associated with modernization where IK artefacts cannot be as effective as western IK artefacts in solving a problem. This ensures the model is applicable in the global context with minimal or no adjustments. Generally, globalization promotes the epistemologies and ontological realities and experiences of those who wield socioeconomic and political power (Shizha, 2013).

The PCA-IK-IPM adds a voice to the decolonization of science pedagogy agenda and creation of a meaningful, African indigenous space in the global science pedagogy. The model supports the struggle for Africans to own their own space at the global arena where they would view their world and see it through their own lenses rather than through colour tinted glasses of westerners, as observed by wa Thiong'o (1993). The PCA-IK-IPM privileges indigenous concerns, indigenous practices, and indigenous participation as required by the indigenous research framework on which the study is anchored as explained in Chapter 3.

6.5 FUNDAMENTAL PRINCIPLES OF THE PCA-IK-IPM

Drawing from the findings and themes that emerged in Chapter 5 and also on the features of the emergent model (i.e. the PCA-IK-IPM), Advanced Level physics teaching process should be anchored on the fundamental principles shown in Table 6.3. These include highly regarded and expected set of moral values that establishes a framework for expected behavior or culture and decision making when applying the model. These values are non-negotiable and even when the nature or goals established, context, strategies might change over time, these principles normally remain unchanged

Table 6.3 Fundamental principles of the PCA-IK-IPM

Principle Targeted	Description and Explanation
Guiding Philosophy	*Unhu/Ubuntu* (Humanism and communalism) is an African philosophy that respects the African way of thinking, seeing and interpretation of the world. Msila and Gumbo (2016) argue that IKS incorporates *Unhu/Ubuntu*, an African humanist philosophy, which is people-centred and focuses on mutual interdependence and collectiveness. Malunga (2006) aptly describes *Unhu/Ubuntu* as a cultural worldview that captures what it is to be human. This is a liberating philosophy that brings about social justice in the teaching and learning of physics. Msila and Gumbo (2016) describe African philosophy as a philosophy that encourages

	teaching and learning that deliberates and explores African experiences and perspectives. African philosophy emphasizes the optimization of the economic wellbeing of the people, social justice, tolerance, dialogue, cooperation, gender based equality, the quest for ecological balance and protection of the environment and a relentless quest for greater wisdom (Mazrui, 2004). It does not emphasize individualism as do the European philosophical worldviews (Msila & Gumbo, 2016).
Epistemology	Epistemology is a theory of knowledge or ways of knowing (Ankiewicz, De Swardt, & De Vries, 2006; Mitcham, 1994). The pedagogical content knowledge and skills are generated collectively with the teachers and community members basing on their own lived experiences and those of the learners. The teaching and learning of physics becomes a negotiated process, which is not based on empirical verification and falsification of facts and ideas (Le Grange, 2007b).
Value Perspective	Nakpodia (2010) defines culture as a way of life of a social group, which includes actions, values and beliefs that can be communicated from one generation to the other. Indigenous populations have been portrayed by their colonizers as uncultured, devoid of culture, primitive and backward (Msila and Gumbo, 2016). All human social groups have a culture. The model values pluralistic of values with possibilities of conflict and coexistence.
Axiological Perspective	The model values sharing and community satisfaction, which is a hallmark of indigenous communities.
Rationale	The provision of a balanced all-encompassing, culturally relevant pedagogical model ensures a multiplicity of explanatory world views and epistemological orientations.
Aims	To improve on the understanding of physics concepts by learners and to produce learners who are deeply rooted in the *Unhu/Ubuntu* philosophy that allows for humanness, interdependency in the community, sharing, empathy with others, caring environmental stewardship, and community cultural sensitivity, which breeds and promotes self-esteem and patriotism.

Physics and the nature of scientific inquiry	The teaching of physics should be consistent with the nature of scientific inquiry. The basic principles and processes of scientific enquiry should be maintained, although there is integration of the indigenous artefacts in the teaching process. The findings from the study do not challenge the nature and processes of scientific enquiry. The results only indicate that the IK artefacts can be part of the teaching and learning enhancement tools or scientific visual mediators which can be used to help learners understand physics concepts. This is in line with Vygotsky"s idea of the ZPD and the concept of „scaffolding" that were included in the theoretical framework of the study. The integration of IK artefacts must not change the physics concepts, laws, theories, and principles. In lessons where an IK artefact like a yoke (*joko*) has been integrated in the teaching of moments in physics, the concept of moment and the principle of moments are not to change but should enhance the understanding of the two concepts by learners. This principle allows physics to be seen as a discipline that can be understood through different ways that can sometimes be integrated to make them more effective in helping people understand it. This view is shared by Kawagley et al. (1998) who argues that there is no one way of thinking and understanding science.
Teaching process and IK artefacts	Strategies and techniques should be based on the IK artefacts of Community members, teachers, and learners. That the IK artefacts have sustained communities for many years means they are important and relevant to their respective communities, along with the physics concepts embedded in them. Therefore integrating them in the teaching of physics concepts will not only preserve them but also provide opportunities for them to be refined to make them more effective and efficient. The findings indicate that IK artefacts were being used to effectively solve communities" problems and pass on ideas and skills from one generation to another. This means that they can be identified and brought into the physics classroom for the same roles.
Nature of the teaching and learning	Teaching should be a collaborative process involving community members, teachers, and learners. Teaching and learning should be socially mediated; therefore the society should be involved. There should be socio-cultural engagements that are mediated by culturally

Processes	constructed tools such as IK artefacts. Teachers, learners, and community members should be considered to be holders of knowledge hidden in pieces of indigenous artefacts around them. The knowledge should also be regarded as valuable in transmitting ideas to the learners. The research findings and the themes that have emerged indicate that local artists and artisans like potters, carvers, weavers, or musicians may be among human resources that can be invited into the classroom to augment the learning by the learners. They would assist teachers in demonstrating, presenting, and describing IK artefacts and their relevant features in the physics lessons. These would also help the teacher in identifying the curriculum physics concepts and practices that are inherent in some of the IK artefacts for effective integration in the physics lessons.

If these principles are observed, then teaching would now involve the art and skill of blending aspects of the artefacts and the relevant conventionally recommended instructional or pedagogical strategies to enable learners to understand concepts. This implies that the physics teacher‟s knowledge of physics should be organized from a teaching perspective, which differs from that of a physics content specialist, who organizes according to a research perspective. Pedagogy is the practice of teaching; framed and informed by a sharedand structured body of knowledge (Pollard, 2010, p. 5). This means that physics curriculum planners and teachers should understand the nature of IK artefacts as much as they understand the nature of physics, since such knowledge would inform the appropriate ways of integration of the artefacts in the teaching of the subject.

6.6 ADVANTAGES AND DISADVANTAGES OF THE PCA-IK-IPM

Considering the implied characteristics of the PCA-IK-IPM, it was noted that the model has strengths and limitations. It is important to refer to the apparent strengths, limitations, and findings of a piece of research. The advantages and disadvantages of the PCA-IK-IPM are indicated in Tables 6.4 and 6.5, respectively.

Table 6.4 Advantages PCA-IK-IPM

Category	Explanation
Opportunities	The model allows for opportunities and prospects for integration of IK artefacts in the teaching of physics in a way that is consistent with the nature of science and scientific inquiry.
Appreciation of Indigenous Knowledge	Integration allows learners to appreciate the importance of their prior knowledge when they enter the physics class. This resonates well with Chinn and Malhotra (2002), who argue that integration allows learners to reflect on the viability of their prior concepts and this enables them to negotiate shared meanings and reformulate new, more meaningful ideas.
Creation of healthy partnerships among teachers, learners, Members of Communities and Community institutions.	Integration of IK artefacts forces teachers to create healthy partnerships with members of communities and community institutions that avail facilities to provide learners with access to knowledge and experiences that extend and compliment the learning experiences in the physics classroom. This resonates well with the views from Gwati and Chasokela (1995), which are that teachers should maintain a harmonious, dignified and healthy relationship with the community. They advised that, this could be done by participating constructively in the community projects and other important community activities such as water supply projects; attending major social functions and gatherings, such as agricultural shows, funerals, and weddings for local people, rain making ceremonies and chief installation ceremonies. This engagement will assist the teacher to identify with the local people and community, thereby enhancing his or her personal image and understanding in the community (Shumbayawonda & Maringe, 2000). This is in agreement with the research finding that *Ubuntu/Unhu* should also

	be one of the virtues the teacher should cherish. The teacher is also encouraged to visit the homes of his or her learners to get a better understanding of their home background including the IK artefacts found in their homes. At such visits the teacher should avoid getting embroiled in controversial or personal attacks and feuds. Marrison and Mclntyre (1980) caution that each time the teacher wants to visit the parents, he or she should get clearance from the school principal.
Community Improvement	With access to indigenous artefacts that reflect the experiences of learners and their communities, the PCA-IK-IPM encourage teachers to integrate them in their teaching to encourage learners to think reflectively and to be proactive learners. Pillay (2011) revealed that learners will reflect on their roles as agents of change in their communities. She adds that an approach which includes communities such as this, takes learners out of the classroom, allows them to bring about improvements in their communities and allows the practical application of knowledge in their daily lives. She further alluded to the approach allowing learners to know (understand), feel (make meaning) and do (apply the skills and concepts) as contributing members in the communities. Clark (2006) notes that integration of IK artefacts would negate the blind spots and fissures currently existing in science education. It leads to sustainable development through promotion of local solutions and a healthy, sustainable lifestyle, environmental protection (Breidlid, 2013).
Engagement with science concepts	Artefacts facilitates learners‟ interaction and active participation in learning and this facilitates effective engagement with science concepts (D Hodson, 2008; Wellington & Osborne, 2001).
Ownership and Control of	The integration of IK artefacts in the teaching of physics instills in learners a sense of ownership, control, and responsibility. Freire

Knowledge and Pedagogy	(1994) suggests that allowing learners or individuals to have ownership of their knowledge is equivalent to respecting their culture, tradition and identity. Learners must not only be competent
Humor	Science teaching is often perceived as overtly serious, ephasising cognitive rationals deprived of laughter anf fun(Roth, Ritchie, Hudson, & Mergard, 2011). The integration of IK artefacts in the teaching of physics adds humor to content and motivates learners. This can lead to the development of positive attitude towards the learning of science in indigenous communities (Jegede & Okebukola, 1991).
Wisdom embedded in the IK artefacts	The model necessitates rediscovering and redefinition of the lost wisdom embedded in IK artefacts and re-examine its value for the present day. Western knowledge has taken over the IK in communities (Semali & Kincheloe, 1999; Shizha, 2005a).
Valuing and maintenance ofIK Artefacts	The model recognizes and re-establishes IK artefacts. The teaching approach allows the indigenous learners to value and maintain the IK artefacts of their elders (Kasanda et al., 2005; Ng'asike, 2011).
Motivation of Learners	The PCA-IK-IPM stimulates learners‟ understanding and interest in the lesson. Learners will no longer view scientific knowledge as alien to their cosmological knowing (Asabere-Ameyaw, Dei, & Raheem, 2012). It reduces the foreignness that non-western learners may feel in a science class (Mashoko, 2014).
Evoking the embodied self and Embodied serves amongst learners	When a familiar invironment is created in the learning area and instruction by way of intergration of IK artefacts and the learners' indigenous language, learners will go through their school and classroom life in a less disembodied state and they will not miss on some of the positive contributions that their experiences can make in their learning processes.
Classroom and textbook-based Physics	As there is lack of laboratory exposure among the indigenous learners, IK artefacts integration will alleviate learners from experiencing only classroom or textbook-based science, which leaves them illiterate in issues relevant to their own lives and communities

	(Chinn, 2007).
Cultural identity	It connects learners with their culture and brings back the role of parents, community, and elders into education (Mawere, 2015; Msimanga & Shizha, 2014). IK contributes to cultural identity, whereas, although western science promotes career opportunities, it has no respect for cultural knowledge (Odora-Hoppers, 2005) .
Parents and teaching of physics	Give parents the opportunity to demonstrate the concepts at home and even at school, which supports Vygotsky sociocultural view that learners learn through social interactions. This will enable learners to view physics as a human enterprise rather than as an esoteric subject that is only encountered in the school environment (; Diwu & Ogunniyi, 2012; Hewson, 2012; Kim, 2015).
Saving the Environment	IKS inclusion will create an awareness of the destruction of natural environments and the denigration of African natural habitats and suggest the ecological action to be taken (Le Grange, 2004).
Widen knowledge Base of learners And teachers (Widening perspectives)	The PCA-IK-IPM exposes learners and teachers to diverse epistemologies, methods, and methodologies. These offer alternatives and broaden horizons for research. There are several options in the world of knowing or doing the same thing in different ways; referred to as "two-eyed seeing" (Aikenhead & Elliott, 2010, p. 336).
Motivation	Opening the classroom to learner participation reinforces motivation, increases their interest, and promotes learning. It helps learners to be participative and critical in learning, seeking grounds for claims made in the classroom.
IK artefacts and	IKS may attract foreign learners and research students who want

foreign learners	something different. Learners from other countries may be keen to know about IKS from other countries.
Relevance	It makes classroom science more relevant by teaching knowledge using IK artefacts that are relevant to the learners‟ daily lives (Keane & Malcolm, 2003).
Teaching from Known to the unknown	Using IK as a tool makes western science more accessible for all; moving from the known to the unknown (Mawere, 2015).
Decolonization	The PCA-IK-IPM emphasizes the decolonization of people‟s minds and advocates against the perception of IK as inferior (Abdi, 2006; Breidlid & Botha, 2015; Dei, Asgharzadeh, & Bahador, 2006; Dei & Simmons, 2009).

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The disadvantages of the PCA-IK-IPM are discussed in Table 6.5.

Table 6.5 Disadvantages PCA-IK-IPM

Category	Explanation
Language Of science and IK artefacts	There may be inappropriate use of language and the language of science. There may be no suitable terms in English to use or describe the complexity of concepts related to some IK artefacts.
Availability And Costs Of IK artefacts	Parents may not be available to deliver or afford the artefacts for use in the schools.
IK artefacts And foreign learners	It is not effective when we want to attract foreign learners. They would also want their artefacts to be considered and integrated in the teaching process.

Integration of IK artefacts And pseudo-physics	In the study, teachers indicated that they would be afraid of teaching pseudo-physics when they integrate IK artefacts into classroom physics, because the features or design of the artefacts are not a result of scientifically proven ideas and methods. This agrees with ideas from Cronje et al. (2015), who observed that teachers fear that they could be teaching pseudo-science when they integrate IK into western science. In my view this idea pays little heed to the idea that soup will taste the same, irrespective of whether you use a plastic or metal spoon, or that using blue or yellow sunglasses has no effect on structure of objects observed. The two analogies show that using the indigenous African eye or the European eye to view physics does not change fundamental physics principles. I believe that tools or apparatus have little effect on introducing misconceptions if properly connected.
Infringement Of The Epistemic right of learners	Horsthemke (2004) believed that the inclusion of myths, beliefs, fabrications, and superstitions can be seen as an infringement of the epistemic right of learners.

6.7 A CRITIQUE OF THE PCA-IK-IPM

In order to avoid being uncritical and over romanticising IK and its associated artefacts in the PCA-IK-IPM, as if all their aspects are impeccable, an impersonal and intellectual critique of the emergent model is needed, done in a way that does not essentialises the IK and associated IK artefacts. Essentialisation enables a group of people to protect themselves from legitimate assessment, evaluation, and criticism by others, but being open to critical comments only from those within the group. The insight was drawn from Le Grange, Accurso, Lock, Agras, and Bryson (2014) who assert that people should avoid over romanticisation of IK.

The PCA-IK-IPM was developed with the community of elders, teachers, and learners. It is the product of a collaborative endeavour among the three groups of participants. It was conceived from the interaction, persuasions, and negotiations among these research participant groups. The

PCA-IK-IPM is thus a collaborative product of shared insights and kaleidoscopic contributions among the elders, teachers, and learners. Community elders, teachers and learners and are empowered by being involved in the process of reforming their own pedagogy and the curriculum, they become owners of the model, and the model is more likely to be adopted and applied successfully. However the views of the samples of the participants on which the model is based cannot be a true representative of all the community elders, teachers, and learners in Zimbabwe.The model indicates that teachers and the elders in the communities should be actively involved in designing the pedagogy. Teachers collaborate with IK holders such as community elders and IK artefacts production specialists. Teachers invite them into the classroom, as also noted by Hewson, Javu, and Holtman (2009). While, this inclusion of end-users adds relevance to the physics taught in the schools and applicability of the teaching model, the idea of non-subject specialist (community elders) contributing to the designing of the model may, however, lead subject specialists to doubt its effectiveness and acceptability among academics.

The proposed teaching-learning feedback in the PCA-IK-IPM allow for much better channels of communication than the customary one way communication channel offered by the traditional transmission model in teaching (see Figure 6.4).

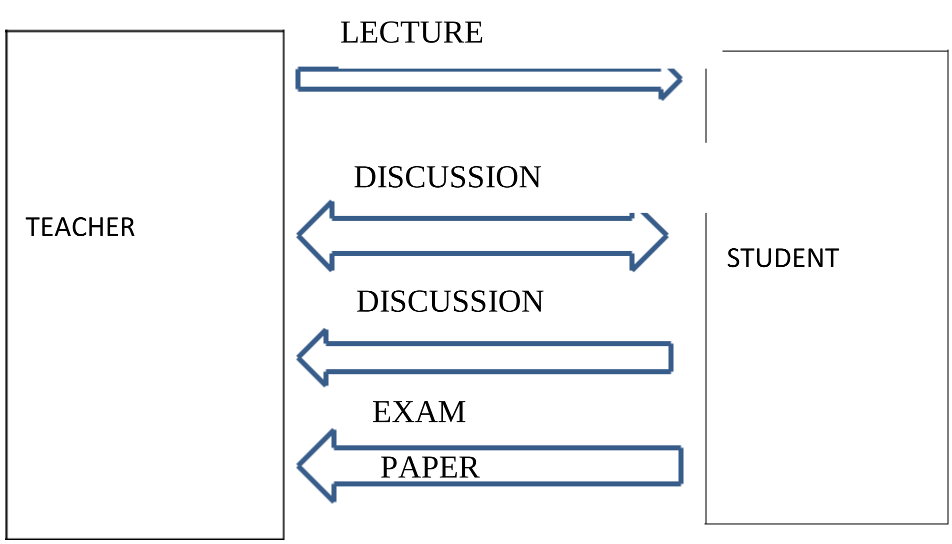

Figure 6.4: Traditional Teaching/Learning Feedback communication channel (mostly one way) [Adapted from http// teaching uchicago edu/etc/94-95/trends html]

Figure 6.4 shows that the teaching and learning feedback communication channel in the traditional model is mostly one way. The teacher is in control of every activity and all the programs that are involved in the teaching process. The traditional model respects the “banking” metaphor of Friere (1999, p. 99), which describes the idea that learners are just passive recipients of knowledge in the teaching and learning process. Yost et al. (2000) refers to this as the transmission model where teachers transmit or pour knowledge on to the seemingly passive learners. Chachashvili, Lissitsa, and Milner (2019) confirms that most teachers apply “chalk” and “talk” and usually impart content of physics to learners by lecture and mostly teachers teach in one-way communication which is more teacher centred.

The proposed teaching-learning feedback channels in the PCA-IK-IPM are summarized in Figure 6.5.

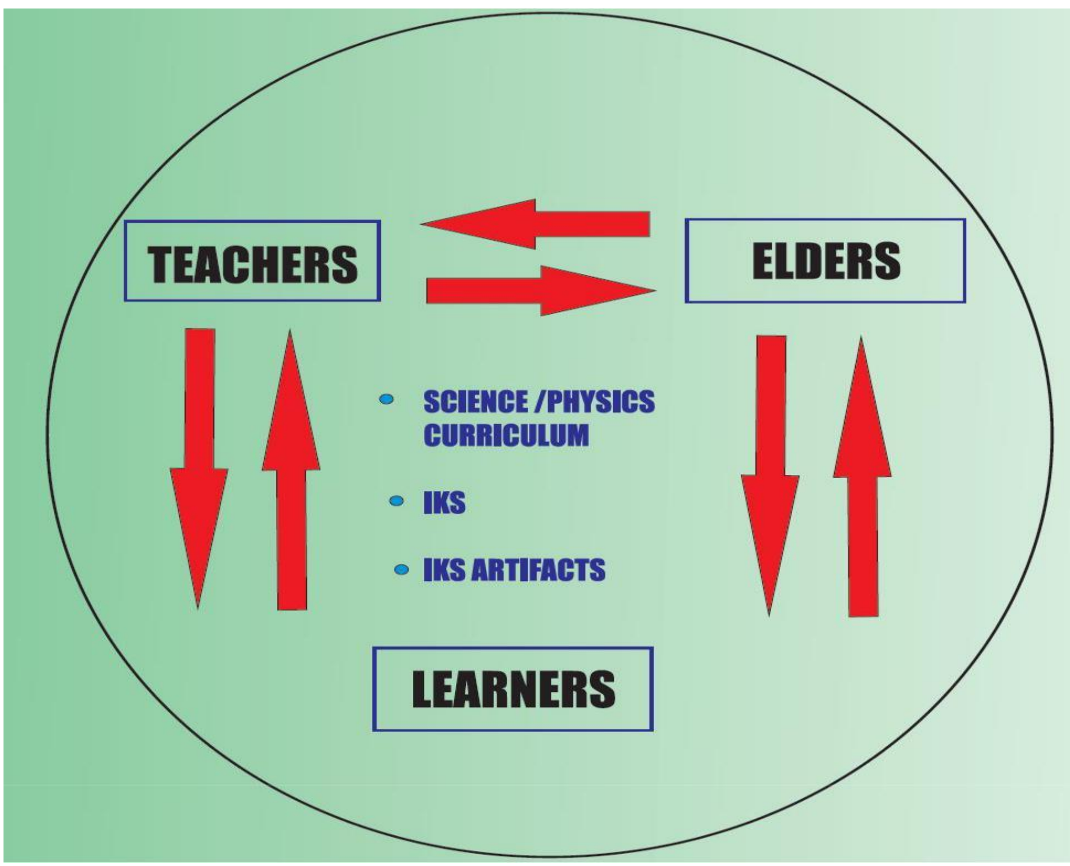

Figure 6.5: Teaching/Learning Feedback communication channel implied in the PCA-IK-IPM model (own design)

The arrows in Figure 6.5 indicate the feedback communication channels implied in the PCA-IK-IPM. The activities and programs are discussed between teachers and learners, between teachers and community elders, among teachers, elders, and learners, among elders, and also among learners themselves. In-depth discussions may include issues on what to include as content of the curriculum, examinations, teaching approaches, teaching strategies, teaching methods, instructional aids, and instructional technology. Contributions of all the participants are respected. This may require a lot of time and resources.

The transformative paradigm based on the principle of personal and social transformation informed the PCA-IK-IPM. Chilisa (2012) posits that the main aim of the transformative paradigm is to dispel the myth that western forms of thinking are superior and empower people to radically change society. The integration of IK artefacts is similar to what Kanu (2008) identified as a strike against the cultural superiority, ideological indoctrination, power and control of the Eurocentric colonization over African indigenous people. When integrating IK and IK artefacts in the teaching of physics, as required by the PCA-IK-IPM, people will be addressing power imbalance between IKS and other knowledge systems so that they all co-exist and work in a complementary manner. A situation where the different knowledge systems co-exist in harmony may be difficult to establish and they may create, unnecessary stigmatisation and clash among the people and the knowledge systems. The adoption and implementation of the model has to be done with enough consultations and approval by all stakeholders to avoid these clashes. This may need a lot of resources and time.

The ontological base of the PCA-IK-IPM respects the existence of multiple realities, shaped by human rights values, democratic and social justice values. Taylor and Cameron (2016) advocate for a theory that addresses ways of valuing IKS in science teaching and learning.

When applying the PCA-IK-IPM, teachers would integrate IK artefacts into physics subject teaching based on western curriculum that is designed to be taught within a western-type setting. Considering these views, IK artefacts would be regarded as another epistemology that we integrate into an imposed norm. Realities vary from one ethnic group to another and within each ethnic group; the same situation may be perceived in different ways. It is difficult to effectively implement the exact model throughout a country or across countries because of this. IKS cannot be essentialised, the same expectations (objectives) and uniformity of experiences and knowledge from western education systems is not possible. However, the ambiguity inherent in IK artefacts has a potential to confuse learners by not allowing them to see the physics concepts and information that the IK artefacts are intended to convey.

Migration, culture diffusion, social dynamism, globalization as a result of technological advancement render it complex to think of IK as an absolute phenomena as observed by (Mpofu, 2016). The interpretation of IK artefacts demands high level cognitive skills and without these, could lead to numerous misconceptions and incorrect ways of reasoning. This agrees with views from Ogunsola-Bandele (2009, p. 56) that African science teachers have the challenge of searching and providing scientific explanations for traditional African culture, beliefs and superstitions.

The PCA-IK-IPM indicates that IK and IK artefacts can be integrated in the teaching of formal physics and can co-exist peacefully with western IK. Questions then remain on what are the most appropriate IK or IK artefacts to integrate, and where and when should this be done? Finley (2009) and Onwu (2009), when commenting on situations like that presented in the PCA-IK-IPM, ask the question of how to tell when the interactions are productive and when they are valid or not? The model requires that IK and IK artefacts be documented. This requires addressing issues of copyright and intellectual property rights, as required by the United Nations Declaration on Rights of Indigenous People (Stamatopoulou, 2009). Oldham and Frank (2008) indicate that the Economic Commission for Africa required that use or exploitation of oral tradition and IK in African communities must follow the guidelines for the protection of intellectual property rights. In protection of these artefacts, the problem faced is that copyright laws are Eurocentric, emphasizing individuality and material, which is inherently contrary to traditional and indigenous cultural norms (Greyling & McNulty, 2011). Indigenous cultural and intellectual property rights require that indigenous people‟s rights to their cultural heritage be legally respected and protected. These rights allow them to continue with their roles as custodians, practitioners, and teachers of cultures and this, in turn, requires partnership between knowledge producers and users. The PCA-IK-IPM ensures this protection by allowing IK holders, teachers, learners and other stakeholders to work together in a way that all parties would now benefit and it even considers the prosperity of future generations.

6.8 SUMMARY

Chapter 6 has provided the answer to the fourth and fifth research questions, which are as follows:

Research Question 4: How can indigenous artefacts be integrated in the teaching of Advanced Level physics mechanics as perceived from the elders, teachers and learners?

Research Question 5: What feasible pedagogic model of teaching and learning can be proposed regarding the integration of IK artefacts into the teaching of physics, considering the views of elders, teachers and learners in the Advanced Level physics in Zimbabwe?

The answers were presented in the form of an IK integrated pedagogical model summarised in Figures 6.1 and 6.2. The model, termed the Physics Concepts Attainment-Indigenous Knowledge-Integrated Pedagogical Model or PCA-IK-IPM, has features that are heavily influenced by and anchored in the responses from the research participants to the first, second, third and fourth research questions. Broad or macro components of the model were summarized diagrammatically in Figure 6.1 and the micro or central part of the pedagogic model was given in Figure 6.2. The fundamental principles respected by the models were outlined in this chapter. The nature or characteristics of the main components of the teaching process as embedded in the model when the PCA-IK-IPM is adopted for teaching physics in schools are also described. These components of the teaching process include teaching methods, teaching strategy, teaching technique, instructional aids and technology, lesson presentation, school environment and activities, classroom and class management and assessment (Figure 6.2). The characteristics of the components were derived from the findings of the research discussed in Chapter 5. Some perceived strengths and weaknesses of the model derived from the research findings and insights have been discussed. Generally the PCA-IK-IPM includes aspects of relevant IK and IK artefacts, it recognizes learners‟ home life backgrounds, their preconceptions and worldviews. It also provides space for different ways of knowing, it decolonises science pedagogy, and encourage critical thinking that can attract and sustain more learners in science generally, and physics in particular, with anticipated improved performances.

CHAPTER 7

SUMMARY, CONCLUSION, RECOMMENDATIONS AND IMPLICATIONS

7.1 INTRODUCTION

This chapter gives a summary of the research process and the conclusion drawn from the research process and the data that was gathered and analysed in the research process.Conclusion, recommendations, and implications are also given in light of the research findings.

7.2 SUMMARY

The purpose of the study was to come up with a culturally aligned decolonized physics pedagogy involving Integration of Indigenous knowledge (IK) artefacts and IK strategies in teaching mechanics basing on insights from community elders, physics teachers, and learners. The study was conducted in Masvingo District in Zimbabwe. The study was conducted with a view to creating a culturally aligned pedagogical model that creates opportunities for IK artefacts to be available and be an integral part of the teaching and learning of physics at Advanced level. The emergent models (i.e. P-IKS-ICM and the PCA-IK-IPM) attempt to connect the home and cultural experiences of the learners with the classroom physics to enhance attainment or understanding of physics concepts by learners. In my research problem statement, I alluded to concerns raised by various scholars within the science education community and my own experiences and observations. The concerns relate to, among other issues, the overly abstract delivery of Advanced Level physics, poor pedagogical skills of the teachers, and the lack of relevance of school physics to the learners‟ lived experiences and home culture.

The PCA-IK-IPM was found to be necessary since the physics syllabus or curriculum statement mentions very little about how the integration of IK and IK artefacts in the teaching process should be done, thus leaving it to teachers to decide which IK artefacts to include in physics teaching and learning and how to do this. However, the literature reviewed indicated that teachers have no ideas on where and how the integration should be done and have limited resources or literature to which they can refer.The theoretical framework which guided and influenced the research was Vygotsky‟s sociocultural theory. The link between the theoretical framework and the study was described. The idea of using mediated actions for facilitating the

Learners underlines the need for teachers to employ indigenous knowledge (IK) and indigenous artefacts as mediating tools through integrating them into the components of the teaching process. The research was grounded in the *Unhu/Ubuntu* philosophy encapsulated in the indigenous research paradigms. Aspects of the indigenous research paradigm, and *Unhu/Ubuntu* philosophy were also discussed in Chapter 3.

A transformative participatory research methodology was adopted, which was formed by combining relevant aspects of transformative research and participatory research methodologies In Chapter 4, details of the methodology were outlined along with discussion of how it, together with the research framework and the theoretical framework, guided the research.

The research findings described in Chapter 5 indicated that there are commonalities in both IK and IK artefacts that can be used for a culturally relevant teaching in school physics. The research participants revealed that there are some physics aspects embedded in some indigenous artefacts. They confirmed that there is a close relationship between the mechanics taught in the physics laboratories and mechanics concepts embedded in the artefacts. The findings have justified and shown the feasibility and desirability of creating an IK artefact integrated pedagogical approach to enhance concepts attainment by Advanced Level physics learners.

Various models for „IK in Science" teaching eg five-step–model proposed by Snively and MacKinnon (1995), which is a learner centred model and the research and development model proposed by Aikenhead (2002) have high degree of respect for the culture of the learners and had great potential for teaching physics concepts. However, none of the models looked at the integration of IK artefacts in teaching physics and even Advanced Level physics in particular. Therefore, the model described here was found to be important as it guides the teachers on the effective integration of IK artefacts in all the components of the teaching process. It is in this regard that this study explored the integration of IK artefacts in the teaching of mechanics concepts at Advanced Level with the aim of deriving a culturally based pedagogical model that incorporated shared views on how physics teaching could be contextualized by way of integrating IK artefacts. Analysis of participants" responses confirmed that such an approach is indeed enacted in the teaching of indigenous knowledge, indigenous artefacts, and technology in indigenous communities and is effective. The model (i.e. The PCA-IK-IPM) was described in Chapter 6.

Chapter 6 has embedded in it, the answer to the fouth research question: “What feasible pedagogic model of teaching and learning can be proposed regarding the integration of IK into physics, considering the views of elders, teachers, and learners in the Advanced Level physics in Zimbabwe?” The answer is presented in form of an IK integrated pedagogical model (PCA-IK-IPM), whose features were heavily influenced by responses to the research questions. Components of the model are summarized diagrammatically in Figures 6.1 and 6.2. The fundamental principles respected by the model were outlined. The main components of the teaching process when this model is adopted for teaching physics in schools include teaching methods, teaching strategy, teaching technique, instructional aids and technology, lesson presentation, classroom and class management, school environment and also assessment. Their nature is described in detail. The characteristics of the components were derived from the findings of the research. Some perceived strengths and weaknesses of the model were also highlighted.

7.3 CONCLUSIONS

In the study, answers to the research questions were found based on the responses given by the participants in to the questions in individual interviews, focus group discussions, questionnaires and also on field observations by the researcher. These answers were synthesized to finalize the conclusions of the study.

Research Question 1:

What are the indigenous artefacts that can be associated with Advanced level mechanics found in Masvingo District, Zimbabwe as percieved by Elders, teachers and learners?

The participants, who were high school physics teachers and learners, and community elders, in their responses to the questionnaires, interview questions, and focus group discussion, revealed twenty IK artefacts that could be associated with Advanced Level mechanics. The researcher had observed some of the artefacts when he was gathering data in the field. These IK artefacts included bows and arrows, mortar and pestle, yokes, grinding stones, African drums, reed baskets, clay pots, catapult, mice traps, fishing lines and hoes. The sources of the artefacts varied among the people. The sources included inheritance, excavations, gifts, and buying. Some elders were producing the artefacts for themselves, for the local market and for the urban market. In the production and use of artefacts, people acquired skills and information from sources such as rock paintings, old photographs, stories, intuition, dreams etc.

Research Question 2:

What are the Advanced Level mechanics concepts that can be associated with these indigenous artefacts identified in Masvingo District, Zimbabwe?

The researcher, as an experienced physics teacher, used his background knowledge of the Advanced Level physic mechanics concepts, the physics syllabus for Advanced Level physics, ideas from focus group discussions with the teachers, learners, and community elders to identify and describe the physics concepts that were associated with the IK artefacts. The concepts that were identified includes: centre of mass, centre of gravity, stability and instability, torque, oscillations, forces, pressure, energy, fluid dynamics, upthrust, projectile motion, Stoke" law, conservation of energy and transfer of energy. It was confirmed that there are numerous IK artefacts that have some associated physics concepts evident in them. The way these concepts related to IK were identified by the elders, which indicates that the community elders or indigenous people know the physics concepts and can explain the concepts in their own way and language, peculiar to their own individual contexts. This was revealed in interviews with an elder, who in his own indigenous way, tacitly explained the concept of stability and instability when he was describing the structure of mortar and pestle. The researcher observed a high level of understanding of the concepts of centre of mass and centre of gravity when the elder was demonstrating and describing the design and shape of artefacts such as the mortar.

The researcher used his knowledge of the Advanced Level physics mechanics concepts, the physics syllabus for Advanced Level physics, ideas from focus group discussions among the teachers, learners, and community elders to identify the aspects of IK artefacts that could be integrated in the teaching of mechanics concepts. These aspects include: the materials, the source of materials, the shape and design of artefacts, designing, and construction process, how the item was used, the idea or thought behind its structure and design, the reasons why it is used in the way it is, and the context in which it was or is produced.

Research Question 3:

How can indigenous artefacts be integrated in the teaching of Advanced Level physics mechanics as perceived from the elders, teachers, and learners?

The participants who were high school physics teachers and learners, and community elders in their responses to questionnaires, interview questions, and focus group discussion had revealed a number of ways in which IK artefacts could be integrated in the teaching of Advanced Level physics. The researcher also observed some of the ways when he was gathering data in the field. These ways are given in form of a model, called the physics-IKS-integrated content model (P-IKS-ICM), which is summarized in Figure 6.1. The model indicates that the teaching of physics should be a collective effort among the community members, teachers, and the learners themselves. The link between the home experiences of the learners and the classroom physics should be created and sustained in a way that facilitates the learners understanding of the concepts and also for them to be able to apply the knowledge learnt in schools to improve their socioeconomic status. The model promotes relevance in the curriculum and indicates appropriate practices for initiating and sustaining the interest and performance of indigenous learners in school science and technology.

Research Question 4:

What feasible pedagogic model of teaching and learning can be proposed regarding the integration of IK artefacts into the teaching of physics, considering the views of elders, teachers, and learners in the Advanced Level physics in Zimbabwe?

The answer to the research question was given in form of a model physics concepts attainment-indigenous knowledge-integrated pedagogical model (PCA-IK-IPM). This model is given in Figure 6.2 and is summarized in Section 6.2. The model gives the details of what the teaching process would look like, if the integration process is to be meaningful and effective according to the findings from the research. In the PCA-IK-IPM, the IK artefacts are seen as meditational tools in the teaching of physic concepts, though which to foster understanding of physics concepts. A detailed description was given for each component of the teaching process, including the nature of the learning environment needed for effective integration of IK artefacts. The components of the teaching process that were identified from The research data included lesson presentation, instructional technology and aids, teaching approach and methods, teaching techniques and strategies, textbooks, and class and classroom management, and assessment. The model indicates that, in each component, IK artefacts should be embedded as a mechanism for their integration into the school Physics and it also shows examples on how this could be done. For example in the case of the learning environment, the model indicates that some physical and psychological space should be created for IK artefacts in the learning environments (i.e. the schools), such as Integrated laboratories, and model traditional homesteads. In lessons presentations, the model indicates strategies associated with IK artefacts that can be used by teachers to integrate IK artefacts. These include indigenous games, analogies, stories and their associated IK artefacts (as implied in traditional games like Mahumbwe and Nhodo) to explain, illustrate, describe, and demonstrate physics concepts. Questions on how the models could be applied across the whole country, where there are learners with different IK artefacts were addressed. In the model, IK is viewed as a tool to access another knowledge system or discipline, that is, school physics. It is used as a theoretical and methodological resource for teachers and learners to advance science. A question may be asked as to whether or not it can stand on its own.

Although some weaknesses in the model were identified, they seem not to be outweighed by the advantages. The main advantages being that it improves relevance and accessibility of physics as a subject to indigenous learners and that it provides a practical and philosophical attempt to decolonize the physics pedagogy.

7.4 RECOMMENDATIONS

It is the researcher‟s aspiration that the policy makers in science education recommend integration of Zimbabwe‟s IK artefacts in the physics curriculum. The government should develop a policy framework or document that is acted upon concretely to support strategies for integration programs and practices. The policy document would instill a sense of purpose and official direction to schools that offer physics as a subject and to physics teachers in particular. In this view, adequate training on how to integrate IK artefacts in the teaching of physics should be provided for teachers. These policy makers should also recommend that local IK artefacts be provided to facilitate concept attainment by learners. IK artefacts of different tribes in Zimbabwe should be documented and introduced in teaching. Curricular approaches should be adjusted to suit the context of the learners.Teachers should aso be trained and encouraged to integrate IK artefacts in their teaching. Scholars with specialization in indigenous knowledge and science should be encouraged to provide mentorship as well as to become role models for current and prospective science learners.

The researcher recommends that more studies exploring the integration of IK artefacts in the teaching of physics should be encouraged and supported. It would be particularly important to study the impact on the performance of physics learners of integrating IK artefacts using the PCA-IK-IPM. People should continue to advocate and lobby with policy makers and physics education stakeholders to make IK a more visible pillar of science education at the local and global levels. They should also support efforts targeted on mainstreaming IK and its associated artefacts into all learning areas particularly the science ariented subjects.

7.5 IMPLICATIONS

Local IK custodians (elders) should be involved in the identification of artefacts and indigenous pedagogical practices for inclusion in school physics teaching. Community members need to be involved in presenting or demonstrating indigenous practices during science lessons.

Classroom instruction should occur on the community- school interface in order to address the relevance of academic knowledge for local people.There is a need for further protection, reservation, studying, documentation, and dissemination of IK artefacts and related information as was also observed by Semali and Kincheloe (1999). This could be in the form of cultural museums in schools or districts.

7.6 PERSONAL JOURNEY

I brought into this study my own life experiences as described in Chapter 1, and many times I drew on those experiences to guide my relationships with community elders and teachers and learners in this study. I learnt about research, indigenous research methodologies, IK and IK artefacts. I also learnt about myself as a researcher. In the process of the study, I can say that I have undergone a deep philosophical change and experienced a decolonization of my traditional approaches to teaching physics and in so doing my identity as a teacher in the community has been reaffirmed.

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APPENDICES

Appendix A: Record of field work participants and sessions

IDENTITY	LOCALE	GENDER	SESSION DATE
Focus Group with Elders	Community centre	Mixed	
FG with teachers	One of the high schools	Mixed	
FG with Learners	One of the high schools	Mixed	
Interview			
Elder 1		Male	
2		Male	
3		Female	
4		Male	
5		Male	

Appendix B: QUESTIONNAIRE FOR ADVANCED LEVEL PHYSICS TEACHERS

SECTION A

GENDER

Male

Female

Academic Qualifications:

Ordinary level

Advanced level

Professional Qualifications:

Diploma

Degree

Other (specify)

……………………………………………………………………………………………………

…………………………………………

Experience in teaching Advanced Level Physics:

0 – 4 years

5 – 10 years

11 – 15 years

16 – 20 years

Home Area

Masvingo Province:

Masvingo District:

SECTION B

Where there is a box, put a tick in the BOX if you agree and a cross if you disagree with the idea. For other questions use the spaces provided.

1. Indigenous artefacts are objects made by people belonging to a particular place especially of historical or cultural nature. They are part of indigenous technology (I-Tech) and are produced by traditional approaches or methods and skills. IK Artefacts reflects the wisdom of people who

have lived a long time in a place and have a great deal of knowledge about their environment. They can be modified in order to improve their efficiency and outlook.

Examples are

Mice traps [*mariva*]

Grinding Stone [*Guyo*]

Bow and Arrow [*museve*]

Give more examples

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………..

3. Where are people getting the indigenous artefacts which they have?

Inheritance

Buying

Making

Other sources specify: ……………………………………………………………………………………………………
……………

4. How do people come to know about the Indigenous artefacts design, uses and the sources of raw materials for making the artefacts?

Story telling [Ngano]

Rock paintings

Revelations

Intuitions

Proverbs

Traditional games and songs

Initiation and cultural ceremonies and rituals

Archaeological structures

☐

Other sources specify:……………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

……………………………………………………………………………

SECTION C

1 Mechanics in Physics refers to an area of physics concerned with the behaviour of physical bodies when they are subjected to forces or displacements and subsequent effects of bodies on their environments. Generally it is concerned with motion of and forces on bodies. Include topics such as; Forces, Kinematics, and Dynamics.

State three more topics that fall under Mechanics in Physics

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………

2. Identify the mechanics concepts embedded in the following indigenous artefacts. You can include sketch diagrams where necessary [You can also use attached blank pages at the end of the questionnaire]

- Mortar [Duri]
-
- Mice trap [Riva]
- Grinding stone[Guyo]
-
- Bow and arrow [Museve]

Add one indigenous artefact of your choice

3. Do you think the artefacts can be integrated in the teaching of mechanics concepts in Physics at Advanced level?

Yes ☐

No ☐

If your response is NO, Give reasons

…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………

4. What aspects of the artefacts should be integrated in the teaching of mechanics concepts in Physics at Advanced level?

- Design ☐
- Shape ☐
- Uses ☐

Specify other

…………………………………………………………………………………………………
…………………………………………………………………………………

5. How do you think the integration can be done?

- Giving as examples during lessons
- Using the artefacts in demonstrations
- Using the artefacts as apparatus in experiments/Investigations
- Using them to illustrate ideas and concepts
- Can be part of the subject content.
- As projects or tasks[application of concepts]

Specify others

………………………………………………………………………………………

6. What do you think the teacher can do to ensure effective integration of the artefacts in his teaching of mechanics concepts in Physics at Advanced level (Teaching approach and method)?

………………………………………………………………………………………

7. What would be the roles of the learners and the community members?

Learners:

- Help in identifying indigenous artefacts.
- Identifying the physics concepts embedded in the indigenous artefacts
- Relating the indigenous artefacts to the concepts being

taught Specify any other:

……………………………………………………………………………………………

Community members:

……………………………………………………………………………………………………

…………………………………………………………………………………………

Teachers

……………………………………………………………………………………………………

…………………………………………………………………………………………

8. What problems do you think would be encountered when integrating the artefacts in the teaching of Advanced Level Physics?

- Finding suitable indigenous terms or words to describe some of the artefacts

……………………………………………………………………………………………

9. What do you think can be done to address the problems that are faced in an attempt to integrate the artefacts in the teaching of mechanics concepts in Physics at Advanced level?

……………………………………………………………………………………………………

…………………………………………………………………………………………

Thank you for your participation…

Appendix C LEARNERS' QUESTIONNAIRE

SECTION A

GENDER

Male

Female

Age

Home Area

Masvingo Province:

Masvingo District:

SECTION B

Where there is a box, put a tick in the BOX if you agree and a cross if you disagree with the idea. For other questions use the spaces provided.

1. Indigenous artefacts are objects made by people belonging to a particular place especially of historical or cultural nature. They are part of indigenous technology (I-Tech) and are produced by traditional approaches or methods and skills. IK Artefacts reflects the wisdom of people who have lived a long time in a place and have a great deal of knowledge about their environment. They can be modified in order to improve their efficiency and outlook.

Examples are

Mice traps [*mariva*]

Grinding Stone [*Guyo*]

Bow and Arrow [*museve*]

Give more examples

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…

3. Where are people getting the indigenous artefacts which they have?

Inheritance

Buying

Making

Other sources specify:
…………………………………………………………………………………………………

4. How do people come to know about the Indigenous artefacts design, uses and the sources of raw materials for making the artefacts?

Story telling [Ngano] ☐

Rock paintings ☐

Revelations ☐

Intuitions ☐

Proverbs ☐

Traditional games and songs ☐

Initiation and cultural ceremonies and rituals ☐

Archaeological structures ☐

Other sources specify

SECTION C

1 Mechanics in Physics refers to an area of physics concerned with the behaviour of physical bodies when they are subjected to forces or displacements and subsequent effects of bodies on their environments. Generally it is concerned with motion of and forces on bodies. Include topics such as; Forces, Kinematics, and Dynamics.

State three more topics that fall under Mechanics in Physics

………………………………………………………………………………………………

2. Identify the mechanics concepts embedded in the following indigenous artefacts. You can include sketch diagrams where necessary [You can also use attached blank pages at the end of the questionnaire]

- Duri
- Mice trap [Riva]

- Grinding stone[Guyo]

- Bow and arrow [Museve]

Add one indigenous artefact of your choice

3. Do you think the artefacts facts can be integrated in the teaching of mechanics concepts in Physics at Advanced level?

Yes ☐

No ☐

If your response is NO, Give reasons

……………………………………………………………………………………………

4. What aspects of the artefacts should be integrated in the teaching of mechanics concepts in Physics at Advanced level?

- Design ☐
- Shape ☐
- Uses ☐

Specify other

……………………………………………………………………………………………

5. How do you think the integration can be done?

- Giving as examples during lessons
- Using the artefacts in demonstrations
- Using the artefacts as apparatus in experiments/Investigations
- Using them to illustrate ideas and concepts
- Can be part of the subject content.
- As projects or tasks[application of concepts]

Specify others

6. What do you think the teacher can do to ensure effective integration of the artefacts in his teaching of mechanics concepts in Physics at Advanced level (Teaching approach and method)?

……………………………………………………………………………………………

Thank you for your participation…

Appendix D: INTERVIEW GUIDE FOR ADVANCED LEVEL PHYSICS TEACHERS

Male

Female

Academic Qualifications:

Ordinary level

Advanced level

Professional Qualifications:

Diploma

Degree

Other (specify)

Experience: in teaching Advanced Level Physics:

0 – 4 years

5 – 10 years

11 – 15 years

16 – 20 years

Home Area

Province:

District:

QUESTIONS

1. What are artefacts?
2. What are indigenous artefacts? Can you give examples?
3. Where are people getting the indigenous artefacts which they have?
4. How do people come to know about the artefacts design, use and the sources of raw materials?
5. What do you understand by Mechanics in Physics?
6. Can you describe and explain the design and structure of any three indigenous artefacts of your choice .Include the mechanics concepts embedded in the indigenous artefact.You can include sketch diagrams [Use attached blank pages at the end of the questionnaire]

8. Do you think the artefacts facts can be integrated in the teaching of mechanics concepts in Physics at Advanced Level?

9. What aspects of the artefacts should be integrated in the teaching of mechanics concepts in Physics at Advanced Level?

10. How do you think the integration can be done?

11. What do you think the teacher can do to ensure effective integration of the artefacts in his teaching of mechanics concepts in Physics at Advanced Level? (Preparation and presentation?)

12. What would be the roles of the learners, teachers and the community members?

13. What problem do you think would be encountered when integrating the artefacts in the teaching of mechanics concepts in Physics at Advanced Level?

14. What do you think can be done to address the problems that are faced in an attempt to integrate the artefacts in the teaching of Advanced Level Physics?

Thank you for your participation…

Appendix E: INTERVIEW GUIDE FOR ELDERS

SECTION A

GENDER

Male

Female

Academic Qualification

Ordinary Level

Advanced Level

Other

Professional Qualification

Area of specialisation

Age

Place of BIRTH

PROVINCE

DISTRICT

SECTION B

1. What are artefacts?
2. What are indigenous artefacts? Can you give examples?
3. Where are people getting artefacts?
4. How do people come to know about the artefacts of designs, sources of raw materials and use?
5. Can you describe and explain the design and structure of any three artefacts of your choice
6. What do you understand by mechanics in physics?

6. Do you think the artefacts can be integrated in the teaching of mechanics concepts in Physics at Advanced Level/of science/physics in schools?

7. What aspects of the artefacts should be integrated in the teaching of mechanics concepts in Physics at Advanced Level?

8. What do you think would be the roles of the teachers and the learners when integrating indigenous artefacts in the teaching of Physics?

9. How do you think the integration can be done?

10. What do you think the teacher can do to ensure effective integration of the artefacts in his teaching of mechanics concepts in Physics at Advanced Level? (Preparation and presentation?)

11. What would be the roles of the learners and the teachers?

12. What problem do you think would be encountered when integrating the artefacts in the teaching of Advanced Level Physics?

Thank you.

Appendix F: LEARNERS' INTERVIEW GUIDE

GENDER

Male

Female

SUBJECT

AGE

PLACE OF BIRTH

PROVINCE

DISTRICT

SECTION B

1. What are artefacts?

2. What are indigenous artefacts? Can you give examples?

3. Where are people getting artefacts?

4. How do people come to know about the artefacts of designs, sources of raw materials and use?

5. Can you describe and explain the design and structure of any three artefacts of your choice

6. What do you understand by mechanics in Physics?

7. Do you think the artefacts can be integrated in the teaching of mechanics concepts in Physics at Advanced Level?

8. What aspects of the artefacts should be integrated in the teaching of mechanics concepts in Physics at Advanced Level?

9. What do you think would be the roles of the teachers and the learners when integrating indigenous artefacts in the teaching of mechanics concepts in Physics at Advanced Level?

10. How do you think the integration can be done?

11. What do you think the teacher can do to ensure effective integration of the artefacts in his teaching of mechanics concepts in Physics at Advanced Level? (Preparation and presentation?)

12. What would be the roles of the learners and the teachers?

13. What problem do you think would be encountered when integrating the artefacts in the teaching of Advanced Level Physics?

Thank you.

Appendix G: FOCUS GROUP DISCUSION QUESTIONS FOR ELDERS

1: OPENING PRAYER FROM ONE OF THE PARTICIPANTS

2: ESTABLISHING RAPPORT

Thank you for coming to this discussion. I am Edson Mudzamiri, a PhD student (Science Education) with the University of Kwazulu Natal [UKZN].In our last meeting, I explained that we were to meet so that we can talk about the integration of IK artefacts in the teaching of Advanced Level Physics/Science. Like I stressed in the consent letter, your name will be kept confidential. You are kindly asked to be honest in giving your views. You should not feel forced to say something that you are not comfortable with. If you wish to withdraw from the research you are free to do so and will not be penalized.

3: Purpose

The purpose of this group discussion is to get your views on the integration of IK artefacts in the teaching of Advanced Level Physics/Science. The information you provide will help guiding me in coming up with a culturally integrative pedagogical model for teaching Advanced Level Physics.

4: Time line

The focus group discussion should take about 45 minutes

5: QUESTIONS

1. What are artefacts?
2. What are indigenous artefacts? Can you give examples?
3. Where are people getting artefacts?
4. How do people come to know about the artefacts of designs, sources of raw materials and use?
5. Can you describe and explain the design and structure of any three artefacts of your choice
6. Do you think the artefacts can be integrated in the teaching of science/physics in schools?
7. What aspects of the artefacts should be integrated in the teaching of mechanics concepts in Physics at Advanced level?
8. What do you think would be the roles of the teachers and the learners when integrating indigenous artefacts in the teaching of mechanics concepts in Physics at Advanced level ?

9. How do you think the integration can be done?

10.What do you think the teacher can do to ensure effective integration of the artefacts in his teaching of mechanics concepts in Physics at Advanced level (Preparation and presentation?)

11.What would be the roles of the learners and the teachers?

12.What problem do you think would be encountered when integrating the artefacts in the teaching of mechanics concepts in Physics at Advanced level?

CLOSING

I appreciate the time you have devoted to this discussion. If you need to talk more about this please fill free to get in touch with me

Thank you very much.

Appendix H: FOCUS GROUP DISCUSION QUESTIONS FOR PHYSICS LEARNERS

1: INTRODUCTIONS

2: ESTABLISHING RAPPORT

Thank you for coming to this discussion. I am Edson Mudzamiri, a PhD student (Science Education) with the University of Kwazulu Natal [UKZN].In our last meeting, I explained that we were to meet so that we can talk about the integration of IK artefacts in the teaching of Advanced Level Physics. Like I stressed in the consent letter, your name will be kept confidential. You are kindly asked to be honest in giving your views. You should not feel forced to say something that you are not comfortable with. If you wish to withdraw from the research you are free to do so and will not be penalized.

3: Purpose

The purpose of this group discussion is to get your views on the integration of IK artefacts in the teaching of Advanced Level Physics. The information you provide will help guiding me in coming up with a culturally integrative pedagogical model for teaching Advanced Level Physics.

4: Time line

The focus group discussion should take about 45
minutes 5: QUESTIONS

1. What are artefacts?
2. What are indigenous artefacts? Can you give examples?
3. Where are people getting artefacts?
4. How do people come to know about the artefacts of designs, sources of raw materials and use?
5. Can you describe and explain the design and structure of any three artefacts of your choice
6. Do you think the artefacts can be integrated in the teaching of mechanics concepts in Physics at Advanced level in schools?
7. What aspects of the artefacts should be integrated in the teaching of mechanics concepts in Physics at Advanced level?
8. What do you think would be the roles of the teachers and the learners when integrating indigenous artefacts in the teaching of mechanics concepts in Physics at Advanced level?
9. How do you think the integration can be done?

10. What do you think the teacher can do to ensure effective integration of the artefacts in his teaching of mechanics concepts in Physics at Advanced level (Preparation and presentation?)

11. What would be the roles of the community members, learnerss and the teachers?

12. What problem do you think would be encountered when integrating the artefacts in the teaching of mechanics concepts in Physics at Advanced level?

6: CLOSING

I appreciate the time you have devoted to this discussion. If you need to talk more about this please fill free to get in touch with me

Thank you very much.

Appendix I: FOCUS GROUP DISCUSION QUESTIONS FOR PHYSICS TEACHERS

1: OPENING PRAYER FROM ONE OF THE PARTICIPANTS

2: ESTABLISHING RAPPORT

Thank you for coming to this discussion. I am Edson Mudzamiri, a PhD student (Science Education) with the University of Kwazulu Natal [UKZN].In our last meeting, I explained that we were to meet so that we can talk about the integration of IK artefacts in the teaching of Advanced Level Physics. Like I stressed in the consent letter, your name will be kept confidential. You are kindly asked to be honest in giving your views. You should not feel forced to say something that you are not comfortable with. If you wish to withdraw from the research you are free to do so and will not be penalized.

3: Purpose

The purpose of this group discussion is to get your views on the integration of IK artefacts in the teaching of Advanced Level Physics. The information you provide will help guiding me in coming up with a culturally integrative pedagogical model for teaching Advanced Level Physics.

4: Time line

The focus group discussion should take about 45

minutes 5: QUESTIONS

1. What are artefacts?
2. What are indigenous artefacts? Can you give examples?
3. Where are people getting the indigenous artefacts which they have?
4. Can you describe and explain the design and structure of any three indigenous artefacts of your choice
5. How do people come to know about the artefacts design, use and the sources of raw materials?
6. Do you think the artefacts facts can be integrated in the teaching of Advanced Level Physics?
7. What aspects of the artefacts should be integrated in the teaching of physics?
8. How do you think the integration can be done?
9. What do you think the teacher can do to ensure effective integration of the artefacts in his teaching (Preparation and presentation?)
10. What would be the roles of the learners and the community members?

11. What problem do you think would be encountered when integrating the out facts in the teaching of Advanced Level Physics?

12. What do you think can be done to address the problem that are faced in an attempt to integrate the out facts in the teach

6: CLOSING

I appreciate the time you have devoted to this discussion. If you need to talk more about this please fill free to get in touch with me

Thank you very much.

Appendix J : OBSERVATION SCHEDULE

Gathering data about indigenous artefacts and their integration in the teaching of Advanced Level Physics

Researcher:

Location:

Observed participants:

Date:

AREA OF OBSERVATION	OBSERVATION	COMMENTS
IK artefacts observed on-site and off-site		
Sources of artefacts		
Sources of knowledge about artefacts		
Mechanics embedded in the artefacts		
Attitude towards integration in the teaching of Physics		
Member" behavior		

Appendix K: Ethics Clearance certificate: UKZN

UNIVERSITY OF
KWAZULU-NATAL
INYUVESI
YAKWAZULU-NATALI

11 June 2018

Mr Edson Mudzamiri 213574257
School of Education
Edgewood Campus

Dear Mr Mudzamiri

Protocol reference number: HSS/0206/018D
Project Title: Exploring Physics Teachers' integration of Indigenous Knowledge (IK) Artefacts and IK strategies in Mechanics in Zimbabwe.

Full Approval – Expedited Application

In response to your application received 12 March 2018, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol has been granted **FULL APPROVAL**.

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment /modification prior to its implementation. In case you have further queries, please quote the above reference number.

PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for a period of 3 years from the date of issue. Thereafter Recertification must be applied for on an annual basis.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

....
Prof Shenuka Singh (Chair)

/px

cc Supervisor: Prof Nadaraj Govender
cc. Academic Leader Research: Dr Simon B Khoza
cc. School Administrator: Ms T Khumalo and Ms M Ngcobo

Humanities & Social Sciences Research Ethics Committee
Professor Shenuka Singh (Chair)
Westville Campus, Govan Mbeki Building
Postal Address: Private Bag X54001, Durban 4000
Telephone: +27 (0) 31 260 [illegible] **Facsimile:** +27 (0) 31 260 4609 **Email:** [illegible]
Website: [illegible]

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Founding Campuses: Edgewood Howard College Medical School Pietermaritzburg Westville

Appendix L: Conduct of Research Authorities

L-01: Masvingo Province: Ministry of Primary and Secondary Education.

ALL communications should be addressed to
"The Provincial Education Director for Primary and Secondary Education"
Telephone: 263585/264331
Fax: 039-263261
moesacmasvingo@gmail.com

ZIMBABWE

Reference: C/440/1

Ministry of Primary and Secondary Education
P O Box 89
Masvingo

31 October 2016

Mudzamiri Edson
Victoria High
Bag 421
Masvingo

RE: PERMISSION TO CARRY OUT AN EDUCATIONAL RESEARCH AT VICTORIA, ZIMUTO AND GOKOMERE HIGH SCHOOLS: MASVINGO DISTRICT: MASVINGO PROVINCE

Reference is made to your letter dated 03 October 2016 concerning the above matter.

Please be advised that the Secretary of Primary and Secondary Education has granted permission to carry out your research on;

"EXPLORING PHYSICS TEACHERS INTEGRATION OF INDIGENOUS KNOWLEDGE (IK) ARTEFACTS AND IK STRATEGIES IN MECHANICS IN FORM 5/6: A CASE STUDY IN MASVINGO DISTRICT."

You are also advised to liaise with the District Schools Inspector who is responsible for the schools which are part of the sample for your research.

MINISTRY OF PRIMARY & SECONDARY EDUCATION
PROVINCIAL EDUCATION DIRECTOR
MASVINGO
31 OCT 2016
P.O. BOX 89, MASVINGO
ZIMBABWE

Z. M. Chitiga
Provincial Education Director
MASVINGO PROVINCE

L-02: Masvingo District: Ministry of Primary and Secondary Education.

All communications should be addressed to
"The Provincial Education Director for Education Sport and Culture"
Telephone: 63585/63542
Fax: 039-63261

ZIMBABWE

Reference: C/4 40/1
Ministry of Primary and Secondary Education
Masvingo District
P O Box 89
MASVINGO

2 NOVEMBER 2016

MUDZAMIRI . E.
VICTORIA HIGH SCHOOL
BAG 241

MASVINGO

RE: PERMISSION TO CARRY OUT AN EDUCATIONAL RESEARCH AT VICTORIA, SOKOMERE, ZIMUTO HIGH SCHOOLS: MASVINGO DISTRICT: MASVINGO PROVINCE

Reference is made to your application to carry out a research at the above mentioned schools in Masvingo District.

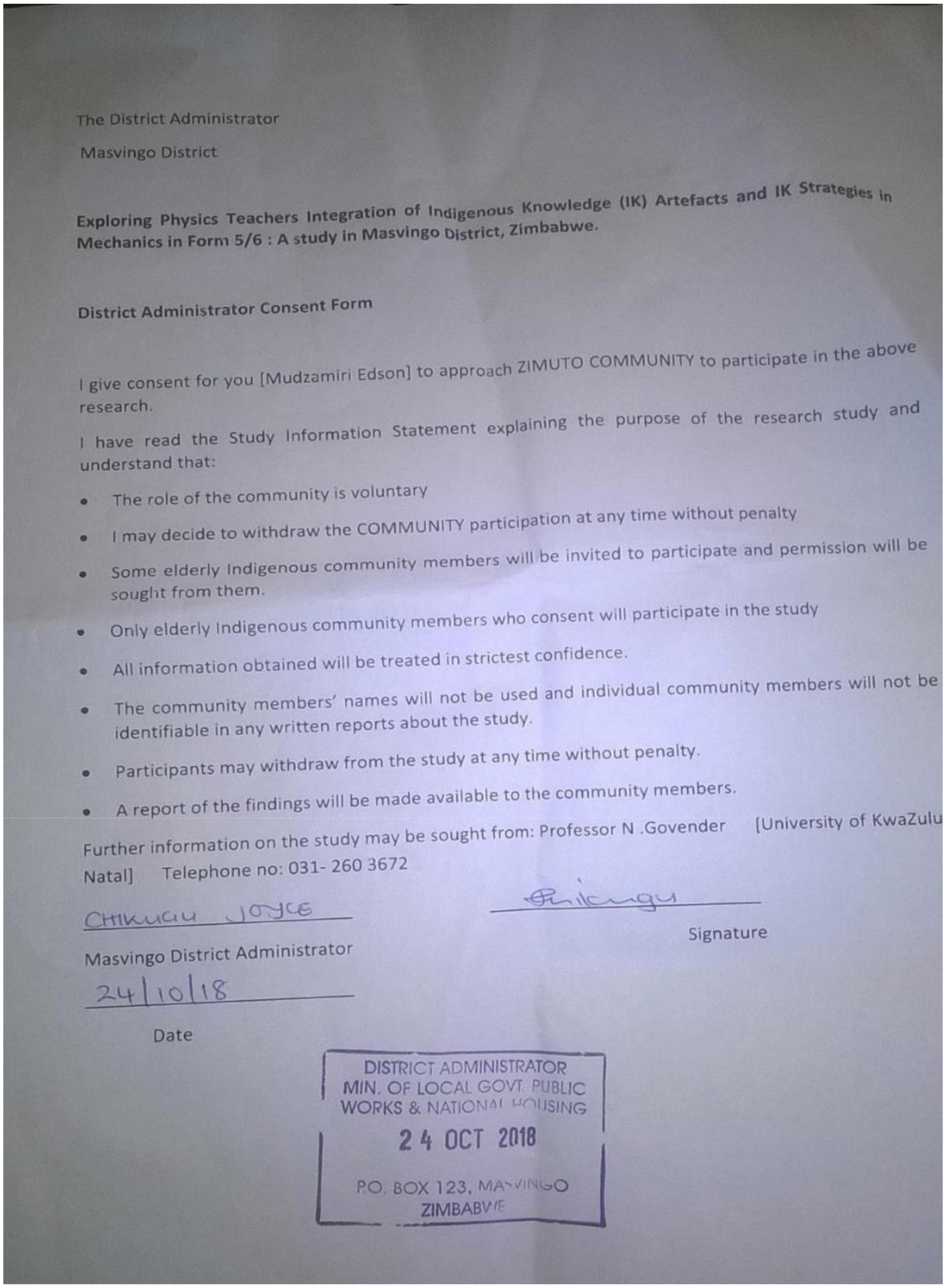
Please be advised that the Provincial Education Director has granted youpermission to carryout your research on;
"EXPLORING PHYSICS TEACHERS INTEGRATION OF INDIGENOUS KNOWLEDGE (IK) ARTEFACTS AND IK STRATEGIES I MECHANICS IN FORM 5/6: A CASE STUDY IN MASVINGO DISTRICT

You are also advised to liase with the Heads responsible for the schools which are part of the samples for your research.

MINISTRY OF EDUCATION
DISTRICT EDUCATION OFFICER
0 2 NOV 2016
MASVINGO DISTRICT
P.O. BOX 89
MASVINGO

I.CHIGABA
DISTRICT SCHOOLS INSPECTOR- MASVINGO

L-03 District Administrator



The District Administrator

Masvingo District

Exploring Physics Teachers Integration of Indigenous Knowledge (IK) Artefacts and IK Strategies in Mechanics in Form 5/6 : A study in Masvingo District, Zimbabwe.

District Administrator Consent Form

I give consent for you [Mudzamiri Edson] to approach ZIMUTO COMMUNITY to participate in the above research.

I have read the Study Information Statement explaining the purpose of the research study and understand that:

- The role of the community is voluntary
- I may decide to withdraw the COMMUNITY participation at any time without penalty
- Some elderly Indigenous community members will be invited to participate and permission will be sought from them.
- Only elderly Indigenous community members who consent will participate in the study
- All information obtained will be treated in strictest confidence.
- The community members' names will not be used and individual community members will not be identifiable in any written reports about the study.
- Participants may withdraw from the study at any time without penalty.
- A report of the findings will be made available to the community members.

Further information on the study may be sought from: Professor N .Govender [University of KwaZulu Natal] Telephone no: 031- 260 3672

CHIKUKU JOYCE

Masvingo District Administrator

Signature

24/10/18

Date

DISTRICT ADMINISTRATOR
MIN. OF LOCAL GOVT. PUBLIC
WORKS & NATIONAL HOUSING
24 OCT 2018
P.O. BOX 123, MASVINGO
ZIMBABWE

Appendix M: RESPONSES OF PARTICIPANTS (Sample)

Respondent	Excerpt	Theme category
	Interviewer: Midziyo iyi ichakakukosherai here mukurarama kwenyu? (Are your indigenous artefacts still of value in your livelihood?). Elder: Eee, Ko ndizvo zvatinoshandisa zvichitiraramisa zve.Munhu ane midziyo iyi pamusha pake ndiye "munhu".Vechidiki vanenge vachizvisvora asi zvinoshanda chose kana zvakanyatso gadzirwa.Dai vana ava vadzidziswa nezve midziyo iyi isa parara ,tingafa nenzara,uye nezvirwere. (Yes, this is what we use for our livelihoods. A person with these artefacts is among the respected in our community. We wish to see our children being taught about these artefacts so that they do not go extinct. If these artefacts disappear we would die of hunger and diseases). Our learners come from rural communities were the indigenous artefacts are used for their livelihoods and development, therefore failure to	Relevance of IK artefacts

	include IK in our lessons shows that western artefacts are superior but they do not help in the community developments. We need to include IK and IK artefacts when teaching to strengthen and improve livelihoods in indigenous communities. Interviewer: Your artefacts are out-dated, don‟t you think its high time that you buy modern tools from shops? Elder: Our IK artefacts are not out-dated because they are still helping use to solve some of our current problems and even increase our production in the fields. We expect that our children will continue to improve the efficiency, design and outlook of the artefacts like our generation has done. The hoe (badza) that you are now seeing did not have the original form; it was improved over the years.	

	Isu nevana vedu tine ruzivo chose pamusoro pemidziyo yedu yatinoshandisa (All the Elders in the community together with our children have deep knowledge about all our artefacts). Ungatadza kuzviziva ugoita munhu here mwanangu. Wese abvazera anototi azive (Without this knowledge you will not be a respectable member of the community, all the grown-ups have to know the artefacts). Unototi uzive midziyo iyi nekuti ndiyo inoshandiswa pakuita mabasa anoraramisa mumisha medu".Vakuru vedu vanotidzidzisa (You have to know these artefacts, because we use them in our work, our Elders teach us a lot about them).	Knowledge about IK artefacts
	"Zvimwe zvatinoshandisa zvakaita semakuyo, inhaka dzemadzitateguru edu.Joko raunoona iri ndakaripihwa panhaka yasekuru vangu kare kwazvo". (We have inherited some of these artefacts from our ancestors. The yoke you are seeing is one of the artefacts that I inherited from my uncle).	Sources of information/skills about IK artefacts.

		Sources of IK artefacts
	I think it is important to integrate IK artefacts in the teaching of physics because it helps learners to relate what they know to what they do not know. This helps them to understand better. He added that "it gives parents opportunity to assist their children in the subject". Ngazvishandiswe tiwane kuudzavo vana vedu nezve midziyo yedu.Kana pavanoda rubatsiro tinovabatsira.(Artefacts should be integrated in the teaching of science because we will have an opportunity to teach our learners about them .If teachers need help we will assist) Elders: School physics is damaging our environment. There is need for our children to come up with another way of knowing. Learners need to be exposed to our old learning ways which were meaningful and safe to the environment. Aaa, zvakanaka chose nokuti ruzivo rwevana vedu nerwedu runowandavo patinosanganisa	Views on the integration of IK artefacts in the teaching of Physics

	pfungwa dzeva"chena" idzi nedzedu dzechivanhu chedu (Aaa, this is very good,because our knowledge and that of our children would be increased when we integrate our ideas and with those of whites) Our learners struggle to make sense of the concepts explained in English. This usually frustrate them and demoralise them. The use of some terms from the IK languages especially in situations where IK artefacts are being integrated in the teaching process would actually motivate the learners to learn and enhance their understanding Tikaramba tongoshandisa zvava chena mukudzidzisa muzvikoro medu tinenge tisati tasununguka.Kushandisa zvigadzirwa zvedu chiratidzo cherusununguko rwakazara. We teach learners so that they pass	

	examinations. We do not have to waste time teaching learners things that are examined at the end of the course. We rarely see IK artefacts in the final examination questions. If we integrate IK artefacts in the teaching of Physics, we will not be teaching proper physics to our learners, that is pseudo-physics. Hadzisi Science dzakaongororwa dzikaonekwa kushanda kwadzo.(The applicability of the science in these IK artefacts has not been scientifically tested and proved). The power and prestige associated with physics as a subject will be diluted. Concepts would lose their original detail and may lose their original meanings as they will be analysed and explained in contexts different from those in which they were originated. There is need for a clear policy on how the integration should be done. Teachers should be trained on the methods that they would use in the physics classrooms. If this is not done, there will be confusion.	

	ELDER. Kungoonavo nemamwe maonero.Zvakaipei? Ndiko kuwanda kweruzivo. This way of seeing things. There is no problem with that. This would actually broaden our horizons. Learners find it difficult to understand concepts because the recommended terms to be used in explanations and demonstrations whether technical or non-technical present new and different language to learners I am excited to see different IK and IK artefacts being used to explain some physics concepts. I derive satisfaction from the way the IK would be linked to the western IK and science concepts Our IK artefacts are similar in designs, shapes, and structure to some western artefacts which are used in our science textbooks and also used by our teachers to explain and demonstrate some physics concept in the classroom. Therefore we	

	can also use them instead of using the western artefacts which are not familiar to us. If teachers use examples, illustrations and demonstration from our everyday home experiences the concepts will be easy to understand and the subject will not appear and sound exotic to us. It is also our right to be exposed to education in our familiar cultural contexts. The integration of our IK and IK artefacts by our teachers when teaching us Physics is a sign of respect for our grant parents" creative minds and hard work .People need to continue to attach value to this and make effort to preserve these ideas and technology.	
	says "Kana tichivadzisa tinovarega vachiitoita zvekutogadzira chinhu chacho, Kutaura kwega nekuvaratidza hazvina kukwana." We teach them through making them make the artefacts, showing the learners artefacts and explanations only are not effective enough." This excerpt indicates that the elders also recommend some teaching methods and approaches, which they have seen to be effective when teaching about the artefacts.	Views on how the integration could be done

E L	Vana vanofanira kunyora Zama,Ndiko kuti tizive kuti vari kugona zvavari kudzidziwsa here. Uye tinoda kuziva kana tichibhadharira school fees chiripo. (Learners should be assessed, This would allow us to check on their performances and to see if something is being secured for the money that we pay as school fees)This resonates well with views of Baker, 2001and Linn, 2001 that assessment should be done for public accountability and also to monitor the quality and standards. Nepamibvunzo yacho, ngazvisanganiswe, zvedu nezvavachena zvacho, Kana kungovhunza zvinoenderana nemagariro, midziyo, nemashandiro udu Amazuva ose. I the assessments there should be a mixture of items related to our IKS and IK artefacts or something related to our day-to-day life experiences and IKS and related IK artefacts. This implies that the elders advocate that assessment tools and procedures should be contextual. We have problems in understanding the English language which our teachers use when teaching us. This is making the subject difficult for us. We would appreciate a situation where teachers use our indigenous languages as medium of	

	instruction or mix indigenous terms and English terms. This would also give us opportunity to express our cultural views of the world and our existence.	
L	Learning environments enable us to be psychologically, physically and emotionally used to the conditions found in our communities where we would be expected to apply the knowledge that we would have learnt from our physics classes. The environments should bear imprints, connotations, and footprints of IK and associated IK artefacts. Such an environment would allow us to be creative and innovative.	
L L	We have seen buildings in some schools with architectural designs and shapes that resemble western artefacts. We have some laboratories and building in some schools with western names. These remenance of colonial legacies do not help us in any way. We can make can have designs and names that resembles some aspects from our own culture.	

Appendix N: Sources of the indigenous artefacts (Sample)

Source	Description
Inheritance	Receiving something from a predecessor, the participants valued the culture of inheritance.
Buying	Those who could not make artefacts bought them from other community members.
Designing and Making	Most of the people could make artefacts for themselves using locally available simple materials.
Archaeological sources	Some people got the artefacts from ancient settlements and abandoned settlements.
Gifts	Some claimed that they were given some pieces of artefacts by friends and relatives.
Souvenirs	Some got the artefacts from places which they had visited

Appendix 0: Sample of Identified sources of information about IK artefacts (Sample)

Source	Description
Story telling	Narration of events
Rock paintings	Pictures of objects, animals etc. drawn on rocks. Some rock paintings were at Mazambara mountain, Chivavarira mountain and Gokomere (Mangwandi) mountain near Gatoramuzondo.
Revelations	The process of disclosing something previously kept secret in a dramatic or surprising way.
Proverbs	Short saying containing some commonplace fact.
Traditional games/songs	These are songs and games belonging to a particular country, people, family, or institution over a long period. These were handed down from generation to generation
Archaeological sources	Sources related to the scientific analysis of the material remains or ancient of IK artefacts. Some excavations were done at Gokomere mountain.
Initiation and cultural ceremonies	Ceremonies that are often secret, initiating young members into adulthood. This is no longer popular among the tribes in the area.
Traditional children play games (Shona: Mahumbwe)	Traditional children play games (Shona: Mahumbwe), which is a game where youth are allowed to stay away from home usually in the fields during harvest, where they mimic family life. In this game, boys learn to provide for the family mimicking the roles of the men in

	the communities. This would involve engaging in some activities that involved the making and use of some of the IK artefacts.
Dreams and visions	Some artefacts were passed to the people from their ancestors indirectly through dreams and visions. This response was common among the elders and the teachers. They claimed that it was part of their knowledge revealed to some of them by their ancestors. They claimed that they have translated the visions and dreams into the physical objects.
Intuitions and by accidents	Some artefacts came into being through intuitions and by accidents. Intuitive knowledge is that knowledge that a person finds within himself in a moment of insight or intuition which the sudden pre-emption into consciousness of an idea or conclusion produced by a long process of unconscious work.
Photographs	Some indicated that they have seen some of the artefacts on old photographs. They tried to copy the designs from the photographs and made similar artefacts. Some of the photographs that I observed include that of rock paintings and clay pots.

END